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POWER DIVISION

BANGLADESH POWER DEVELOPMENT BOARD

Vol 1:

EXECUTIVE SUMMARY

Prepared under Environmental Impact Assessment (EIA) Study for

Repowering of

Unit-4 of Ghorashal Power Station

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1.1 Background

1. Sustainable power supply is an important precondition for the socio-economic development of Bangladesh. At present, about 60% (including off-Grid Renewable) population of Bangladesh has access to electricity. The present electricity demand growth is 12% per annum, with installed generation capacity of around 10,817 MW. This includes 4,437 MW from private sector and 500 MW of electricity import from India. At present, most of the power plants are natural gas based. Considering limited gas reserves in the country, BPDB under its Power Sector Master Plan of 2010, planned to enhance the electricity generation by converting/re-powering the existing simple cycle gas plants to combined cycle plants. Ghorashal Unit 4 repowering is one such initiatives taken by the Bangladesh Power Development Board (BPDB). This environmental impact assessment (EIA) is conducted to assess the impacts due to the repowering of Unit 4 from steam cycle to combined cycle. The proposed Project falls under the 'Red' category of industrial classification made under the Environment Conservation Rules (ECR), 1997 of Bangladesh Government. BPDB is planning to seek financial assistance from the World Bank to implement the project. Therefore, the EIA took into consideration the environmental rules and regulations of the country as well as the World Bank's operational policies and guidelines, including the IFC's Environmental, Health and Safety Guidelines.

1.2 Policy, Legal and Administrative Framework

2. All applicable acts, rules, policies, and conventions related to the re-powering of unit 4 has been carefully studied. The ECA 1995, the ECR 1997 (subsequent amendment in 2005), the Environment Court Act 2000 and the National Water Policy 1999 are critically examined and set for compliance to protect ecologically critical areas, fisheries, and maintain air, water, and effluent quality during decommissioning, construction and operation stage of the proposed project.

1.3 Project Brief

3. Ghorashal Power Station (GPS) is a major power generation center of Bangladesh Power Development Board (BPDB). Currently, it has six generating units with an installed capacity of 950 MW (2x55 MW and 4x210 MW) based on gas fired conventional steam turbine technology. The average efficiency of the Plants at Ghorashal is around 31%, which is quite poor compared to the efficiency of around 55% for the modern combined cycle power plants. The purpose of the current project is to re-power Unit 4 (installed capacity of 210 MW) of GPS. The project involves the re-powering of the current steam plant with a more efficient Combined Cycle technology. As part of the new Plant, a gas turbine will be installed and the present boiler will be replaced with a Heat Recovery Steam Generator (HRSG). Existing Unit 4 has a steam turbine with 210 MW generation capacity, but due to its age, the plant has become unreliable and less efficient. Currently, maximum output of this Unit is 180 MW. BPDB, therefore, has taken the decision to repower the unit to a 403.5MW combined cycle power plant (CCPP).

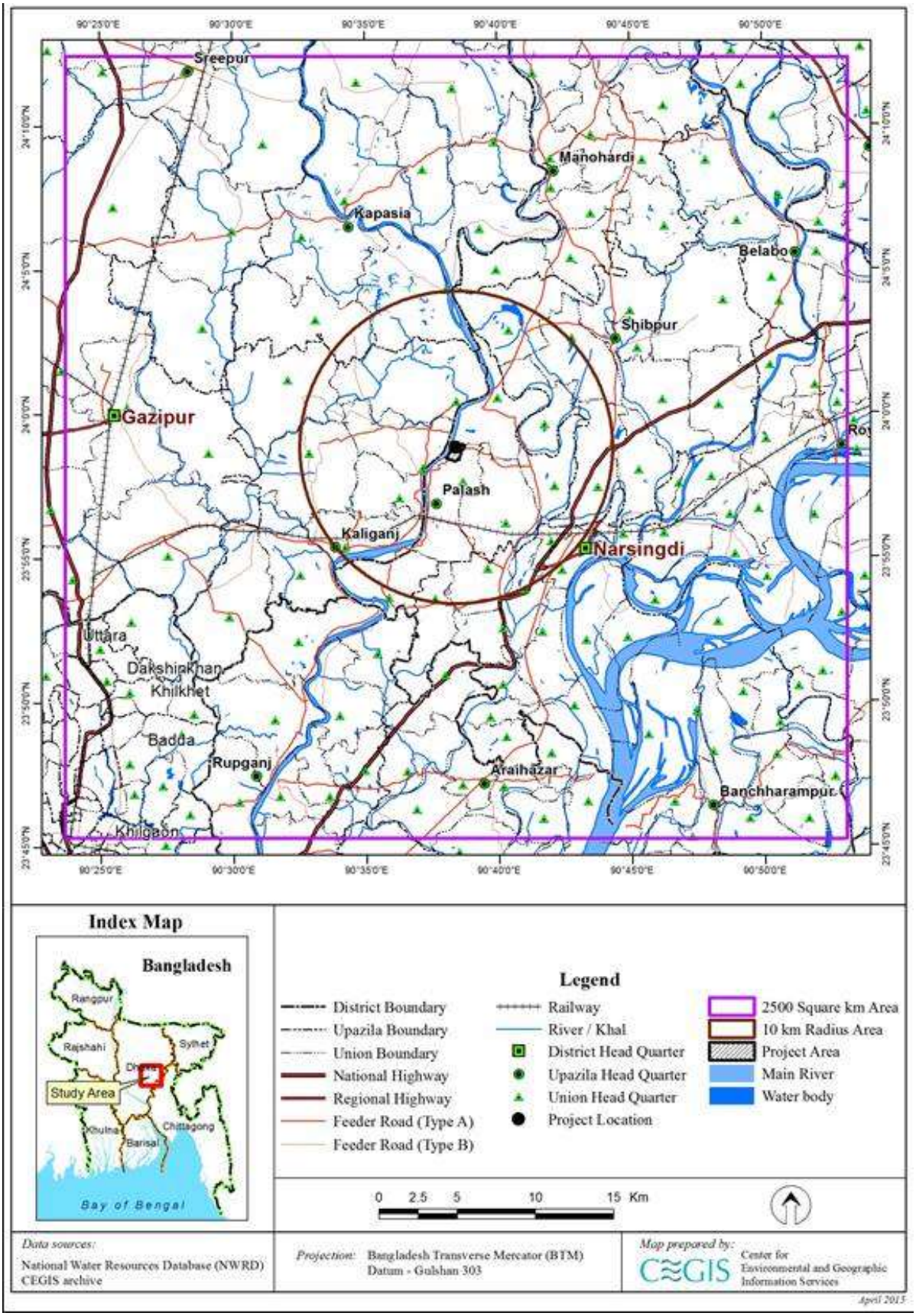

Figure 1: Location of the project and influence area

4. The proposed construction site is located in Palash Mauza of Ghorashal Municipality under Palash Upazila of Narsingdi district (Figure 1). Natural gas for the repowering unit will be supplied from the existing allotment of Petrobangla to the GPS through the existing regulating and metering station (RMS) of Units 3 and 4. Surface water from the Shitalakhya

River will be used for condenser cooling and other purposes. Generated power of the gas turbine will be evacuated through the proposed 230 kV Gas insulated sub-station (GIS) switchyard and 230 kV high voltage Tongi transmission line via 340 MVA unit transformer. On the other hand, power generated from the steam turbine (ST) will be evacuated through the existing bay of the 230 kV Air insulated sub-station (AIS) switchyard via the existing 2x125 MVA unit transformers. This repowering of the system will be done by installing one HRSG, one Gas Turbine (GT) of 246 MW capacity and re-furbishing the existing 210 MW ST along with decommissioning of the existing boiler. The hot exhaust gas of 238.5 MW GT will pass through the HRSG and main stack to the atmosphere. The HRSG in turn will generate HP, IP, and LP steam that will be directed to the steam turbine which will in turn generate 165 MW of power making plant output to 403.5 MW (Combined cycle). The Project after re-powering will augment 224 MW power generation and supply to the national grid, of which about 165 MW will be generated without additional fuel, due to the use of combined cycle technology.

1.4 Proposed Project Description

1.4.1 Decommissioning of Existing Unit 4 Boiler

5. The existing boiler of Unit 4 is a conventional drum boiler and is fired with natural gas. The boiler is designed and built by Taganrog type, TGME-206 COB (a Russian manufacturing). The boiler is provided with two rotating air heaters and flue gas recirculation. The high pressure water-steam loop encompasses an economizer, a HP drum, HP evaporator, a low temperature ceiling super heater (SH), a radiant wall SH, a platen SH and a convective final SH. The boiler consists of various insulation materials like mineral wool, glass fiber, asbestos, aluminum powder, glass and steel. A partial list of insulation materials were retrieved from the erection reports available in the GPS library. After extensive search and consultation with GPS staff, the full-list of the boiler materials was not available. It is understood that a huge quantity (about 50 tons) of asbestos is present in the insulation material. The boiler decommissioning contractor will carefully assess the total quantity and prepare a full account prior to dismantling of the boiler.

6. The existing boiler is old and not usable. It will become redundant after repowering and require dismantling. The boiler components and associated parts will be removed one by one and stored at temporary storage area identifies in the northeastern side of the boiler, before being transported to final disposal site or collection by recycling companies.

1.4.2 Refurbishment of Existing Steam Turbine

7. The existing steam turbine Type K210-130-3 of Unit-4 is designed and built by LMZ (Russian Manufacturer). It consists of an HP cylinder, an IP cylinder and a double LP cylinder. The HP and IP cylinder are in opposite positions to balance the axial force from the pressure differences. There are two condensers placed at the bottom of the LP Cylinder. The turbine is provided with an electro hydraulic governing system. The blades are mainly of the impulse type.

8. After repowering, Unit 4 will operate another 20-25 years, it is recommended to keep the steam turbine process conditions lower than the design conditions. The steam from the HRSG will have a temperature of 530 ºC. The pressure of steam produced by the existing boiler does not exceed 120 bars. The original design parameters of steam turbine are 540 ºC and 130 bars.

9. The stack temperature of the HRSG is low due to the condensate temperature of 40-45 ºC from the condenser. It is designed so the total heat delivered by the HRSG with or without additional burning are: (a) heating up condensate to saturated water and a

pressure of about 125 bar (drum pressure) including evaporation heat and superheating of the steam, which takes about 3,245 kJ/kg energy and (b) reheating a thermal input in the water/steam system for a flow of ~125 kg/s, which is about 460 MJ/s.

10. The above considerations led to the following assumptions for the existing steam turbine refurbishments:

- Approximately 125 kg/s of steam flow;
- Steam temperature 530 ºC; and
- HRSG exhaust gas inlet temperature minimal 570 ºC to produce the needed steam temperature.

11. Since the existing steam turbine will be rehabilitated without major efficiency modifications it is recommended to slightly de-rate the original steam parameters of the turbine. With this in mind, de-rating with 10 °C in steam temperature and ~10 bar in pressure for the HP-steam and 10 °C and ~5 bar for the IP steam are recommended.

1.4.3 Refurbishment of Existing Cooling System

12. The present condenser cooling system is an open cycle once through cooling system, which requires 7.6389 m^3/s of Shitalakhya River water. The condenser cooling water discharge flows through a long open channel for natural cooling. A portion of this water is channeled to the nearby agriculture fields for irrigation purposes and the rest is returned back to the river at a temperature higher than the ambient temperature (outside the mixing zone). During winter, when Shitalakhya water is relatively low or during any break down of circulating water (CW) pumps, cooling tower is used to support the existing cooling operation.

13. The existing cooling system is a common system for both Units 3 and 4, so each unit can take cooling water out of the common cooling system. The existing cooling towers comprise of five open air coolers (one is spare), each with 6 fans. The make-up water and the evaporation losses of the cooling towers are supplied by water from the river. The typical temperature of cooling water discharge is about 38^0C. In case of non-availability of any pump, the shortage of cooling water is compensated by using the standby cooling tower. The existing cooling tower is not operating properly due to poor maintenance for a long period of time. Most of the blower fans and motors including the induced fan at the top of the tower are not working and require replacement. This led to elevated thermal plume discharge in the river water, which is in violation of IFC's EHS Guidelines. In addition, existing cooling towers are not adequate to meet the capacity of condenser cooling of Unit 4. Therefore, it is recommended that EPC Contractor assess the capacity and design a close-cycle cooling system by refurbishing the existing cooling system and enhance with new towers if needed. This will bring Unit 4 in compliance with IFC Guidelines on thermal plume. It is estimated that the repowering will require about 0.38194 m^3/s of water as make-up due to the close-cycle cooling system.

1.4.4 Other Equipment and process that require refurbishments or upgrading

14. Existing steam turbine generator and its auxiliaries will require renovation/ modification/ retrofication to maximum capacity in order to use it with combined cycle operation. In general, the following refurbishment may be required:

- all system/components belonging to turbine (HP,IP, LP) parts, turning gear assembly,
- main oil pump, AC Aux lube oil pumps,AC control oil pump,DC emergency lube oil pump, oil coolers, vapor exhauster, oil filters, valves and etc.,

- gland steam system with gland steam condenser and valves,
- feed water system: Currently hydrazine is used in Unit 4 as a scavenger chemical to remove oxygen. It is a toxic chemical (a carcinogen) which requires proper treatment prior to disposal in the river, which also supports food processing systems in up and downstream. It is recommended that hydrazine should be replaced with more environmentally friendly scavengers. The EPC Contractor in their bid, should state possible alternative to replace hydrazine as the scavenger chemical. Owner's engineer will review the proposal and in consultation with GPS a final decision will be made.
- condensate water system, circulating water (CW) system and their auxiliaries (vacuum pump, drainage pump, delivery valve, etc.),
- fire-fighting system, and
- generator rotor, stator, generator other auxiliaries (gas cooling pump, stator cooling pump, sealing oil pump) and etc.

15. The existing instrumentation and control system are old and obsolete compared to the latest control systems currently available. It is very difficult, time consuming and costly to interface the out-dated control system with the state-of-the-art control system of the modern Gas Turbine. A visit to the control room of Unit 4 indicates that insulations in two doors have been damaged and noise level in the control room is a little higher than the standard. These doors will require replacements.

1.4.5 Project Layout and Site Drainage

16. The detailed layout plan showing all structures, internal road, drainage network, different pollution abatement measures, waste water and effluent treatment facilities shall be developed by the EPC contractor before construction. The EPC contractor will be appointed after receiving the approval of the EIA report from the DoE. BPDB will submit the final layout plan to DoE for their review and comments considering availability of land, landscape, ground features, elevation, environmental aspects and social concerns recommended in this EIA study. The EPC contractor will be required to indicate waste storage and sorting areas as well as secured disposal of hazardous waste location on the layout plan. Given the sensitivity of the decommissioning activity, it is recommended that the EPC Contractor is certified in OHSAS 18001.

17. There is an existing drainage network in GPS for storm water runoff. Runoff flows through open drains and is stored in a common basin for sedimentation and the overflow is connected to another drain to finally discharge to the condenser cooling water discharge channel for ultimate disposal to the Shitalakhya River.

18. Drainage network of GPS requires improvement with the re-powering as new equipment will be installed and the existing structure will be demolished and an on-site asbestos pit will be established. Segregation of storm water runoff and cooling water discharge may be required to avoid possible contamination at the disposal site close to the Jetty area. Moreover, it is recommended to avoid decommissioning work during the monsoon season.

1.4.6 Land Requirement

19. The proposed repowering of Unit 4 will require about 8 acres of land, including the construction of new RMS. The site is partially fallow land on the northern side of the existing Unit 4 and close to the oil tanks with bushes, trees and tin shed warehouses. Land is

available within the property line of GPS and no land acquisition will be required for the proposed expansion.

1.4.7 Fuel requirement and performance

20. The repowering of Unit 4 requires a gas supply of 67.28 MMSCFD (20.86 Nm^3/s) for the gas turbine including supplementary firing of the HRSG. The current natural gas required for Unit 4 amounts to 49.17 MMSCFD, based on 180 MW gross power output. This is an increase in gas consumption of 18.11 MMSCFD (5.62 Nm^3/s), which is about 37% more gas consumption compared to the current consumption of Unit 4. Unit 4 has a design efficiency of 37.79% and current de-rated efficiency is 33.63%. After repowering, net efficiency will be 54.6%.

1.4.8 Water requirement

21. At present, approximately 8.9629 m^3/s of surface water from the Shitalakhya River is used in Unit 4, for condenser cooling, other cooling systems like ST generator stator cooler, ST generator sealing oil cooler, cooling water pumps, generator gas cooler and etc. By repowering, water requirement will be significantly reduced due to the close-cycle cooling system. It is estimated that about 0.46583 m^3/s of Shitalakhya River water will be required for cooling tower make-up, auxiliary cooling, coagulator flushing, and other plant uses. A water balance diagram of Unit 4 is presented in Figure 2. There are a number of small-medium industries along the upstream of Shitalakhya River, which also abstract water from the Shitalakhya River and they are Desh-Bandu Sugar Mills, Gazi Textile, and Ghorashal and Palash Urea fertilizer factories. Besides there are also brick fields, which require minimal water consumption.

1.4.9 Technology Selection and Process Description

22. The rated capacity of Unit 4 is 210 MW, but the present maximum power generation capacity is 180 MW. After repowering, the total gross Unit output will be 411.7MW and net Unit output will be 403.5 MW (Ambient condition) and average net capacity over life time will be 391.4 MW (auxiliary power use of 8.2 MW and impact of ageing and fouling of 12.1 MW).

23. The compressed natural gas is mixed with compressed air in the combustor to perform firing. The hot gas is directed to the gas turbine where it expands and loses its pressure and temperature and finally generates 246 MW electrical power in the generator. The hot exhaust gas of the GT will pass through the HRSG. The HRSG in turn will generate HP steam that will be directed to the steam turbine which will eventually generate 165.7 MW of power, increasing plant output to 403.5 MW (combined cycle).The condensed steam in the condenser will be pumped by the condensate extraction pumps to the HRSG deaerator. The deaerated water will be pumped to the HRSG drums by feed water pumps and thus steam feed water cycle will be completed. All existing feed cycle equipment and piping will be retained and used in the proposed repowering of Unit 4.

1.4.10 Power station facilities

24. The new gas turbine and HRSG will be designed to match the generated steam amount and conditions with the requirements of the existing steam turbine, producing the highest feasible output. The original steam turbine, condenser and its auxiliary equipment can be used. The new gas turbine and HRSG can fit in place of the existing boiler. The new gas turbine transformer will be connected to the external grid and the existing station transformers can stay in place. Modifications required for the existing systems are as follows:

- Installment of new gas turbine, generator, and HRSG,

- Adjustment in balance of plant (BOP) in case of higher condensate flow,
- Large expansion switch yard and grid due to augmented power output,
- A gas compressor to augment natural gas pressure for gas turbine(s),
- Renew control system as old system is no longer exists, to cope with the new Gas Turbine,
- Bypass stack(s) for flexibility, shorter start-up time. Gas turbine can run in open cycle mode, when needed, and
- Overhaul steam turbine to improve efficiency.

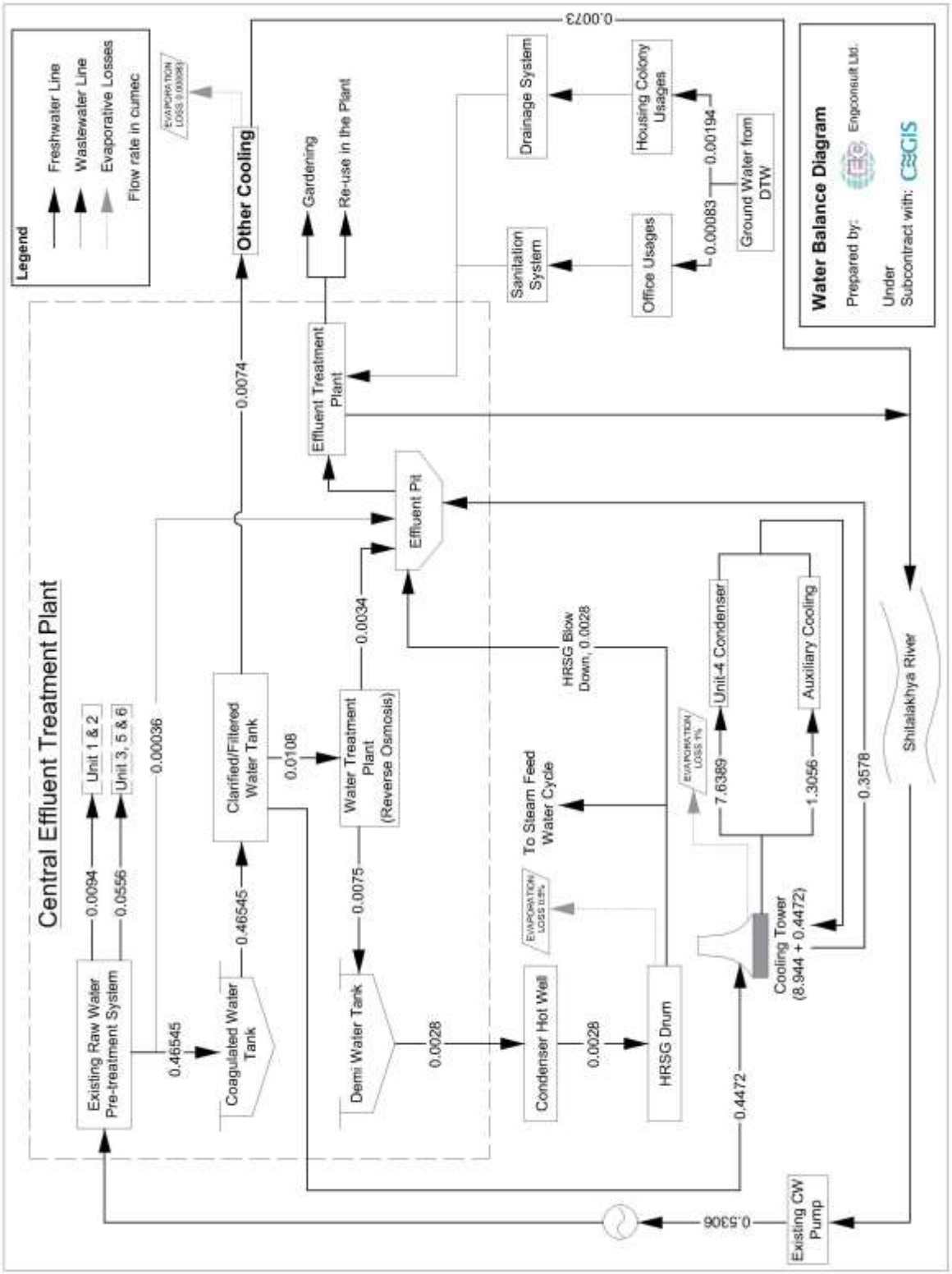

Figure 2: Water balance diagram of Unit 4 repwoering

1.4.11 Plant control system

25. In full repowering, a digital PLC based distributed control system compatible with the HART communicator and with analogue to digital converter and vice versa is proposed. An interface will be developed to integrate the old and new digital control system as a mitigation measure.

1.4.12 Central Water/Effluent Treatment System

26. The current water and effluent treatment system in Unit 4 is isolated and does not follow the standards to meet the ECR 1997 and IFC Guidelines. Under the repowering, a central water/effluent treatment plant is proposed to integrate raw water, demineralized water, plant effluent, and sludge treatment together. The CETP will be an integral part of the Environmental Infrastructure of the GPS. This centralized facility will meet all statutory norms laid by the DoE, Bangladesh. It will be a state-of-the-art technology based on Sequential Batch Reactor (SBR) System. It will be an environmentally sustainable and cost viable system for the collection, treatment and ultimate discharge of effluents from Unit 4.

27. *Raw water supply and treatment system*: There are two sources of water supply in GPS: (i) Shitalakhya River and (ii) Groundwater through tubewells. River water is used for condenser cooling and other cooling system and the preparation of demineralized water for HRSG make up and cooling tower make up. The rawwater treatment system comprises of coagulation, clarification, and filtration.

28. *Demineralized water treatment system*: Demineralization is the process of removing mineral salts from water by using the ion exchange process. Demineralized water is completely free (or almost) of dissolved minerals and is used as feed water makeup for HRSG. It is difficult to meet makeup water requirement of all four units with the present DM plant. DM water requirement will be increased after full repowering of Units 3 and 4 and addition of new 365 MW combined cycle unit. It is proposed that a Reverse Osmosis (RO) plant is established for combined use of the entire plant to replace current resin based demineralization. The plant capacity can be finalized based on the detailed design. Economic analyses has demonstrated that when the total dissolved solids content of feed water is above 200 mg/l, RO is the most cost-effective demineralization technology.[1] Based on the Shitalakhya water quality analysis, TDS content observed is between 210-239 mg/l. The following parameters will be considered to design a new DM Plant:

- The auxiliary cooling water for the present gas turbine accessories requires treated DM water. The amount of water required shall be worked out during the detailed engineering stage.
- Due to this additional DM water requirement, a new plant shall be installed at an appropriate location. DM Plant capacity shall be decided based on whether all four units are likely to be converted to full repowering.

29. *Effluent treatment system:* The effluent from the water treatment plant and other systems, like the clarifier is collected in the neutralizing tank where the sludge gradually settles at the bottom of the tank. After a couple of years, the sludge is collected and buried in the waste disposal pit to be located at the North side of the existing pond within the GPS premises. Effluent Treatment Plant/system will be provided to maintain the standards of Industrial Waste as mentioned in the ECR, 1997. A central monitoring basin (CMB) of RCC construction will be provided to collect all plant effluents. Quality of the effluents will be monitored using continuous emission monitoring system and treated to comply with ECR 1997 requirements. Through a set of waste effluent disposal pumps and piping, the same will be disposed of from CMB up to final disposal point at a safe distance.

[1]The Dow Chemical Company (2009-2013), http://www.dowwaterandprocess.com/en/Industries%20and%20Applications/Industrial_Water/Boiler_Feed_and_Process_Water/Demineralization/Reverse_Osmosis, Page visited on May 16, 2015

30. *Septic tank and sewage handling*: The sludge to be generated from the proposed re-powering will be treated and discharged into the underground pit with concrete revetment or encircled with durable polythene sheet. For monitoring the effluent quality, a continuous monitoring system has been considered in the design. The following measures are included in the project design:

- EPC Contractor will provide septic tank for a building or cluster of buildings or connect to existing septic tank depending upon the layout to be decided during detailed engineering for the new buildings. The maximum size of septic tank is proposed to be 4.6m×1.15m.
- The sludge removal from the septic tanks is expected to be done once a year or as per the requirement of local laws and regulations by the Project Proponent.

31. *Sludge from water and effluent treatment plants:* About 0.5306 m^3/s of raw water will be drawn from the river and pass through the pretreatment system. From where about 0.00036 m^3/s of waste water is generated which will be transferred to neutralization pond. The remaining 0.46545 m^3/s of water will pass through the coagulation tank, about 0.0074 m^3/s of water will be used for other cooling purposes after passing through the clarified filter and finally disposes to the river through open channels. The other 0.0108 m^3/s of water will be treated in the reverse osmosis system from where about 0.0034 m^3/s of water will go to neutralization pond as waste water and 0.0075 m^3/s will transfer to the De-mineralized water tank for continuous feeding to HRSG via condenser hot well. The sludge generated in the neutralization pond is disposed of annually to the designated site close to the pond.

1.4.13 Human resources required for the project

32. It is estimated that workers will be required during the construction and operation phase. The EPC contractor is expected to have manpower of around 700 at peak, including unskilled, skilled, supervisors, engineers, management staffs and etc. and BPDB employees will be around 35 during the construction phase. On the other hand, during O&M phase, EPC Contractor will employ 3 persons for the period of warranty (i.e., 2 years from plant takeover) and BPDB employees are expected to be around 219 (139 from present workforce and 80 additional).

1.4.14 Emission Control system

33. Natural gas of Bangladesh is known as sweet gas. Its sulfur content is negligible and hence the emission of sulphur dioxide (SO_2) is negligible and emission of particulates (PM) is fairly low. Modern Gas turbines are provided with dry low NO_X burners to keep the NO_X level below 25 ppmv. During repowering, dry low NOx burners will be installed to reduce NOx emissions.

1.4.15 Stack Emission Monitoring System

34. Online continuous emission monitoring system (CEMS) will be installed consisting of electronic emission analyzers like CO, CO_2, NOx, PM and etc. that will take flue gas samples from the stack. A periodic (once every shift) flue gas sample will be collected and analysis will be carried out in the chemical laboratory to cross check the values obtained by the CEMS.

1.4.16 Environmental Quality Monitoring System

35. Two ambient air quality monitoring stations (to monitor CO, NOx, $PM_{2.5}$, PM_{10} and SO_2) and one weather station to monitor meteorological parameters (wind speed, direction, temperature, rainfall, humidity, etc.) are recommended in the project impact area. The locations of the stations will be based on the dispersion modeling output of maximum ground

level concentrations in downwind directions. Noise level will be monitored at the same locations where environmental quality baseline monitoring were conducted. In addition, two monitoring wells are recommended, one close to the newly proposed hazardous waste disposal site and one close to the neutralization pond to monitor ground water quality.

1.4.17 Continuous Effluent Quality Monitoring System

36. Online effluent quality monitoring is proposed to monitor pH, TSS, TDS, Temperature, EC of the effluent and to detect unacceptable change in water quality matrix immediately. Continuous online monitoring of waste water also ensures that effluent levels in discharged water at the outlet is within regulatory norms of ECR 1997.

1.4.18 Power Evacuation

37. Power generated from the new gas turbine will be evacuated through the proposed 230kV gas insulated sub-station (GIS) switchyard and 230 kV high voltage Tongi transmission line via 340 MVA unit transformer. While power generated from the steam turbine will be evacuated through the existing bay of the 230 kV Air insulated sub-station (AIS) switchyard via the existing 2x125 MVA unit transformers.

1.4.19 Life Cycle Overview

38. A life cycle overview was conducted for the project. Since natural gas is not a renewable resource, the life cycle efficiency (which gives the total energy balance for the system) is negative, indicating that more energy is consumed by the system than is produced in the form of electricity. Excluding the consumption of the natural gas feedstock, the low values of the external energy efficiency and the external energy ratio indicate that upstream processes are large consumers of energy. This process block can be broken up into natural gas extraction, processing, transmission, storage, and distribution. Of these, the largest consumers of energy are the natural gas extraction and pipeline transport steps. Diesel oil is combusted to meet the energy requirements of the drilling equipment, while pipeline transport uses a combination of grid electricity and natural gas to move the natural gas from its point of origin to its destination. Additionally, the net energy ratio shows that for every 1 MJ of fossil energy consumed 0.39 MJ of electricity is produced.

1.5 Analysis of Alternatives

39. An alternative analysis was conducted on the Project components in terms of infrastructure siting, selection of re-powering options, technology options, selection of cooling water system, various water and effluent treatment system, and a comparison with ‘no’ Project scenario. Alternatives are compared in terms of potential social and environmental impacts, costs, technical requirements, constructability, operation and maintenance requirements. The alternative analysis has been carried out in reasonable detail to enable the BPDB, World Bank and others, if any, to appreciate the recommended options and confident on the preferred options. The recommended and selection options of various alternatives are presented in Table 1.

Table 1: Recommended and selected options of Unit 4 Repowering.

Component	Design Features Included in Engineering Design Report
Repowering Options	Full Repowering is technically the most attractive option for repowering of Unit 4 Ghorasal PowerStation because the expected output and efficiency is much higher compared to the hybridrepowering solutions.
Plant Layout	For full repowering 1 GasTurbine, 1 HRSG and 1 Steam

Component	Design Features Included in Engineering Design Report
Alternatives	Turbineconfiguration has been chosen over other options. First gas turbine generator will be placed and commissioned, then existing boiler will be shutdown and dismantledand the new HRSG will be installed at the footprint of the existing boiler. Limitation of space is one of the major reason for rejecting 2:2:1 configuration.
Cooling water system	Closed-cycle cooling system with new cooling tower construction is considered in the repowering of Unit 4 to comply with the IFC guideline of effluent discharge quality (3^0C difference between effluent water at mixing zone and ambient water temperature)
Water/effluent treatment plant	New central water treatment plant is recommended with state-of-art equipment to treat raw and effluent water and sludge produced in the GPS including the requirements of repowering and new 365 MW combined cycle power unit. The new plant will have (a) an effluent treatment plant with a capacity of 450 tons/h, (b) a reverse osmosis (RO) system to treat demineralization water with capacity of about 225 ton/h (3 cells @ 75ton/h), two cells in service and one standby, (c) rawwater treatment plant with capacity 450 ton/h, and (d) sludge treatment plant with capacity 100 ton/h.

1.6 Description of Environment

40. The project impact area mostly lies in flat topography. Presently, the area is dominated by agricultural practices followed by settlements and fishing during wet season. The ground elevation gently lowers from east to west. The Project site is situated at around 0.63 m PWD. The entire area is vulnerable to occasional riverine floods.

41. The total land of the project impact area is 31,415 hectares. The land cover of the project impact area is derived from multi-spectral color RapidEye satellite images of 15th February, 2013 and 29th March, 2014. The major classes extracted from the images are as follows: agricultural land, char land/sandbars, forest, industrial area and other land uses (i.e., road, rural settlement with homestead vegetation, built-up area and water bodies). Figure 6-3 shows the detailed general land use map of the study area.

42. The area is mostly surrounded by *agriculture land* (15,457 ha, which is 49.2% of the total area) followed by *rural settlements with homestead vegetation* of 38.5%, *water bodies* 5.74%, built-up area amounting to 1.7%, *forest land* cover of 1.5%, *industrial area* (including Ghorashal Power Plant) of 1.3%, *road coverage* 1.01%, *other land uses* of 0.78% and char land/sandbar occupying a very insignificant area of 0.04%.

43. Physiographically, the area falls partly in the Young Brahmaputra – Jamuna floodplain and Madhupur tract. The area is located in the central part of the Bengal basin– an extensive alluvial plain of the quaternary sediments laid down by the Ganges-Brahmaputra-Meghna river system.

44. The surface of the area is covered by paludal deposits. As per tectonic classification, the area falls under Madhupur Tripura threshold of eastern platform flank of the Bengal basin. Tectonically this area is inactive and no apparent major structure like fault or fold exists in the region that might be geologically significant.

45. Ghorashal was under Zone II with design Peak Ground Acceleration (PGA) value of 0.15g (Z=0.15) according to the seismic zoning map of Bangladesh provided in BNBC. Thus, the nearby areas were considered as Medium Risk Zone for earthquakes.

46. However, the BNBC adopted a new code in 2010 after Bangladesh experienced several shock waves of higher intensity. In the newer adopted code of BNBC 2010 (Figure

6-5), it is observed that the Project area is on the border line of the Seismic Zone II (seismic coefficient 0.20 g) and Seismic Zone III (seismic coefficient 0.28 g). This zone has the mediocre vulnerability for earthquake in Bangladesh with a risk of possible earthquake of magnitude 6 (on Richter scale).

47. The Shitalakhya River, a distributary of the Old Brahmaputra River, is the main water system that flows in close proximity of GPS. The off-take of this river is the Banar River. It remains navigable round the year. The river flows through Gazipur district forming its border with Narsingdi for some distances and then through Narayanganj and ultimately falls into the Dhaleswari River.

48. Shitalakhya is a tidal river and the maximum average variation of water level is 20 cm between high tide and low tide. The river is perennial in nature and the average lowest discharge is during the dry season (January) with a flow of 83 m^3/sec and the average lowest water level during low tide is 0.94 m PWD close to the study area. The average highest flow is observed during the rainy season (Jul - Sept) and varies from 1,181 m^3/sec to 1,066 m^3/sec and the average maximum water level during the high tide is 6.62 m PWD. There is no other significant surface water system found around the project area.

49. The river inundates nearby agricultural lands during the monsoon and remains navigable round the year. The tendency of river erosion is very low. Based on water availability and navigation facilities, a large number of industries have been established along its banks both up and downstream. Bangladesh Inland Water Transport Authority (BIWTA) declared this river as a class III route of Bangladesh. The relatively inert geo-morphological characteristics of the Shitalakhya River guarantee fairly suitable water depths for navigation throughout the year.

50. For assessment of water availability of Shitalakhya River, the models (hydrological and hydrodynamic) have been simulated for four scenarios; baseline condition, future without project, future with project and other developments including the consideration of upstream flow reduction and climate change impacts.

51. From the historical data analysis, it has been found that the annual flow of the Brahmaputra River is increasing due to climate change but flow of the Old Brahmaputra River is decreasing which is mainly due to the change in off-take morphology of the Old Brahmaputra River. Around 268 Mm^3 of flow reduction per year is estimated in the Old Brahmaputra River.

52. Water balance study has been done to assess the water resources and its use in the system. The main principle of water balance is that the difference between total incoming water and total losses should equal to the storage change in the system. The calibrated and validated model has been simulated for the period of 1981 to 2012 to estimate the availability of water for the study area. The simulation results of the annual and monthly water balance for the study area are shown in Figure 6-8.

53. The average annual rainfall in the study area is 2,055 mm. The monsoon starts from April and reaches its peak in July. There is a decreasing trend of rainfall during the month of August, a slight increase in September and then rapid decrease again. The maximum monthly precipitation is about 375 mm.

54. Rainfall in watersheds/catchments is the main inflow, whereas the evapo-transpiration and percolation and other abstraction are the main losses. The balance contributed into the river as surface runoff and subsurface flow. The annual actual evapo-transpiration of the area is 776 mm, which is 37% of the annual rainfall. The percolation rate for the study area is 575 mm per year, which is 28% of the annual rainfall. After the losses of water through evapo-transpiration and percolation, the remaining water contributes to stream flow as overland flow and lateral (subsurface) flow. Around 43% (874 mm) of rainfall

contributes to stream flow through surface runoff while the lateral flow is negligible, only 83 mm.

55. The annual discharge distributed seasonally in Shitalakhya is about 7% (980 Mm^3) in dry (December-March), 6% (842 Mm^3) in pre-monsoon (April-May), 72% (10,545 Mm^3) in monsoon (June-September), and 16% (2,300 Mm^3) in post-monsoon (October-November) seasons. The flows are mainly concentrated during the monsoon period (highest) and pre-monsoon (lowest). The outflow of the basin has been reduced gradually after the year 2000. Before the year 2000, the annual flow was 16,000 – 22,000 Mm^3, while it has been reduced to 9,000 – 14,000 Mm^3 in recent years.

56. After analyzing the average minimum water level of 1981-2012 and longitudinal profile of the river, it is found that throughout the year the Shitalakhya maintains a minimum of more than 4 m depth in the whole reach of the river. The relatively inert geo-morphological characteristics of the river made fairly suitable water depths for navigation. Moreover, due to its lesser fluvial activity, riverbank erosion is negligible and shifting of the thalweg or navigation channel from one bank to the other is not dynamic in nature. These characteristics of the river have facilitated the growth of industries, commercial centers and power plants on either side of its banks.

57. In the GPS, potable water is generally used from the ground water source while river water is used for condenser cooling and other plant purposes. There is a good availability of ground water abstracted using tubewells for drinking and domestic purposes. Most of the industries are using water from deep tube wells in their premises to meet the water requirements. The scattered homesteads are using hand tube well (HTW) to meet their domestic demand, having no specific complaint about non- availability of ground water.

58. Bangladesh is susceptible to several natural hazards, such as floods, drought, river bank erosion, cyclones and etc. This is due to the combination of geographic, physiographic, morphological and other natural features which have led to the direct loss of life and properties, sometimes on a massive scale. Among these various natural hazards, flooding is the most recurring one, hence analyzed within the framework of this study.

59. Bangladesh is receptor of flows from three major rivers, namely the Ganges, the Brahmaputra and the Meghna. When a water level in the major river systems rises simultaneously and crosses the danger levels, floods usually occur all over the country. This was observed during the three major floods of 1987, 1988, and 1998. Water levels crossing the danger levels start occurring from mid-July and continue till mid-September. Sometimes, Individual rivers may also experience extreme flood events due to excessive rainfall in the respective river catchments independently.

60. According to the topographical survey, land elevation of the proposed Project site has a formation level of 10 m.PWD. The highest water level was recorded at 7.84 m.PWD in 1988 which was an extreme flood event in Bangladesh. These observations indicate that the proposed project site is not vulnerable to flooding, unless any extreme natural hazards occur in the future.

1.6.1 Climate and Meteorology

61. *Temperature:* Temperature data of Dhaka Station from Bangladesh Meteorological Department (BMD) for 34 years (from January 1980- December 2013) has been analyzed to see the monthly variation of the average maximum temperature which is between 39.6^0C to 30.1^0C. The monthly variation of the average minimum temperature is 22.5^0C to 6.5^0C.

62. *Rainfall:* Monsoon is a prominent season in the project area. The average monthly rainfall during monsoon (June-September) season from 1980-2013 is 332 mm. Annual average rainfall is 2066 mm/year and the highest recorded yearly rainfall was 3028 mm in

the year 1984. The driest period of the year is winter when the average monthly rainfall varies from 21 mm/month to 7.21 mm/month.

63. *Humidity:* The average relative humidity remains higher during the monsoon season. The variance in the average relative humidity throughout the year is 83.77% to 62.47%, whereas during monsoon the variance is 83.77% to 82.40%. from January 1980 to January 2013.

64. *Wind Speed and Direction:* The direction of wind varies depending on the seasons. Wind speed data and direction have been collected from the Dhaka BMD station at a height of 10 m from the ground level. It is observed that during December to March and October to December, wind direction is predominantly from northwest to southeast direction, inclined towards east and for April to June and July to September it is predominantly from south and southeast to north and northwest. During December-March, calm wind prevails for 27.2% of the total period, similarly it is 11.0% for April-June, 12.5% for July to September, and 56.9% for October to December, respectively.

1.6.2 Ambient Air Quality

65. Continuous Ambient Monitoring Station (CAMS) from Narayanganj is used to establish the ambient air quality in the project site. The usage of this data was deemed appropriate since Narayangani is located approximately 30 km away from the project site and shares the same airshed. Hourly measurements for NO_2, CO, O_3, PM_{10} and $PM_{2.5}$ were available from November 2012 to May 2015. USEPA NAAQS guidelines along with other guidelines were used to refine the data and find ambient concentrations for 8 h, 24 h and annual averaging periods. The ambient concentrations for NO_2, CO and O_3 in the airshed were found to be within the ECR 1997 (amended in 2005) and WHO guidelines. The ambient concentrations for PM_{10} and $PM_{2.5}$ exceed Bangladesh National Standards and WHO Guidelines for both 24 h and annual averaging periods. The ambient 24 h SO_2 concentration exceeds WHO Guidelines but is in compliance with Bangladesh National Standard.

1.6.3 Acoustic Environment

66. Ghorashal power plant has six units among which 5 units were functional during the collection of baseline noise data. These 5 units, 2 RMS units, construction work of Max-power plant and operation of Aggreko power plant were the major sources of noise in the area. Noise levels were measured at 23 locations including 19 sensitive receptors inside and outside GPS.

67. The permissible level of noise as per ECR 1997 for industrial area is 75 dBA (as per WBG Guidelines it is 70 dBA) during day (7:00-22:00) and 70 dBA during night time (22:00-7:00) and for residential/institutional/educational zone are 50 dBA during day time (as per WBG Guidelines it is 55 dBA) and 40 dBA during night time (as per WBG Guidelines it is 45 dBA). The turbine Area, Control Room, near RMS area of the GPS and the nearby places of Fertilizer Factory, considered as “industrial area”, are exceeding the standard noise level both in day and night time; whereas residence inside and outside the Fertilizer Factory, residence near Aggreko, Army residence exceeded the standard in day time.

1.6.4 Surface Water Quality

68. Baseline water quality samples were collected for laboratory analysis. From the result, it is observed that only 3 parameters out of 21 were beyond the acceptable limit and they were temperature, turbidity and nitrate levels (NO_3). The pH at intake point is around the upper limit of the ECR 1997. Temperature is higher than the WBG Guideline values on temperature increase by thermal discharge from cooling system. This is due to the fact that

the cooling system in GPS is not working properly resulting in a higher temperature release than is recommended.

1.6.5 Ground Water Quality

69. Groundwater samples were collected and analyzed in the laboratory and results indicate that most of the parameters of groundwater fall within ECR 1997. However, iron levels exceed Bangladesh National Standards.

1.6.6 Transportation System

70. The proposed Project site is accessible by three different modes of transportation. These are: roads, railway and waterway. One of the major regional highways (R-301) from Tongi to Ghorashal via Kaliganj passes through the project area. Another important regional highway adjacent to the project area is the Dhaka Bypass road which is a shorter route between Dhaka-Chittagong highway and the Jamuna Bridge. From these regional roads, there are Upazila roads to access the GPS.

71. Ghorashal Railway Station is the nearest railway facility from the GPS and the distance from the site is about 5 km in the south. The Shitalakhya River is a scheduled navigation route which provides 22 km of water ways.

1.6.7 Agriculture Resources

72. *Cropping pattern and intensity:* The most prominent cropping pattern of the study area is Fallow; Fallow–HYV Boro which covers about 21% of net cultivated area (NCA), then Fallow–T Aman–HYV Boro which covers about 20% followed by others. The project site is a fallow land having warehouses, trees etc. The single, double and triple cropped area is about 21%, 69% and 10% of the NCA, respectively. Cropping intensity of the study area is about 189%.

73. *Crop production and damage:* The Project site is surrounded by two fertilizer factories and their colonies, Shitalakhya River, bazaar, residents, jute mills and etc. Crop fields are located around 1.5 to 2 km away from the site. In the study area, the total cropped area is about 29,214 ha of which rice is about 74% and the non-rice is about 26%. Total crop production is about 129,335 tons. The annual total rice production is about 59,717 tons after the loss of 4,739 tons due to manmade pollution like industrial wastes, drought, shortage of surface water, pest and disease infestation and etc. Annual non-rice production is about 69,618 tons, of which Jute 2%, Mustard 2%, wheat 2%, Kheshari 1%, winter vegetables 67% and summer vegetables 27%.

1.6.8 Fisheries resources

74. The seasonal and perennial Beels (depressions) along with floodplains of the study area function as fresh water fish habitats.

75. The estimated overall fish habitats of the study area account for 4,412 ha. Capture fishery constitutes about 3,767 ha (about 85%) and the rest is shared by the culture fishery . The estimated total fish production of the study area is about 2,337 tons, where culture fishery contributes the most, amounting to 72% and the rest is shared by the capture fishery.

76. *Fish habitat degradation:* Cumulative effects of all contaminants along with the untreated effluents of the industries and power plants cause fatality to fish species along with other aquatic eco-elements.

1.6.9 Ecological Resources

77. The study area contains general types of eco-elements with low to medium biodiversity and does not possess any kinds of specialized habitat or hot spots. The identified major ecosystems include homestead/settlements, crop-field, roadside, woodland, Sal forest, riverine, seasonal wetlands and etc.

78. The entire study area possesses both terrestrial and aquatic ecosystems, having moderate to low floral and faunal diversity.

79. The Government of Bangladesh in 2009 declared 4 rivers around Dhaka city (Buriganga, Shitalakhya, Balu and Turag) as Ecologically Critical Areas (ECAs). Most of the ECAs are suffering from encroaching, pollution and management problems in terms of sustainability. ECAs are already degraded areas and need special protection and care. There are government restrictions on setting-up polluting industries in ECA's. By repowering of GPS Unit 4, there will be a net benefit in thermal plume discharge and improvements in effluent quality to Shitalakhya River by introducing closed-cycle cooling system and installation of a CETP.

1.6.10 Socio-Economic Resources

80. Baseline scenario of the socio-economic environment is assessed based on primary and secondary data considering 22 unions of five (5) upazilas of Narsingdi and Gazipur.

81. *Population:* The study area is home to 526,463 people, belonging to 114,503 households. Of the total population; 261,856 (49.7%) are male and 264,607 (50.3%) female. The average household size is 4.6, which is slightly higher than the national average of 4.50 [BBS, (HIES) 2010]. The average population density is 2,088 per square kilometer which is more than double compared to national average of 1,055.

82. *Ownership and utilization of land:* The Census of Agriculture, 2008 conducted by BBS classified land holdings into two broad categories- one is farm-holdings and another is non-farm holdings. The study area shows that out of total holdings, 51.5% is farm-holder and the rest 48.5% is non-farm holders.

83. *Occupations and livelihoods:* Out of total 526,463 population, 155,331 (29.5%) are economically active which include 80,139 (41.4%) employed, 836 (0.4%) are looking for work, and 74,356 (38.4%) engaged in household work.

84. Distribution of employed population at reference period of the 2011 census shows that 16% are engaged in agricultural activities, 10% in industry and 15% in service.

85. *Labor Market:* The employment rate in the study area is 51.6%, whereas the unemployment rate is 48.4.%. It is evident that about half of the total economically active population is still unemployed. Most of the unemployment populations are females who are solely involved in household work, and only 0.5% populations are looking for work.

86. *Standard of living:* Data shows that about 84.5% households are under electricity coverage. The study area has access to both PGCB and the adjacent quick rental power and benefited from generated power which in turn improved the standard of living.

87. Collection of drinking water from tubewell is predominant (92%) throughout the study area. Supply of “tap water” is mainly used in municipal areas on rental basis. However, 3% households are still depending on open water bodies for drinking water.

88. Fuel consumption shows that almost all households located within the municipal area have gas supply. However, households in rural area usually use firewood, cow dung, chips for fuel and etc.

89. *Poverty:* In the study area, poverty has been measured following the Multidimensional Poverty Index (MPI) method.

90. Analyzing poverty status, it is found that about 27% households are multi-dimensional poor (index value 0.27 out of 1= **MPI**). About 53% populations are living in these poor households (poverty head count=**H**) and on average 52% poor people are deprived of any indicator (intensity of deprivation=**A**).

1.7 Environmental Impacts

91. Major significant impacts anticipated from the proposed project activities include inhalation of airborne asbestos fiber during boiler decommissioning, elevated noise level from the operation of heavy equipment, felling of trees during site preparation, and labor camp induced sanitation and social stresses.

92. The major positive impacts of the project are the augmentation of the generation capacity of the electricity and improving the socio-economic condition and lifestyle of the country's population and reduction in thermal plume in the Shitalakhya River during plant operation.

1.7.1 Impact Assessment Methodology

93. Potential environmental and social impacts were identified on the basis of the review of feasibility reports, field visits, environmental quality baseline monitoring, ecological and fisheries surveys, and stakeholder consultations. The significance of potential impacts was assessed using the criteria and methodology given below.

94. *Impact Magnitude***:** The potential impacts of the project have been categorized as major, moderate, minor or nominal based on consideration of the parameters such as: duration of the impact, spatial extent of the impact, reversibility,) likelihood, and legal standards and established professional criteria.

95. *Sensitivity of Receptor***:** The sensitivity of receptors has been determined based on review of the population (including proximity / numbers / vulnerability) and presence of features on the site or the surrounding area. Each detailed assessment has defined sensitivity in relation to the topic.

96. *Assigning Significance***:** Following the assessment of magnitude, the quality and sensitivity of the receiving environment or potential receptor has been determined and the significance of each potential impact established using the impact significance matrix shown in Table 2.

Table 2: Significance of Impact Criteria

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

1.7.2 Generation of Hazardous Waste

97. *Hazardous Solid Waste***:** Decommissioning of the existing boiler is expected to generate more than 50 tons of asbestos containing material (ACM). The airborne asbestos

fiber when inhaled may cause various respiratory ailments including 'asbestosis' with long term exposure leading to the development of cancerous tumors in the lungs. Thus, abatement measures to control airborne asbestos fiber must be taken before boiler demolition.

98. *Hazardous Effluents***:** Water is sprayed on insulation materials such as asbestos in order to prevent the release of fibers in the ambient air. Therefore, contaminated sprayed waters may pollute soil and the nearby water bodies. Condensate is generated at RMS, which requires proper handling and storage. The potential toxic effluent may include acids and alkalis, which are used to maintain the pH level of various water usages as well as removing any dissolved impurities.

1.7.3 Environmental Impacts during Boiler Decommissioning Stage

99. *Impact on Ecosystem:* Clearance of vegetation to create space for storage of boiler parts and disposal of insulation materials after demolition is of concern. Clearance of vegetation has a wide range of adverse environmental impacts such as loss or shifting of habitats for dependent birds and wildlife to nearby bushes which would create pressure on the wildlife of the new area and its quality. This impact is characterized as Moderate Adverse.

100. *Impact on Ambient Air***:** Airborne asbestos fibers generated from asbestos containing materials such as steam carrying pipes, boiler drum roof and boiler walls is of major concern. Other toxic materials also include metal rust, rock and glass wool fibers, which have air contamination potential when mixed with the local air. Inhalation of such fiber or dust particles generated from the above mentioned sources is injurious to lungs and may cause 'asbestosis' leading to lung cancer or tumor and other lung diseases or respiratory complexity. This impact is characterized as Critical Adverse.

101. *Impact on Ambient Noise***:** Excessive noise generated from decommissioning activities may cause hearing related disturbances, increase in blood pressure, amnesia, distaste to food and etc. to the workers and nearby residents. Major activities that may produce high levels of noise include cutting of boiler parts using gas cutter, grinders, loading of boiler materials on truck/lorry, and its transportation. This impact is characterized as Moderate Adverse.

102. *Impact on Water Bodies***:** Water is typically sprayed on insulation materials such as ACM, rock and glass wool and etc. to prevent the dispersion of fibers or dusts. Asbestos and other insulating materials are not soluble in water and may be ingested by fish or local residents when untreated contaminated water is disposed to receiving water bodies. Ingestion of high amounts of asbestos may lead to intestinal polyps or tumors. This impact is characterized as Major Adverse.

103. *Impact on Soil***:** Water spraying on insulation materials to suppress dispersion of fibers and dusts may pollute soil and the nearby water bodies through leaching if not collected in a lined pond and treated properly. Asbestos may stay deposited in soil and, if not managed properly, the dry asbestos particles may be blown away by winds during dry season and may pose threat of being inhaled by nearby bystanders. This impact is characterized as Major Adverse.

104. *Impact on Occupational Health and Safety of Workers*: Activities such as cutting and welding, segregation of solid waste, and transportation of insulation materials and metals, working at heights, and lifting of heavy materials are dangerous and a safety concern. Workers may be susceptible to injuries, such as burns and cuts, from cutting and welding activities; lung disease and eye irritation while segregating insulation materials; broken

bones, and casualties. Working at heights and falling rubbles may cause accidents and casualties. This impact is characterized as Major Adverse.

105. *Hazardous Solid Waste Disposal*: There is a significant risk from airborne fiber or dust, rust mixed water, etc. from the likely prolonged piling up of solid wastes, such as asbestos, rock and glass wool, metal rust, metals and etc. due to decommissioning of the boiler. Chrysotile asbestos or dust particles may be deposited on soil leaves of plants and fruits, limiting photosynthesis. Chrysotile asbestos may cause oxidative stress and phyto-toxicity to vegetation leading to retardation of plant growth. This impact is characterized as Critical Adverse.

106. *Social Impacts*: The engagement of workers, engineers and technicians from abroad for boiler decommissioning may lead to increase in sexually transmitted diseases like HIV/AIDS, etc. Which might become epidemic due to the engagement if necessary preventive measures are not taken. This impact is characterized as Moderate Adverse.

1.7.4 Construction Stage Impact

107. *Impact on Landform***:** Excavation of trenches, construction of buildings and sheds, movement of traffic, widening and improvement of existing earth road and etc. may affect the natural landform of the project site and adjoining area which is covered with bushes and grasses.

108. *Impact on Natural Resources***:** No extra pressure is expected to be created on gas as electricity needed for construction activities will be taken from existing distribution system. Water from the nearby river using low lift pump (LLP) or ground water using shallow tube well may be used for civil construction, washing, cooking and sanitary purposes for the stationed construction workers and staff members. Apart from these, the construction process is not expected to cause any burden on the natural resources.

109. *Impact on Ecosystem***:** Impact on terrestrial vegetation is characterized as Moderate Adverse as the ecological survey in the Project site did not recorded any tree species which have national and international conservation significance. The ship/cargo that will carry machineries and ancillaries may discharge ballast and bilge waste water into the river. This ballast and bilge water may have oil, grease, food waste and other contaminants which might affect the fisheries resources and their habitat quality. Having disposed of such harmful substances into the river water a localized and temporary disturbance to fish breathing may lead some species to die. Dredging for accessing ship to the jetty may also disturb the benthic habitat which may require a substantial time to recover. Discharge of wash water from the construction site may increase the turbidity of the local fish habitat. This would affect the food supply for fishes temporarily.

110. *Impact on Ambient Air***:** Site preparation activities, material transport, piling up of construction materials, excavation of trenches for laying gas pipes, RMS, turbine, and HRSG foundation, batch mixing plant, etc may generate fugitive dust particles. In addition to these, operation of construction equipment and vehicles may generate CO, Particulate matter, NOx, SOx, etc. Prolonged inhalation of dusts by the site engineers and workers will suffer from lung diseases with symptoms of shortness of breath, coughing, wheezing; chest pain; loss of appetite; tiredness etc. This impact is characterized as Moderate Adverse.

111. *Impact on Ambient Noise***:** The operation of different machines and equipment and welding operations during laying of gas pipes, may generate excessive noise and vibration during the construction period. Prolonged exposure to such high noise, the staffs of offices, construction workers, site engineers, residents and school children close to the construction site may be adversely affected like hearing difficulties, discomfort, loss of concentration, high blood pressure, etc. This impact is characterized as Moderate Adverse.

112. *Impact on Water Bodies***:** Leachate from construction material wash-water and spillage of oils and lubricants from machineries may contaminate surface water, particularly during wet season. These contaminants may increase turbidity of the water around the discharge point and may create oil slicks, both of which are detrimental to the aquatic organisms, including fisheries. This impact is characterized as Moderate Adverse.

113. *Impact on Soil***:** Earthworks during site preparation will impact the fertile top soils that are enriched with nutrients required for afforestation and plant growth. This impact is characterized as Moderate Adverse.

114. *Impact on worker's health and safety***:** The transportation of machinery and heavy equipments from the ship to site, lifting heavy equipments using cranes and their erection, welding operations during laying of pipeline, and working at heights may cause injuries to the workers, even casualty. The major health risk may come from the toppling of structures or falling of heavy machineries/equipments from high heights. Fire may cause during welding operation. This impact is characterized as Moderate Adverse.

115. *Impact on Key Point Installations & others***:** The noise generated from construction activities may affect the residents of the colony of Fertilizer Factory located close to the site. Loud noise will also affect the daily activities of the residents of the GPS, educational institutes including school, madrasa and mosque, situated inside the GPS. This impact is characterized as Minor Adverse.

116. *Solid Waste Disposal***:** Wastes generated during construction activities may include cleared vegetation from the site, construction debris, excavated spoils, abandoned or broken machine parts and etc. Moreover, food waste, plastic, papers, cock sheet, carton, metal or plastic binders and etc. Space for storage and disposal of materials generated during construction along with existing solid wastes is limited. Soil contamination may be caused by unarranged piling up of such materials and equipments may cause spillage and leakage from improper storage. This impact is characterized as Moderate Adverse.

117. *Social Impacts***:** The recruitment of foreign skilled technicians might be required during construction of GT and HRSG. The flow of manpower from abroad may bring with them diseases such as HIV/AIDS, which might become epidemic if not taken preventive measures from the beginning. Accommodating foreign workers in community settlements outside the project boundary on rental basis might create extra burden on human habitation, worship places, purchasing capacity, etc. Migrant workers coming from different parts of the country would have cultural diversity. So, there might be cultural conflicts between workers and communities. Increased traffic on access road due to movement of construction vehicles might also affect easy access of the inhabitants to the local market and houses close to the road, deteriorate safety (especially the school children). Labor migration and associated impact of HIV/AIDS is characterized as Moderate Adverse.

118. *Impact due to transportation of raw materials***:** The transportation of construction materials may have impact in-terms of spillages and leakages of construction materials while being transported to the construction site. The vehicles carrying the construction materials might also get into an accident. The resultant construction materials might be spilled to nearby water bodies and affect the environment. Explosion/fire caused by the accident, might damage nearby properties and cause injuries to people. This impact is characterized as Moderate Adverse.

1.7.5 Operation Stage Impact

119. *Impact on Natural Resources***:** Water and natural gas are the resources used by Unit 4. Operation of the Plant with close cycle technology will reduce the water requirement by about 95% of current requirement. In terms of saving resources, this will result in the

conservation of water resources which is already under stressed condition. Repowering of the proposed unit from 180 MW to 403.5 MW will require an additional 18.11 MMSCFD of gas. As a result, gas consumption will be reduced in this Project for the same quantity of augmented power.

120. *Impact on Ecosystems***:** Under repowering a small amount of water (0.4686 m^3/s) will be withdrawn from Shitalakhya River. In the intake pump, local fish habitats may be destabilized due to alteration of substrates of the intake area in the river. Thus, aquatic community structure and diversity may be affected. This impact is characterized as Moderate Adverse.

121. The once through cooling system will be changed to a close cycle cooling system, requiring less water and leading to no discharge of condenser cooling water into the river. Thus, thermal plume discharge in the Shitalakhya will be eliminated and this will lead to reduced stress on the river, the fish habitats and other aquatic organisms. This impact is characterized as Critical Beneficial.

122. *Impact on irrigation facility***:** Irrigation of about 1,619 ha of farmlands is currently covered by the diversion of condenser cooling water. About 6,000 tons of rice is produced annually from the irrigated fields. This is very much cost effective for the farmers as they have to pay about Tk. 800/ha/season, while for using low lift pump (LLP) from the Shitalakhya River the cost is about Tk. 6,500/ha/season. This irrigation also indirectly benefits vegetation growth, bird wading area, aquatic and amphibian habitats, fish aquaculture and etc. Changing of once through cooling system to close cycle cooling system in Unit 4 repowering will reduce the quantity of condenser cooling water discharge by approximately 22.2% to overall GPS discharge of 27.22 m^3/s. However, condenser cooling water discharge from other operating units will continue supplying irrigation water to BADC irrigation network. Therefore, crop production of the area will be unaffected. GPS will bear 6 years of pump operating costs (3 years during construction and 3 years during operation), BADC will assume responsibility to maintain pumps from the 7^{th} year. This impact is characterized as moderate adverse.

123. *Impact on Air quality (including dispersion modeling):* Emissions from the Ghorasal power station are estimated for the baseline and the re-powering case. USEPA regulatory model AERMOD is used to predict the effects of criteria pollutants (NO_2, CO, $PM_{2.5}$ and PM_{10}) on the ambient air quality in the airshed. A Tier-1 and Tier-2 (Ambient Ratio Method) modeling approach is used for NO_2 prediction. In addition, two different methods are used to predict the 1-hr NO_2 compliance concentrations; USEPA method and EU method.

124. For the baseline case, the maximum ground level NO_2 for 1-hr (USEPA and EU method) and annual averaging are predicted to be 175.8 (USEPA), 161.9 (EU) and 21.3 $\mu g/m^3$, respectively. For repowering, the maximum ground level NO_2 for 1-hr (USEPA and EU method) and annual averaging are predicted to be 159.0 (USEPA), 148.3 (EU) and 19.2 $\mu g/m^3$, respectively. Both baseline and repowering values are in compliance with national standards and WHO guidelines. For CO, the predicted maximum ground level 1-hr and 8-hr averaging values are found to be well within the national standards for both the baseline and repowering case. The background concentration of $PM_{2.5}$ in the project area is found to be 44.13 $\mu g/m^3$ for 24-hr and 9.10 for annual averaging period, which exceeds WHO guidelines but meets WHO interim target-2 (50$\mu g/m^3$) and national standard (65 $\mu g/m^3$). The background concentration of PM_{10} for 24-hour and annual averaging is found to be 113.1 and 21.86, respectively. These values exceed WHO guidelines but meet the WHO interim target-1 (150 $\mu g/m^3$) and interim target-3 (30 $\mu g/m^3$), respectively. For both the baseline and repowering case, the power station's contribution to ambient $PM_{2.5}$ and PM_{10} concentration in the airshed is found to be fairly low. There is a decrease in maximum predicted ground level concentrations from baseline to repowering case for all modeled criteria pollutants.

125. The contour diagrams show plume dispersion is predominately towards the north for all pollutants; the wind carries the plume away from the major population centers of Dhaka, Narsingdi and Ghorasal. The highest concentration areas occur close to the power station. The distance of maximum ground level concentration is the same in the baseline and repowering cases for NO_2, $PM_{2.5}$ and PM_{10} at 549.6 m, 699.24 m and 648.25 m, respectively. For CO, the maximum concentration for baseline is at a distance of 550 m, whereas for repowering it is 650 m. A stack sensitivity analysis was conducted by increasing stack heights to predict the effect on maximum ground level NO_2 concentrations. Results indicate that increasing the stack height by 20 meters for both units 3 and 4 lowered the 1-hr NO_2 concentration the most (by 4.9 and 7.7 $\mu g/m^3$ for the USEPA and EU methods, respectively). Air quality impact is characterized as Major Adverse.

126. *Impact on Ambient Noise***:** It is expected that noise levels in the complex would increase during unit 4 boiler demolition activities and construction and hoisting of new equipment. Further, due to the operation of the existing units and the future repowering units, the power station area would experience a high level of noise. A simulation of the noise propagation during the operation of the plant was done by using CUSTIC 3.2 software.

127. Simulation of noise propagation for baseline case showed that 8 sensitive receptors experience higher level of noise than the standard of ECR 1997 and WHO Guideline. These receptors include near RMS (91.72 dBA), near fertilizer factory (75.04 dBA), Residence in fertilizer factory -West side (58.37 dBA), Resident Fertilizer Factory -Outside Boundary (66.70 dBA), Residence Mosque Fertilizer Factory (58.37 dBA), Residence FF Near Aggreko (58.37 dBA), Army Residence (60 dBA) and Residential Area (58.37 dBA).

128. Similar to the baseline case, simulation of noise propagation for repowering case showed that 8 sensitive receptors experience higher level of noise than the standard of ECR 1997 and WHO Guideline. These receptors include near RMS (92.33 dBA), near fertilizer factory (75.54 dBA), Residence in fertilizer factory -West side (58.76 dBA), Resident Fertilizer Factory -Outside Boundary (67.15 dBA), Residence Mosque Fertilizer Factory (58.76 dBA), Residence FF Near Aggreko (58.76 dBA), Army Residence (61 dBA) and Residential Area (58.76 dBA). As the noise levels in the Ghorashal Power Plant Complex exceed the standard of ambient noise level in numerous receptors, additional simulation was conducted considering noise barriers in selected locations to attenuate noise. A brick boundary wall of 3 m height and thick plantation and green cover were considered before the residential area in the modeling to attenuate noise. Some greenbelts were also considered outside the boundary wall of Ghorashal complex in the side of fertilizer factory residence. The resultant noise level in different sensitive receptors considering the barriers comply with ECR 1997 and WBG Guidelines. Impact on ambient noise is characterized as Major Adverse.

129. *Impact of cooling water discharge (including thermal plume modeling)***:** After traveling 1 km distance through an open channel, condenser cooling water from Ghorashal Power Station discharges directly into Shitalakhya River. At the outfall, water temperature is recorded as 39°C. The present thermal plume dispersion is not in compliant with the mixing zone temperature requirements of WBG Guidelines. The ambient temperature of the river has been recorded (30.5^{o}C) almost 5 km upstream from the outfall point of Shitalakhya river. Cornell Mixing Zone Expert System (CORMIX 3) software is used to predict unsteady and steady-state mixing behavior and plume geometry.

130. The modeling showed that the intake point is mainly influenced by thermal plume at the time of high tide period. However, the predicted temperature at intake point would be 31.8^{o}C after using cooling tower complying with WBG Guideline values (i.e., 33.5^{0}C) at the distance of 100m from the outfall. At present, the thermal plume temperature is not limited to any direction (u/s or d/s).

131. *Impact on Occupational Health and Safety*: During operation phase, there may be risk due to explosion caused by gas leak from and corrosion of underground pipes, mechanical failure of machineries, faulty electrical equipments/transmission lines and spillage of flammable chemicals and oily substances. Possible health and safety risk also include contact with fine insulation particles (made of glass wool, asbestos etc.) while repairing old insulated pipelines. These particles could be inhaled by the workers accidentally and may cause breathing difficulties, irritations if proper PPE is not worn. They may also slip and accidentally fall from high heights, resulting in severe injuries and fatalities. Health risks will increase if proper safety measures are not adhered to.

132. *Impact on Public Health and Safety***:** The Plant may become a risk factor for those people living/working adjacent to it in case of any serious accident. There may be safety risk to the nearby residential areas, school and offices. It is apprehended that fatalities may take place if any accident occurs.

133. *Impact on Traffic Movement***:** There may be a risk of spillage due to accidents during movement of various Cargoes and Lorries, carrying lube oils, chemicals and other volatile substances. These materials may be then washed away into nearby vegetation area; or could be leached into the river which may cause harm to the aquatic ecosystem. Road accidents due to these spilled chemicals may also cause injuries to passerbies, workers and may even cause damage to properties and structures.

134. *Gas compressor fouling*: Polymer deposits on compressor internals which increases frictional losses and alters flow pattern and lead to loss of compressor efficiency, pressure drop increase in after coolers, potential for unbalancing, rotor, and seal damage.

1.7.6 Cumulative Impacts

135. *Impact on Air Quality***:** The cumulative impact of all major emission (power stations, brick fields, major roads and etc.) sources in the air-shed is assessed using USEPA regulatory model AERMOD. The assessment also includes emissions from the proposed 365 MW combined cycle gas turbine power plant which will be located within the property line of GPS.

136. The maximum ground level NO_2 for 1-hr (USEPA and EU method) and annual averaging are predicted to be 453.88 (USEPA), 337.5 (EU) and 65.8 µg/m³, respectively. The maximum predicted annual concentration exceeds WHO Guidelines but meets the Bangladesh National Standard. The maximum predicted 1-hr average concentration exceeds WHO Guidelines and the corresponding USEPA standard by a significant margin. A source contribution analysis shows that the Aggreko quick rental plants (which have 120 stacks of 3 m height each) contribute a significant portion of the 1-hr and annual average NO_2 concentration (76% and 86%, respectively). Contribution from GPS is only 17% and 9.8% for 1-hr and annual averaging, respectively. The maximum 24-hr and annual average concentration of $PM_{2.5}$ are predicted to be above the Bangladesh national standards and WHO Guidelines. The maximum 24-hr and annual average concentration of PM_{10} is predicted to meet the Bangladesh national standards but exceed WHO Guidelines. The maximum $PM_{2.5}$ and PM_{10} concentrations in the air shed are found close to the N-3 highway, which is approximately 28 km away from the power station. The source contribution analysis showed that most of the $PM_{2.5}$ and PM_{10} at this point is the result of the N-3 highway and all other sources contribute a negligible amount.

137. Based on cumulative assessment results and as per I*FC Health, Safety and Emission Guidelines, 2008* it is concluded that the airshed is degraded since the predicted maximum ground level concentrations of NO_2, $PM_{2.5}$ and PM_{10} exceed the Bangladesh standards and WHO guidelines. With the implementation of this project there is a significant reduction in emissions from the baseline to repowering case for the Ghorashal power

station. After repowering, NO_x, $PM_{2.5}$ and PM_{10} emissions from GPS decrease by 810 tons/yr (13%), 113 tons/yr (41%) and 62 tons/yr (23%), respectively. Thus, with the implementation of this project the air quality in the airshed will be brought closer to compliance with national ambient air quality standards and WHO Guidelines.

138. *Impact on Ambient Noise***:** A simulation of the noise propagation during the operation of the plant and considering other nearby sources was done by using CUSTIC 3.2 software. Noise propagation modeling for cumulative scenario indicates that noise levels will exceed both day and night time standard according to ECR 1997 and WHO Guideline inside Aggreko-Max (102 dBA) and the Residence FF Near Aggreko (59.5 dBA). Noise levels will exceed only night time standard according to ECR 1997 and WHO Guideline near Resident Fertilizer Factory -Outside Boundary (51 dBA).

139. *Impact on Water Bodies***:** Four scenarios for assessment of water availability of Shitalakhya River were simulated; baseline condition, future without project, future with project and other developments including the consideration of upstream flow reduction and climate change impacts.

140. Frequency analysis showed that the river is tidally influenced under low flow regimes such that reverse flow (down stream flow) will tend to maintain constant water level despite of surface water (40.3 m^3/s) withdrawal from river for the cooling purpose of GPS. Hydrological analyses for different options indicate that the changes of average minimum water level are insignificant. The increasing demand for river water conflicts with the environmental needs for sustaining flows during drought and low flow periods and leads to competition between water demand and river flow needs. During dry season, E-flow for base condition is 92.2 m^3/s whereas 83.4 m^3/s is available which is partially sufficient for the good condition of aquatic habitat. However, due to climate change impact in 2050s, dry season flow of Shitalakhya River will be increased for Option 1 and Option 2. Consequently, environmental flow will be increased in that period. Dry season flow for those scenarios (Option 1 and Option 2) is fairly available to meet the E-flow in future. The environmental flow for the Shitalakhya River during dry season is expected not to be a major concern as there is a tidal influence during that period. Even, if water is diverting from this river, downstream flow (tide) will even out the withdrawal and maintain a constant water level. Besides, the major part of the diverted amount will return to the river as return flow after the condenser cooling process. In options 2 and 3, without considering climate change, both dry and wet season flows will roughly be reduced by 10%. The E-flows in option 2 would be 920.7 m^3/s (available flow 1,205 m^3/s) and in option 3 would be 664 m^3/s (available flow 800 m^3/s). So even without climate change, the flow would be sufficient during monsoon season and dry period (considering tidal impact).

141. The following observations were concluded (i) Flow of Shitalakhya River will be increased in near future due to climate change and adequate flow will be available at the project site, (ii) Current abstraction of surface water at the rate of 40.3 m^3/s for condenser cooling and other operational purposes will have no or slight impact on availability of water in Shitalakhya River for the next 30 years, (iii) Monsoon flow will be increased in 2050s which may intensify the flood level in and around the study area, and (iv) Dry season flow and water level will also increase in future which will further facilitate the navigation.

1.8 Mitigation Measures

142. The proposed repowering of Unit 4 has considered a number of environmentally friendly refurbishments of old technology, such as single cycle to combined cycle, once through cooling to open cycle cooling, conventional treatment to central water/effluent treatment system, etc. Since, the Unit is part of an existing operating power plant, which contains other old units, refurbishment of other units, and future expansion with new unit, it

requires particular attention to harmonize development activities in the facility. The following measures or changes are proposed in this Project:

1.8.1 Changing project layout

143. In the existing project layout “asbestos pit” is near the existing Jetty, Gas insulated sub-station (GIS) near the pond and Jetty, a drainage plan around the existing stack of unit 4 and a temporary storage area for scrap materials of existing boiler of Unit 4 by demolishing the existing old structure in the north east side of Unit 4 have been added.

1.8.2 Engineering design

144. A major change in the engineering design has been proposed. Change of existing open cycle cooling system supported by cooling tower to a full close cycle cooling system with a new cooling tower, a central water/effluent treatment plant, and an on-site asbestos pit are receommended.

145. *Close-cycle cooling system:* Main function of the existing cooling tower is to support the open cycle cooling system by cooling a small portion of hot water and adding the same to cold water channel during dry season (when Shitalakhya River flow is minimal) and occasionally during cooling water pump maintenance. The condition of cooling towers is poor and require major refurbishments. Most of the blower fans including the induced draft fan are not working mainly due to the defective motors and other mechanical problems. With all these defects, the present cooling system is unable to mitigate the thermal plume generated from Unit 4. Although the availability of Shitalakhya water for next 25 years is confirmed, water quality will not pose any immediate threat. However, thermal plume will be a continuous threat to the river and its eco-system. Considering this factor, it is proposed to replace the present open cycle cooling system to close cycle cooling system constituting refurbishment of existing cooling towers and addition of new cooling towers to meet the capacity of the repowering of Unit 4 and other Units’ requirements. This will drastically reduce the present cooling water demand of 7.6389 m^3/s to 0.38194 m^3/s and bring the Unit under compliance with WBG Guidelines on thermal plume discharge.

146. *Central water/effluent treatment plant:* The existing water treatment plant at GPS is an old plant with small capacity. It has no effluent and sludge treatment facility. It uses Hydrazine as oxygen scavenger in the boiler feed water system and aluminum sulfate for raw water treatment.

147. The proposed central plant will have effluent and sludge treatment system, and a reverse osmosis plant for de-mineralized water with two cells in service and one standby. It will use more environment friendly chemicals like, Sodium Erythorbate or Halamin as alternatives to hydrazine to treat feed water.

148. *On-site asbestos pit:* An on-site secured asbestos facility is proposed to bury asbestos containing material generated from boiler decommissioning of both Units 3 and 4, future repowering and plant refurbishment work. It is also proposed to scientifically manage the existing hazardous material burial ground to avoid any future risk.

1.8.3 Decommissioning Phase

149. *Airborne asbestos fiber:* The boiler decommisioning area will be protected by temporary peripherial G.I sheet fence of 3 m height both for existing boiler and temporary asbestos disposal site for regulating trespassing of unauthorized people. The decommsioning workers will use appropriate personal protective equipments (PPEs) during decommisioning work. They will be prevented from eating and smoking inside the protected

boundary. They must follow the OHSAS 18001 guidelines. Water sprinkling will be done before comencing the work.

150. *Water bodies:* This project will deal with hazardous/special waste like asbestos. So proper drainage system will be developed at the decommisioning premises before starting the decommisioning activities. Waste water from the decommisioning site will be collected at a sump for temporary storage and treated in central effluent treatment plant (CETP) before final disposal.

151. Chemical substances and scrap will be kept on a specified covered areas so that contaminants from these substances do not come into contact with the natural environment. The Contractor will train workers on handling abnormal or emergency situtions, like oil spill, asbestous release, chemical spill and etc., as detailed in Vol 5: Emergency Response Plan.

152. *Soil quality:* Asbestos containing effluent water could degrade soil quality if allowed to flow into the soil. A leak-proof sump needs to be constructed and the asbestos containing effluent water needs to be drained safely into the sump for collection. The boundary of the sump will be protected so that effluent waters do not wash away to the nearby vegetation or into the surface water during heavy rainfall. The effluent content of the sump should also be monitored regularly and treatment of those should be done accordingly before disposing of into the natural environemt.

153. *Occupational health and safety:* During decommissioning, activities such as boiler dismantling, cutting, grinding, lifting heavy machineries, segregating materials, working at heights, etc. may lead to injuries, casualties. Proper health and safety training on how to handle equipment and hazard identification will be required before starting the work. Use of appropriate PPEs will be made mandatory during decommisioning work. The Contractor's Occupational health and safety (OHS) officer, entrusted with worker's safety, must ensure that the equipments and safety control mechanisms are working properly before the workers start their work. In case of the discovery of faulty equipments and safety harness, they must be replaced promptly. They must also ensure workers hygiene and health status. An on-site medical team will be set up and emergency first-aid medical kit will be at hand in case of any accidental injuries (burns, cuts, broken bones etc.). They will also conduct monthly health check-ups to check the worker's health condition and provide appropriate treatment for any ailments. Finally, the contractors will ensure all compliance issues for the workers during the course of the decommissioning and construction process, as per Bangladesh Labour Act, 2006.

154. *Hazardous solid waste:* Special handling of solid hazardous material will be followed for segragating asbestos from insulation and other boiler materials. At first, asbestos containing waste will be segregated from demolished material before disposal. The contractor will establish a means to prevent any visible emissions outside the temporary and on-site asbestos disposal pit during handling, segregation, and final disposal operations. They must maintain the integrity of leak-proof containers and/or packaging at all times during the handling and disposal operations. Minimize the release and exposure of asbestos containing material after placement in the asbestos pit without compaction of the waste prior to application of cover. Finally, in presence of the official of BPDB, the on-site asbestos pit will be covered to ensure complete coverage of the disposed asbestos and prevent re-exposure during continuing disposal operations. During the operation, the worker will follow the guidelines of WBG's General EHS Guidelines on hazardous materials management.

155. *Labor migration:* Migrant workers in the construction works may aggravate the risk of HIV/AIDS and STI. Awareness programs on HIV/AIDS infection through well-designed campaign will be implemented; targeting all risk prone groups. The spread of the disease can be prevented by adopting and carrying out Behavior Change Communication (BCC)

among target groups. It is recommended that the EPC Contractor arrange a referral healthcare facility to deal with medical aspects of HIV/AIDS treatment with specialized services. The in-house medical facility will diagnose for STD/STI and TB infection in workers and provide treatment as necessary. Serious cases of infection may be referred to specialized treatment facilities of the region. Women are also an integral part in curbing the spread of STD infections. Creating awareness on HIV infection amongst the women involved in construction activities may prevent the spread of such diseases.

1.8.4 Construction Stage

156. *Aquatic habitat quality:* Dredging operation will be carried out in the routes having minimum aquatic habitats. Contractor will conduct appropriate benthic survey prior to the dredging activities. Various ships/cargos navigating in these routes might also disturb aquatic habitats and thus the shipping companies must ensure that the ship/cargo carrying machineries and ancillaries, construction materials and other raw materials, obey the appropriate International Maritime Laws.

157. *Ambient air*: During excavation and operation of equipment dust and pollution will be genrated. Casing will be used when buried pipes cross a road. The trench shall be carefully cut so that the pipe is evenly bedded throughout its length with sufficient joint holes and trial holes made where necessary. Before any back filing is performed, the pipeline will be evenly bedded upon the bottom of the trench throughout its length and will be correctly positioned. Compaction of back filling material shall be performed by an approved method to prevent any subsequent settlement.

158. *Ambient noise:* During construction activity and welding, noise might be generated from moving and idling vehicles and heavy machineries. The machines/equipments/vehicles should be turned off when not in use, to minimize noise generation. The workers in the construction site should also use PPEs during any construction activities.

159. *Water pollution:*. Improper storage and handling of fuels, lubricants, chemicals, hazardous goods/materials on-site; wash down of plants and equipments; and potential spills may contaminate the water bodies and harm the environment and health of construction workers. Oils, lubricants and other hazardous materials will be bunded and stored separately to minimze spills. Workers will be trained on safety precautions on using/handling hazardous materials. They will also be encouraged to use PPEs everytime when handling petro-chemicals and other hazardous materials.

160. *Occupational Health and Safety:* Transportation of machineries and equipments from the ship to the site; their installation/erection; lifting of heavy materials; handling of hazardous materials, working at heights and other construction-related activities may lead to casualties or deaths of the workers. Proper health and safety training on hazard identification, handling of hazardous material and equipments, and training of staff who can potentially come into contact with the material to avoid damage and prevent exposure before starting construction activities.

161. *Fire hazards*: Shield arc welding and cutting by noncombustible or flameproof screens which will protect welders and other persons working in the vicinity from the direct rays of the arc. Tthe welders should use appropriate PPEs and welding trucks shall be equipped with approved fire extinguishers and first aid.

162. *Solid waste storage and visual effect:* Unplanned disposal of old and used equipments and other solid wastes can lead to poor aesthetic views. Moreover, spillage and leakage from improper storage can result in contamination of soil. During construciton, rubbles generated from the construciton site will be stored in approriate bins/skips; will be well-covered and later buried in an approved landfill sites. All solid wastes generated from

the construction site, both hazardous and non-hazardous, will be disposed of in on-site asbestos pit and a designated space, respectively. Food waste and other bio-degradable waste, generated by workers and power plant staff memebers, will be placed at designated site prior to final collection and disposal by local municipality.

1.8.5 Operation Phase

163. *Ambient air quality:* Repowering of Unit 4 will contribute positively to air quality due to combined cycle technology with low NOx burners. However, high officials of BPDB should take initiative at the policy level to limit the emission of pollution concentration of the adjacent Power Plant especially Aggreko Ltd. This Power Plant needs to increase their stack height individually or collectively for reducing the heat wave to the adjacent areas as well as reducing NO_x level to the sensitive receptors.

164. *Ambient noise:* Based on the baseline noise measurements and noise prediction, it is confirmed that noise level has been violated as per ECR 1997 and WBG Guidelines in eight locations. Elevated noise level from the plant operation can lead to hearing complexity and loss along with increased blood pressure; disturbances and discomfort to the technicians, workers and surrounding communities due to noise generated from rotator machineries at exceedance level. The machines/ equipments/ vehicles, which are not is use, will be turned off to limit noise generation. Install acoustic enclosures for equipment (turbines, pumps, fans etc.) casing radiating noise. Brick walls, thick plantation, and greenbelts will be developed around the power plant area to limit the emission of noise to the nearby community. However, exceedance of noise standard values are still expected in some receptors. Therefore, it is receommended to conduct periodic noise monitoring during operation. If the monitoring found constant exceedance of the standards, additional noise attenuation measures will be considered and implemented. Workers working inside the power plant must use appropriate PPEs (soundproof earpiece, mufflers etc.). Replace two doors in the control room and install proper insulation in other doors and windows of the control room to attenuate noise to the ECR 1997 recommended level.

165. *Water bodies:* Sludge generated from the chemical assisted raw water at pretreatment, water, and effluent treatment plants may impact groundwater quality and receiving water bodies*.* Construction of a leak-proof sump will be made to store sludge temporarily and limit the spills. Effluent will then be transferred to sludge treatment plant for treatment. The sump will be monitored and maintained using online continuous effluent monitoring and ensure the quality of effluent and spill control.

166. GPS through their waste treatment action plan will practice the following to reduce the generation of other waste and subsequent treatment:

- Establish waste management priorities at the outset of activities based on an understanding of potential Environmental, Health, and Safety (EHS) risks and impacts and consider waste generation and its consequences;
- Establish a waste management hierarchy that considers prevention, reduction, reuse, recovery, recycling, removal and finally disposal of wastes;
- Avoid or minimize the generation of waste materials, as far as practicable;
- Recover and reuse when waste generation cannot be avoided; and
- Treat, destroy, and dispose of waste in an environmentally sound manner, when cannot be recovered or reused.

167. If waste materials are still generated after the implementation of feasible waste prevention, reduction, reuse, recovery and recycling measures, waste materials will be treated prior to disposal. Selected management approaches should be consistent with the

characteristics of the waste and DoE regulations, and may include one or more of the following:

- On-site or off-site biological, chemical, or physical treatment of the waste material to render it nonhazardous prior to final disposal
- Treatment or disposal at permitted facilities specially designed to receive the waste. Examples include: composting operations for organic non-hazardous wastes; properly designed, permitted and operated landfills or incinerators designed for the respective type of waste; or other methods known to be effective in the safe, final disposal of waste materials such as bioremediation.

168. *Corrosion of gas pipes:* Gas pipes will be coated using 3 layer polyethylenes (3 LPE). Buried pipes and fittings shall be protected against corrosion by means of external coating and wrapping. Cathodic protection test points shall be installed and connected to temporary cathodic protection facilities in accordance with the specification as the final operation of lowering or tieing-in is in progress.

169. *Gas compressor fouling:* A cleaning regime in Bangladesh would be a combination of on-line cleaning and semi-annual off-line washing. On-line cleaning is intended to avoid the build-up of a layer of dirt. The first measures to be implemented after the start of commercial operation should include daily washing of the compressor with fully demineralized water. Off-line cleaning with an appropriate cleaner will result in more intensive cleaning at crank speeds.

170. *Gas pipeline leak:* Tie individual welded joint sections of the pipeline into a continuous system in such a manner that no stress will be induced into the pipe as a consequence of the tieing-in operation

1.9 Environmental Management Plan

171. The EMP includes various categories of mitigation measures and plans: (i) general and non-site-specific measures in the form of environmental codes of practices (ECPs) to address general construction and operation matters identified as moderate and minor in significance prior to mitigation; (ii) project specific and to the extent possible, site-specific mitigation measures; (iii) Boiler Decommissioning Action Plan to be prepared by the Contractor, and (iv) Construction Environmental Action Plan (CEAP) with site-specific and contract-specific management plans to be prepared by the contractor, which include pollution prevention, occupational health, safety and environment, and emergency response.

172. In order to make the Contractors fully aware of the implications of the EMP and responsible for ensuring compliance, technical specifications in the tender documents will include compliance with mitigation measures proposed in the EIA as well as WBG's General Environmental Health and Safety Guidelines. The Contractor must be made accountable through contract documents for the obligations regarding the environmental and social components of the project.

The management plan includes:

1.9.1 EMP during Construction

173. Environmental Management Plans will be prepared by various contractors prior to the commencement of decommissioning and construction activities. The Plans to be prepared by the contractors for various aspects of the environmental management will mostly include the detailing of the measures included in the ECPs and Mitigation Plans, providing where applicable, location details, layouts and drawings, timelines, roles and responsibilities,

methodologies and procedures, and key performance indicators. A brief description of each of these plans is provided below:

174. *Site Preparation:* The site preparation will require base stripping, felling of 25 wood trees and clearance of some bushes. The contractor will prepare a site preparation plan on the basis of ECP 4, ECP 5, ECP 7, ECP 8, ECP 12, and ECP 13 to ensure safeguarding of the environment. This plan must be submitted to OE for review and approval.

175. *Boiler decommissioning plan:* A Boiler Decommissioning Plan is developed under the EIA. The general principle on which this plan is developed is safe handling and disposal of asbestos and following proper safety procedures. 'Wet removal' approach is recommended and will be strictly applied during removing of asbestos containing insulation from boiler and steam pipes. In general the plan includes the following:

- Preparedness for removing ACM;
- Measures to avoid soil and water contaminations, i.e., confining the boiler area with water proofed barrier, polythene sheet cladding to arrest stray asbestos dust, drainage system for managing effluent water;
- Measures to avoid air pollution, i.e., use of thick plastic sheet to confine the boiler structure, water spray system, concrete water proof system for collected sprayed contaminated water, asbestos contaminated water collection system, treatment and final disposal of effluent water;
- Asbestos disposal plan;
- Code of Practices for Asbestos Handling, Removal and Disposals;
- Procedure of permits to work;
- Safety measures for personnel;
- Process of Dismantling of boilers;
- Managing Asbestos in Working Place; and
- Monitoring Plan (continuous groundwater monitoring using monitoring well and periodic soil quality using borehole samples)

176. *Asbestos Management Plan*: In the Contractor's Boiler Decommissioning Action Plan, asbestos management should be clearly detailed out, which will be applied during decommissioning and dismantling of boiler, construction of asbestos pit, managing existing asbestos burial site, etc. The identification of asbestos or asbestos containing material will be done before starting boiler decommissioning and updated as the work proceeds.

177. It is recommended that an on-site asbestos disposal pit is developed with sufficient capacity to accommodate all ACM generated from current and future repowering and plant refurbishment work. There exists free space at the jetty site for disposal of asbestos. There will be three compartments to accommodate all ACM. One compartment will be reserved for operating plant waste. The total quantity of asbestos containing material in the existing boiler is unknown, it is recommended that boiler decommissioning contractor study carefully the quantity of ACM in the boiler and in consultation with GPS assess the design capacity of on-site asbestos pit.

178. Presently, some hazardous waste (including asbestos) has been buried and placed two meters below the top soil in the form of a trench. The trench has a concrete pad at the bottom but no synthetic liners are placed and there are neither storm water diversion channels nor any arrangement for collection and treatment of the leachates.

179. *Erosion, sediment and drainage control plan*: An Erosion, sediment and drainage control plan will be necessary to manage rainfall run-off in the construction site. This plan will be prepared by each contractor on the basis of ECP 4 and 6, and the mitigation measures given in EIA. The Plan will be submitted to the OE for review and approval before contractor mobilization.

180. *Pollution Prevention Plan*: This will be prepared and implemented by the Contractor on the basis of ECP 1, ECP 2, ECP 11, and IFCEHS Guidelines (2007), as well as the mitigation plans given in EIA. The Plan will be submitted to the OE for review and approval before contractor mobilization.

181. *Waste Disposal and Effluent Management Plan:* This plan is mandatory to manage the construction waste and effluent, including waste and effluent from labor sheds. A detailed plan will be prepared and implemented by the Contractor on the basis of ECP 1, ECP 4, and WBG EHS Guidelines (2007), as well as the mitigation plans given in this EIA.

182. *Borrow Area Management and Restoration Plan:* An environmental plan for management and restoration of borrow areas will be prepared by the Contractor on the basis of ECPs 8 and 9 and other requirements described in the mitigation plans. This Plan will aim at minimizing the environmental and social impacts during borrowing activities and restoring as much as possible the original natural situation of these sites by various measures (refill, levelling or smoothening). Restoration methodologies will be included in the Plan. The Plan will be approved by the OE and PMU.

183. *Drinking Water Supply and Sanitation Plan*: Separate water supply and sanitation provisions might be needed for the temporary facilities, labor camp and workshops, in order not to cause shortages and/or contamination. A Plan will be prepared by the Contractor on basis of ECP 3. The Plan will be submitted to the OE for review and approval before contractor mobilization.

184. *Good Handling and Operation of Construction Equipment:* The equipments and machinery from construction activities should be handled and operated in a way that would ensure low noise, low emission of SOx, NOx, smoke, no oil leaks, no accidental event and etc. A detailed plan of handling and operation of construction equipment will be prepared by each Contractor on the basis of ECP 2, 10 and 11.

185. *Fuel and Hazardous Substances Management Plan:* The plan will be prepared by each Contractor on the basis of ECP 2 as well as the mitigation plans given in this EIA and in accordance with the standard operating procedures, relevant guidelines, and where applicable, material safety data sheets. The Plan will include the procedures for handling oil and chemical spills.

186. *Communication Plan:* A communication plan has been prepared to address project related communication with all stakeholders. While carrying out the communication plan, modifications of process and planning may be done as per the projects requirement.

1.9.2 EMP during operation phase

187. Impact specific Environmental Management Plans have been prepared to address the possible significant environmental impacts identified in this EIA. The EMP has been prepared on the basis of mitigation measures proposed. In the following sections these EMPs are discussed.

188. *Wastewater treatment*: At present, raw water, effluent, sludge and slurry from different water treatment plants (e.g., coagulation, clarification, demineralization, etc.) are drained to a central neutralization pond for neutralization and disposal. A central water/effluent treatment plant (CETP) is proposed for Unit 4 repowering to treat raw, effluent

water, and sludge generated from the Unit. The CETP will include a raw water treatment, effluent treatment, sludge and slurry treatment, sludge and slurry disposal system, treatment facilities for feedwater using environment friendly oxygen scavenger (e.g., Helamin, Sodium Erythorbate) and demineralized water using reverse osmosis process, domestic waste water treatment facilities, etc. The Contractor will design the plant according to the type, characteristics, quantity, and regulatory requirements of DoE and WBG EHS Guidelines on Water and Sanitation. All waste water generated from various processes of Unit 4, and liquid wastes will be treated in the CETP before discharging or disposing to the natural environment.

189. BPDB may consider increasing the capacity of the CETP to treat raw and effluent water of other units of GPS and nearby industries, and Power Plants by charging a fee to others. BPDB may take this matter to the policy level with the support of DoE.

190. *Solid waste management:* It is recommended that GPS shall develop a waste prevention strategy, which will significantly reduce the total amount of waste. The strategy will focus on recycling and the facility wise implementation of recycling plans, considering the following items (as per WBG Guidelines):

- Evaluation of waste production processes and identification of potentially recyclable materials;
- Identification and recycling of products that can be reintroduced into the operation of the plant;
- Investigation of external markets for recycling by other power plant operations located in the neighborhood or region of the facility (e.g., waste exchange);
- Establishing recycling objectives and formal tracking of waste generation and recycling rates; and
- Providing training and incentives to employees in order to meet these objectives.

191. *Occupational health safety and environment:* A detailed Occupational Health, Safety and Environment (OHSE) Plan has been prepared and presented in Volume 4. This plan is prepared in a way, which will be applicable for the entire life cycle of the project. Application of the OHSE plan is the responsibility of all including management, employee, contractors, sub-contractors, vendors in their daily activities. The plan also proposes a management and administration system (organogram) for OHSE Plan application. It is suggested that BPDB develops an OHSE Management System program activities and commitment and ensure the program are implemented during each phases of the repowering project

192. EPC contractors will prepare site specific OHSE plans based on the guidelines provided in the OHSE plan presented in Volume 4 and present to OE and PIU for approval. The plan will address all pertinent issues to create a work place that protects worker health and safety with due respect to the environment, and promotes an atmosphere to grow employee learning and opportunity in a way that is fulfilling, recognized and fairly rewarded during decommissioning and construction phase of the project.

193. *Thermal Pollution Management*: On the basis of the findings of the Impact Assessment , closed cycle cooling system is recommended with cooling towers to prevent thermal plume discharge into the river.

1.9.3 EMP to Address Cumulative Impacts

194. *Air Quality Management:* Based on cumulative impact assessments of ambient air quality, AERMOD dispersion modelling predicted that $PM_{2.5,}$ PM_{10} and NO_2 concentration exceeds ECR 1997 (as amended in 2005) and WBG Guidelines. Major contributor of NO_2 is

Agrekko Quick Rental. Scientific study[2] available, which indicates that $PM_{2.5}$ concentration in Bangladesh is mostly trans-boundary (secondary pollutants formed from NOx and SOx after chemical transformation in the ambient air).The combustion of gaseous fuels such as natural gas does not produce significant particulate matter. Also, natural gas from Bangladesh is naturally very low in contaminants such as sulfur and is considered sweet. This study concludes that on average, 35% of the $PM_{2.5}$ concentration is trans-boundary in nature and can be as high as 67% depending on the season. Therefore, BPDB should take initiative at the policy level to reduce emissions from selected facilities. DOE can also take action to bring specific facility under compliance. In addition, a trade-off between heavy and low polluting industries should be established with the initiative of DoE. For ensuring a sustainable development and non-degraded airshed, some policy intervention and strategic initiatives are essential. For $PM_{2.5}$, Bangladesh Government should coordinate with Indian Government for a possible joint scientific study on trans-boundary pollution to ascertain cause of high $PM_{2.5}$ concentration.

195. *Noise Management:* A comprehensive plan for noise reduction and attenuation is required to control ambient noise limit within the permissible level. Therefore, the contractor should develop an integrated plan on the basis of ECP 11.

196. In addition, BPDB needs to take initiatives to construct a brick wall having capacity of noise attenuation at outer boundary of Power Plant of Agrekko Ltd to buffer noise propagation to nearest community.

197. *Common effluent/water treatment plant:* The water quality of the river is already degraded (high BOD, low DO and presence of other pollutants) due to the untreated effluent discharged into the river. Therefore, it is proposed to develop a common effluent/water treatment plant for all industries in close proximity of GPS, which will save land requirement and cost and would increase efficiency.

198. Department of Environment as a law enforcement Agency may take an initiative at policy makers' level to find a way to build such a plant. BPDB may also take initiative of constructing a large scale common plant and commercially offer effluent treatment services to different industries. Government may also invite private partnership to construct such plants where the industries would contribute as polluter-pay basis (based on the nature and quantity of its effluent) to the common plant authority for treating their water and effluents.

1.9.4 Mitigation Plan

199. The mitigation plan presented in Table 3 is organized around various project activities and includes various actions identified under the mitigation measures discussed in Chapter 8. The plan defines responsibilities for implementation as well as supervision of each action, and also indicate the timing of these actions. Should any changes to the Project design or methods of construction and operation take place, post this assessment stage, the impacts and mitigation measures discussed may need to be revised to reflect such changes to allow the environmental and social implications of these changes to be addressed.

[2] Billah, M., Chatani, S., and Sudo, K. (2009); Application of WRF-CMAQ Modeling System to Study of Urban and Regional Air Pollution in Bangladesh, 8th Annual CMAS Conference, Chapel Hill, NC, October 19-21, 2009

Table 3: Mitigation Plan

VECs/Issues	Environmental Impacts	Mitigation Measures	Institutional Responsibilities	
			Implementation	Supervision
1. DECOMMISSIONING PHASE				
B. Ambient Air B1. Airborne asbestos fiber	Inhalation of airborne asbestos fiber during segregation of hazardous materials and their transportation is injurious to lung leading to lung cancer and other lung diseases or respiration complexity. Skin and eye irritation of the workers may cause due to contact with dust particles.	• Boiler area must be protected by temporary peripherial G.I. Sheet fence of 3m height both for existing boiler and asbestos disposal site for preventing trespasserscome close proximity of the decommissioning site. • The workers should use the appropriate PPEs during decommisioning of existing boiler. • Workers must follow the OHSAS 18000 guideline and observe onsite safety precautions regularly. • Water spraying should be done on all asbestos containing materials in the morning especially before commencing the work and subsequently when required to prevent asbestos particles disperse in the ambient air.	Contractor	Owner's Engineer (OE) and Project Implementation Unit (PIU)-BPDB
D. Water Bodies D2. Water quality	Contamination of nearby water bodies by asbestos containing effluent generated during water spray control airborne asbestos fiber..	• Proper installation of water management system i.e., proofed bund, water proofed slope, water drains and tanks as suggested in the boiler decommissioning plan • In addition, a secondary drain and collection tank will be installed at the outskirt of the primary water bund to prevent water leakage to nearby area • The details of the plan is described in Vol. 3: Boiler Decommissioning Plan • Asbestos containing effluent then pump to the effluent treatment plant for treatment. The treated water will finally be discharged to the river and the collected residual asbestos will be buried in the on-site asbestos pit. •	Contractor	OE and PIU-BPDB
E. Soil E2. Soil quality	Contamination of soil by asbestos containing effluent generated during the water spray to control airborne asbestos fiber.	• The existing boiler floor has been damaged in many places. The floor requires repair with concrete layer of three inches thickness with slope towards ID fan side. • After proper curing of concrete and finishing, apply a coat of water proofed layer to prevent water seepage through the floor. • On the perimeter of boiler floor, install a side wall of one foot height. After curing, apply water proofed coat to prevent water leakage on nearby area.	EPC Contractor	Health and Safety Officer, The Proponent

VECs/Issues	Environmental Impacts	Mitigation Measures	Institutional Responsibilities	
			Implementation	Supervision
		• On ID fan side of boiler, construct two concrete tanks side by side of size 6 ft x 6 ft x 4 ft. The concrete base as well as all side walls shall be water proofed. One of these tanks shall be connected with proper double valve to collect asbestos laden effluent.		
F. OCCUPATIONAL HEALTH AND SAFETY F2. Occupational health and safety	Injuries leading to casualty or death may be caused from the wrecking activities of the boiler as it involves cutting, grinding, lifting heavy machineries, segregating, working at heights, etc.	• Proper health and safety training on how to handle equipments and hazard identification must be provided to the workers before starting with the decommissioning activities. • The health and safety officer will make sure that the equipments and safety control mechanisms are working properly before the workers start their work. If faulty equipments are identified they must be replaced promptly. • An on-site medical team should be available and emergency first-aid kit should be at hand in case of any accidental injuries (burns, cuts, broken bones etc.). • The workers should use the appropriate PPEs and wear appropriate cloths during decommisioning of existing boiler. • Ensure workers hygiene and health status. Conduct monthly health check up to check their health condition and provide appropriate treatment for any ailments. • The contractors should ensure all type of compliance issues for the workers during the course of the decommissioning and construction process, as per Bangladesh Labour Act, 2006.	Contractor and Health and Safety Officer	
G. Solid waste handling and disposal G1. Hazardous solid waste handling	Generation of hazardous solid wastes from the boiler decommissioning containing mostly asbestos fiber, rock and glass wool in insulation materials. Airborne asbestos particles, rock and glass wool fiber are harmful for human health.	• At first, asbestos containing waste should be segregated from other solid wate before disposal. The contractor will establish the means to prevent any potentialdispersion outside the designated asbestos disposal area during handling and disposal operations. • Place two layers of polythene sheet, approximately 200 µm (0.2 mm) thick for packaging, in the cargo-carrying compartment of the vehicle. • Place ACM carefully on polythene sheet to a height of less than 1 m and completely wrap the articles. Seal with adhesive tape. Packages should be small enough to be handled easily. • Workers must maintain the integrity of leak-tight containers and/or packaging at all times during the handling and	Contractor	Health and Safety Officer, The Proponent

VECs/Issues	Environmental Impacts	Mitigation Measures	Institutional Responsibilities	
			Implementation	Supervision
		disposal operations. • Minimize the release and exposure of asbestos containing waste after placement in the disposal area without compaction of the waste prior to use of cover. • Finally, in presence of the official of BPDB, the asbestos containing disposal site is to be sufficiently covered to ensure complete coverage of the disposed asbestos and prevent re-exposure during continuing disposal operations. During this operation, the worker must follow the guidelines of OHSAS 18001 for hazardous waste management.		
H. Social impact H2. Labor migration	Aggravated risks of HIV/AIDS and STI due to the flow of migrant workers.	• Create awareness on HIV/AIDS infection and diseases through a well-designed campaign and implementation plan targeting all risk-prone groups • The migrated worker must respect the local customs and rituals • Adopting and carrying out Behavior Change Communication (BCC) among target groups; • Put in place a referral healthcare facility to deal with medical aspects of HIV/AIDS treatment with specialized services; • Diagnose and treat STD/STI and TB through in-house medical facility constituted by the Contractor for workers' safety; • Serious cases of infection may be referred to specialized treatment facilities; • Empowering women through employment in the construction work; • Frequent medical check-up would also be helpful in controlling the spreading of diseases. Emergency medical services and adequate first aid facilities should always be available at the site.	Contractor	BPDB
CONSTRUCTION PHASE				
I. ECOSYSTEM				
I1. Aquatic habitat quality	Impact on aquatic habitats, including benthic habitat, due to dredging operation for creating sufficient	• Dredging operation should be carried out in the route having minimum aquatic habitats. Appropriate benthic survey must be carried out prior to any dredging activities. • The shipping company must ensure that the ship carrying	Contractor	ESHSU

VECs/Issues	Environmental Impacts	Mitigation Measures	Institutional Responsibilities	
			Implementation	Supervision
	navigation channel for ship carrying heavy plant equipment.	construction materials and other raw materials, obey the appropriate International Maritime Laws.		
J. Ambient air J1. Dust and gases generated from excavation, construction equipments, and vehicles	Emissions of dust and gases will be generated from excavation of trenches for laying gas pipes; RMS, turbine and HRSG foundation, operation of construction equipment and vehicles, and material transport, which is injurious to human health.	• Casing will be used when buried pipes cross a road. • Trench shall be carefully cut so that the pipe is evenly bedded throughout its length with sufficient joint holes and trial holes made where necessary. • Pipeline will be evenly bedded upon the bottom of the trench throughout its length and will be correctly positioned, before any back filing is performed. • Compaction of back filling material shall be performed by an approved method to prevent any subsequent settlement.	Contractor	OE/ESHSU
K. Ambient noise K1. Noise level	Noise will be generated from the moving and idling vehicles, welding operation, and heavy machineries.	• The machines/equipments/vehicles should be turned off when not in use. • Using PPEs during construction work.	Contractor	ESHSU
L. Water bodies L1. Water pollution	Improper storage and handling of fuels, lubricants, chemicals, hazardous goods/materials on-site, wash down of plant and equipment, and potential spills may contaminate the water bodies and harm the environment and health of construction workers.	• Oils, lubricants and other hazardous materials should be bunded and stored separately so as to limit the spillage. • Workers should be trained on safety precautions on using/handling such hazardous materials. • The workers should be encouraged to use PPEs everytime when handling oils, lubricants, chemicals and other hazardous materials.	Contractor	ESHSU
N. Occupational Health and Safety N1. Health and safety hazard	Injuries leading to casualty, or death may be caused during transportation of machinery and equipments from the ship to site, and their installation/erection,lifting	• Proper health and safety training on hazard identification and how to handle hazardous equipments must be provided to the workers before starting any construction activities. • The health and safety staffof contractor must ensure that the equipments and safety harness are working properly before the workers start their work. In identification of a faulty equipment, they must be promptly replaced.	Contractor	ESHSU

VECs/Issues	Environmental Impacts	Mitigation Measures	Institutional Responsibilities	
			Implementation	Supervision
	heavy materials, working at heights, etc.	• An on-site medical team should be set up and emergency first-aid kit should be at hand in case of any accidental injuries (burns, cuts, broken bones etc.). • The workers should use the appropriate PPEs. • Ensure workers hygiene and health status. Conduct monthly health check up to monitor their health condition and provide appropriate treatment for any ailments.		
N2. Fire hazards from welding,	Welding operations during laying of pipeline may cause fire accidents if proper care is not taken	• All arc welding and cutting operations shall be shielded by noncombustible or flameproof screens which will protect welders and other persons working in the vicinity from the direct rays of the arc. • In addition, the welders should use appropriate PPEs and welding trucks shall be equipped with approved fire extinguishers and first aid.	Contractor	OE/EHSU
P. Solid Waste Disposal P1. Storage space and visual effect	Poor aesthetic view due to the storage and disposal of old and used equipments and materials. Moreover, spillage and leakage from improper storage can result in contamination in soil.	• Rubbles generated from the construciton site should be stored in approriate bins/skips, well-covered and later buried in an approved landfill site. • All solid wastes, hazardous and non-hazardous, should be stored in designated sites prior to final disposal	Contractor	Health and Safety Officer
2. OPERATION PHASE				
T. AMBIENT AIR T1. Maximum ground level concentration of air pollutants	Emission of exhaust gas from the stack may contribute elevated ground level concentration of NO_x, $PM_{2.5}$ etc. at the downwind direction.	• Introduction of Low-NO_x burner in GT machine will reduce NO_x emission below 25 ppmv. • High officials of BPDB should take initiative at policy level to limit emission from the adjacent Power Plants (i.e., Aggreko and Max Power Rental). • Agrekko Power Planthas 134 gas generators with stack height of 3 m, which generates excessive emission and het waves to the the nearby communities. The plant requires raise their stacks individually or collectively for reducing the heat wave as well as NO_x level to the sensitive receptors.	BPDB	EHSU
U. Noise level U1. Noise levelinside the	Hearing complexity and loss along with increase blood pressure,	• Construct 3 m high brick boundary walls and thick plantation to attenuate noise in the sensitive receptors. • Replace two doors of the control room with proper insulation.	Contractor	EHSU

VECs/Issues	Environmental Impacts	Mitigation Measures	Institutional Responsibilities	
			Implementation	Supervision
control room, turbine hall	disturbances and discomfort to the technicians and workers and surrounding communities due to noise generated from rotator machineries at exceedance level.	Insulation in all other doors and windows in the control room and other workspace to attenuate noise. • The machines/equipments/vehicles should be turned off when not in use. • The turbines, pumps, fans etc. should be covered with soundproof dampeners to limit the spread of noise. • Greenbelts should be developed around the power plant area to limit the spread of noise to the nearby community. • Workers should use appropriate PPEs (soundproof earpiece, mufflers etc.) while working close to noise equipment.		
V. Water bodies V1. Pollution of receiving water bodies	Sludge generated from the chemical assisted raw water at pretreatment and water treatment plants may impact groundwater quality and receiving water bodies if come in contact to sludge.	• Construction of a leak-proof sump should be made to store sludge temporarily and limit their spillage. They should then be transferred to sludge treatment plant for treatment. • The sump should be monitored and maintained by on board chemist and technicians and make sure everything (e.g. pollutant content, spill control etc.) goes smoothly	BPDB and EHS officers	BPDB and EHS officers
Y. Risks and emergency				
Y3. Corrosion of gas pipes	Corrosion on the internal wall of a natural gas pipeline can occur when the pipe wall is exposed to water and contaminants in the gas, such as O_2, H_2S, CO_2, or chlorides	• Pipe will be coated using 3 layer polyethylenes (3 LPE). • Buried pipes and fittings shall be protected against corrosion by means of external coating and wrapping. • Holiday detector shall be used to detect any holiday and shall be repaired. • Cathodic protection test points shall be installed and connected to temporary cathodic protection facilities in accordance with the specification as the final operation of lowering or tieing-in is in progress. • Conduct inspection after all installation before back-filling.	Contractor	OE/EHSU
Y4. Gas compressor fouling	Polymer deposits on compressor internals which increases frictional losses and alters flow pattern and lead to loss of compressor efficiency, pressure drop	• A cleaning regime in Bangladesh would be a combination of on-line cleaning and semi-annual off-line washing.	Contractor	OE/ESHSU

VECs/Issues	Environmental Impacts	Mitigation Measures	Institutional Responsibilities	
			Implementation	Supervision
	increase in after coolers, potential for unbalancing, rotor, and seal damage.			
Y5. Gas pipeline leak	Poor tieing-in may cause leak of significant amount of gas from the pipe	• Separate welded joint sections of the pipeline shall be tied into a continuous system in such a manner that no stress will be induced into the pipe as a consequence of the tieing-in operation.	Contractor	OE/ESHSU

1.9.5 Emergency Response Plan

200. As part of the EIA, an Emergency Response Plan (ERP) is prepared and presented in Volume 5. Each Contractor, after assessing potential emergencies that could be encountered during construction phase should prepare site specific ERPs (guidance can be taken from the ERP proposed in this EIA) and include in their Construction Environmental Action Plan (CEAP). The CEAP will be submitted to the OE and PIU for review and approval before contractor mobilization. The ERP proposed for BWDB identified possible emergency events during the construction and operation phases. The emergencies could be immediate medical evacuation due to personnel injury, traffic accidents (road), leakage of hazardous materials (airborne asbestos particles), terrorist events/threats and gas leakage/explosion, kidnap and/or extortion, bomb threat, pandemic, significant business loss, pollution incident, fire and explosion, gas leak and structure collapse. The ERP outlines the framework of Emergency Response Strategy which will be followed by the contractor's, operation and maintenance staffs of BPDB during decommissioning, construction, and erection and operation and maintenance phases.

1.9.6 Budget for EMP

201. The cost of implementing the EMP including monitoring is USD 26.8 million. Details of EMP and associated costs are given in Table 4.

Table 4: Estimated cost of EMP

Sl	Items	Unit	Qty	Unit Rate (USD)	Amount (USD)
1	**EPC Contract**				
	Boiler Decommissioning	No	1	4,000,000	4,000,000
	Continuous Stack Emission Monitoring System	No	1	250,000	250,000
	Continuous Effluent Quality Monitoring Instrument	No	1	150,000	150,000
	Central Water and Effluent Treatment Plant	(Included in Cooling Tower System)			
	Noise attenuation measures	LS	1	15,000	15,000
	Continuous Ambient Air Quality Monitoring Stations	No	2	250,000	500,000
	Micro Weather Station	No	1	40,000	40,000
	Environmental Laboratory	No	1	400,000	400,000
	New Closed-cycle Cooling Tower System	No	1	16,000,000	16,000,000
	EHS Staffs of Contractor (3)	MM	78	5,000	390,000
	Contractor's HIV/AIDS Management	LS			59,000
2	**Environmental Management Plan**				
	Plantation Program				2,828
	Emergency Response Plan				2,010,000
3	**Environmental Monitoring**				
	Boiler Decommissioning (6 months)				40,440
	Pre-Construction and Construction (3 years)				475,540
	Independent Monitoring (3 years of Operation)				134,563
4	**Institutional Arrangemen**				
	EHS Consultant of Owner's Engineer				942,000
	EHS Staffs of EHSU Circle (6 years)[1]				445,112
	Capacity Building and Training				131,725

Sl	Items	Unit	Qty	Unit Rate (USD)	Amount (USD)
	Independent Monitor (Fees)				813,780
				Total	**26,799,988**

Notes:

[1] 3 years during construction and 3 years during operation

1.10 Risk Assessment and Management

202. This risk assessment and management strategy has been developed as part of the repowering of Unit 4 of GPS. This strategy is applicable to decommissioning (currently boiler decommissioning for both Units 3 and 4), construction/ erection of Unit 4 repowering equipment, and operation and maintenance stages of the entire GPS. The strategy deals with, (a) Risk/Hazard Identification, (b) Risk/Hazard Management both in onsite and offsite, and (c) On-Site Emergency Response Plan.

1.10.1 Risks/hazards during decommissioning

203. It is key for the EPC Contractor to implement safety measures and the receipt of the necessary permits during decommissioning. The potential hazard points during decommissioning are listed in Table 5.

Table 5: Hazard identification during the decommissioning stage

Hazard category	Hazard points
Mechanical	• Falling debris or machineries • Fall from heights • Cuts, burns and bruises from handling machineries and equipment, slips and falls
Toxic chemical exposure	• Inhalation of asbestos dust, glass wool dust, metal rusts and other small dust particles
Failure mode hazard	• Non-functional equipment • Non-functional safety straps • Non-functional construction pulleys and cranes • Non-functional personal protective equipment (PPEs)
Roads and Highway hazard	• Road accidents • Rollover of vehicles and machineries • Demolition of properties and structures

1.10.2 Risks/hazards during construction/erection

204. In a gas based power generation plant, leakage of flammable natural gas is a potential hazard. This can cause injury or damage resulting from a fire or explosion incident. The possible factors involved in such incident are:

- When the pipelines, vessel or equipment fail in a particular mode causing a release. There are several possible causes of failure, the main ones being corrosion and damage by external agents;
- If the released material come into contact with a source of ignition. In some cases this may be heat or sparks generated by mechanical damage while in others, the possible ignition source could include non-flame proof equipment, vehicles, or flames at some distance from the release;
- Depending on the release conditions, including the mass of flammable material involved and how rapidly it got ignited, the results may be a localized fire (for example a jet fire), a flash fire or an explosion of the vapor cloud formed through

the release;

- Finally, human dimension of such hazards and degree of risk would be dependent if there is presence of people within the harmful range (consequence distance) of the fire or explosion. Degree of close proximity of people will determine the nature and extent of any injuries or fatalities due to such incidence. Environmental damage from gas fire incidents are generally associated with a failure to control fire water used.

205. Natural gas is a buoyant, flammable gas which is lighter than air (density of air is 1.225 kg/m^3 and natural gas is 0.712 kg/m^3). On release into the open space the non-ignited gas tends to disperse rapidly at high altitude. Ignition at the point of release is possible, in which case the gas would burn as a jet (or torch) flame. On release in an enclosed area (for example within the gas turbine housing) an explosion or a flash fire is possible.

206. The gas is non-toxic, posing only an asphyxiation hazard. Due to its buoyancy, any release of credible proportions from operations of this scale, in the open, would not present an asphyxiation hazard. With standard confined space entry procedures and appropriate security arrangements to prevent unauthorized access to any of the facilities, the risk associated with asphyxiation from natural gas will be minimal.

207. Locally, the pressure of the compressed gas may be hazardous in case of an uncontrolled release. These hazards, would adversely affect people working at the site, but do not have implications beyond the immediate location of the release unless the released gas is ignited. Therefore, the risk associated with non-ignited compressed gas does not form part of the scope of the present risk assessment.

208. This potential risk would however need to be closely managed through job safety analysis (JSA) and/or other risk assessment practices used by management and operators of the facility.

209. Other potential hazards are associated with the handling and use of combustible liquids (i.e., the lubricants used for pumps, compressors, turbines etc.).

210. Minor quantities of flammable acetone (used for cleaning) will also pose a potential fire hazard.

1.10.3 Risks/hazards during operation

211. Leakage from Gas supply facilities may lead to series of hazards that may ultimately results in damage of the property and loss of human life. Table 6 lists all identified major potential hazards and hazard sourcing points related to natural gas during plant operation.

Table 6: Potential Hazard Points and Possible Hazards

Hazard Points	Possible Hazards	Consequences
Regulatory and Metering Station	Gas Leak leads to: • Toxic Vapor Cloud Formation • Vapor Cloud Explosion • Jet Fire • Limited Space Explosion • Over Pressure Explosion	• Fire • Poisoning • Suffocation • Damage to Structure • Health Loss

212. Leakage from pipeline or RMS may lead to a sequential hazard. A pipeline of 1,320 m long, 16 inch diameter will supply gas to the power plant. ALOHA (Areal Locations of Hazardous Atmospheres) software has been used to simulate the consequence of gas leakage. ALOHA is a modeling program to estimate threat zones associated with hazardous

chemical releases, including toxic gas clouds, fires, and explosions. The simulation considers that it is possible to close off the gas supply connection through a valve installed at RMS. ALOHA has been applied to simulate the following sequential hazards:

- Toxic Area of Vapor Cloud Formation
- Flammable Area of Vapor Cloud Formation
- Blast Area of Vapor Cloud Formation

213. *Toxic Area of Vapor Cloud Formation:* Based on analysis, ALOHA predicted that toxicity may spread up to 288 m. Life threatening toxicity may spread up to 69 m towards windward. Table 7 presents a brief summary of the toxicity.

Table 7: Threat Zone of Vapor Cloud Formation

Items	Red Threat Zone (meter)	Orange Threat Zone (meter)	Yellow Threat Zone (meter)
Definition	PEC 3: Concentration <17000 PPM More than one hour exposure to this concentration may cause adverse health effects or death	PEC 2: concentration < 2900 PPM, More than one hour exposure to this concentration may cause irreversible or other serious, long-lasting, adverse health effects or an impaired ability to escape	< 1000 PPM, Exposure to this concentration may cause discomfort, irritation, or certain asymptomatic, non-sensory effects
Toxic Area	69 m	167 m	288 m

Note: PAC: Protective Action Criteria

214. *Flammable Area of Vapor Cloud Formation*: The vapor cloud formed from a gas pipeline leakage. ALOHA has been applied to predict the possible flammable area of the vapor cloud. The explosion limit of methane is low, only 5% (LEL) - 15% (UEL). The local area of flame can occur even though the concentration is below the lowest explosion limit (LEL). ALOHA considers 60% of the LEL to cause a flame.

215. 60% of the LEL level, i.e., 30,000 ppm concentration has been considered as high threat zone of occurring flame. 30% of LEL, i.e., 15,000 ppm concentration has been considered as moderate threat zone and 10% of LEL, i.e., 5,000 ppm is considered low threat zone of occurring flame. The model predicted that the high threat zone might spread up to 72 m. The details of the simulation results are presented in Table 8.

Table 8: Threat Zone of Flammable Vapor Cloud Formation

	Red Threat Zone (meter)	Orange Threat Zone (meter)	Yellow Threat Zone (meter)
Definition	LOC: > 30,000 PPM which is 60% of the Lowest Explosion Limit (LEL) of Methane. LEL of Methane if 50,000ppm	LOC: > 15,000 PPM which is 30% of the Lowest Explosion Limit (LEL) of Methane. LEL of Methane if 50,000ppm	LOC: > 5000 PPM which is 10% of the Lowest Explosion Limit (LEL) of Methane. LEL of Methane if 50,000ppm
Toxic Area	72 m	103 m	179 m

Note: LOC: Level of Concern

216. *Simulation of Blast Area of Vapor Cloud Formation:* ALOHA defines three levels of concern for classifying threat zones on the basis of overpressure formed by the shock wave created from the blast:

- High Threat Zone, 8 psi pressure which is destructive for buildings
- Moderate Threat Zone, 3.5 psi pressure serious injury
- Low Threat Zone, 1.0 psi pressure that is enough to shatter window glass

217. The model predicts that the possible blast of the flammable vapor cloud would not be strong enough to create any pressure above 1 psi to shatter window glass.

218. *Simulation of Jetfire:* The simulation of the threat zone shows that, the moderate risk zone (orange threat zone,Table 9) of the area of flammable vapor cloud reache to HFO storage tank (in case of a gas leak when the wind direction is SE and wind speed is 3 m/s). However, based on a discussion with GPS officials, it was learnt that HFO tanks are not operational for a long period of time and these will be dismantled by the BPDB. Therefore, no further risk of explosion of HFO tanks is accepted. This dismantling or relocation of the HFO will mitigate the potential risk of explosion.

Table 9: Threat Zone of Thermal Heat Radiation of a Jet Fire from gas leak

	Red Threat Zone (meter)	**Orange Threat Zone (meter)**	**Yellow Threat Zone (meter)**
Definition	LOC: 10 kw/m^2 Potentially lethal within 60 sec exposure	LOC: 5 /m^2 2^{nd} degree burn within 60 sec exposure	LOC: 2 kw/m^2 Pain within 60 sec exposure
Toxic Area	28 m	47 m	76 m

Note: LOC: Level of Concern

1.11 Environmental Monitoring Plan

219. Various monitoring programs have been proposed in the EIA, which include compliance monitoring, impact monitoring, and external or independent monitoring. The objective of this monitoring program is to ensure that the various tasks detailed in the environmental management plan, particularly the mitigation measures are implemented in an effective manner, and also to evaluate project's impacts on the key environment and social parameters.

1.11.1 Compliance Monitoring

220. To safeguard the protection of environment, compliance monitoring is a very important tool for environmental management. The compliance monitoring will comprise of surveillance to check whether the contractor is meeting the provisions of the contract during construction and operation of the Project including the responsible agencies for implementation and supervision.

221. For monitoring of physico-chemical parameters, actual monitoring time and location will be decided by OE and BPDB. The Contractor will be responsible for carrying out, or contracting to an approved third party, the monitoring of all the parameters as required frequency by his own cost during the construction phase.

1.11.2 Impacts Monitoring during Construction

222. The purpose of the impacts monitoring is to ensure that the contractor implements the mitigation measures given in the EMP effectively and implements them in a timely manner. This monitoring will generally be carried out by the Owners Engineer (OE) with the help of checklists prepared on the basis of the Mitigation Plan.

1.11.3 Independent/External Monitoring

223. The BPDB will engage an independent organization to monitoring the impementation of the EMP. The main purpose of the Independent monitoring will be to ensure that all key entities including EHSU, Owner's Engineer, and contractors are effectively and adequately fulfilling their designated role for EMP implementation, and that all the EMP requirements are being implemented in a timely and effective manner.

1.11.4 Implementation of Environmental Monitoring Plan

224. *Responsible Agency*: The Chief Engineer, Power Station Construction (PSC) is the responsible authority for administrating and implementing the Project. The Project Director of GPS Unit 4 Repowering will implement environmental monitoring program during construction and the Chief Engineer Operation will implement monitoring plan during operation stage. During construction stage, the Environmental Compliance Monitoring will be conducted by the Contractor(s) supervised by the Owner's Engineer (OE) and Environmental Impact Monitoring will be carried out by the by the Owner's Engineer (OE) with support from Contractor(s). In addition, an independent Monitor will also be retained by PIU during three years of construction and three years of post-construction (operation stage). The EHSU Circle of GPS will implement the monitoring program during the operation stage.

1.11.5 Action during Emergent Operation

225. During major failure of control system, plant component, grid failure, etc. an emergent operation can take place. By default, the modern distributed control system (DCS) can handle such emergencies. However, the plant operator/shift in-charge can change the plant control to manual mode and adjust the process variables and finally change the plant back to auto mode after the recovery of the emergency situation. The proposed project will have DCS control system with modern sensors and a proper interface with the existing old sensors/system.

226. The plant will be operated ensuring all pollution control devices are in order. In case of any event of malfunction of a pollution control device, immediate action of resolving the problem will be taken. If any emergent situation arises during operation, the shift in-charge will be immediately notified to take corrective measures and action.

1.11.6 Performance Indicators

227. Performance indicators are identified for efficient and timely implementation of measures/actions proposed in EMP, for the evaluation of the performance of the environmental management and monitoring plan. The indicators are identified for both construction and operation phases. Owner's Engineer will be responsible for compiling the information on these indicators and report to BPDB.

228. Separate performance indicators for both compliance and impacts monitoring have been identified and presented in Chapter 11. To measure the overall environmental performance of the project, an additional list of performance indicators is provided below:

- Number of inspections carried out by OE per month
- Number of non-compliances observed by OE or EHSU
- Continuous period of non-compliance
- Number of grievances received.
- Number of grievances resolved.
- Number of construction and occupational related accidents.
- Timely reporting of documents (as defined in EMP and monitoring plan)
- Availability of environmental and H&S specialists in EHSU.
- Availability of environmental and H&Sspecialists in OE.
- Availability of environmental specialists and H&Swith contractors.
- Number of trainings imparted to stakeholders/other capacity building initiatives

1.11.7 Reporting and Feedback Mechanism

229. During construction stage, the environmental specialist of OE will be engaged in monthly discussion meetings with the project implementation unit, and the contractor for giving necessary feedback. The project implementation unit may arrange a discussion meeting quarterly with the financer regarding environmental compliance.

230. During the operation phase, the EHSU Circle will carry out the monitoring activities and keep all the records and results of monitoring with proper documentation and will produce quarterly reports on Environmental Monitoring. Besides, the third party Independent Monitor will prepare and submit environmental compliance monitoring report annually to the power plant authority. All the reports will be submitted to DoE which is a condition of renewing the Environmental Clearance Certificate from DoE and to the World Bank for post-completion monitoring and evaluation of the project.

231. During operation, the EHSU Circle will give necessary feedback instantly to the person in concern. The EHSU Circle will arrange a monthly meeting to disclose the results of environmental monitoring to the personnel.

1.11.8 Budgets for Monitoring

232. Summary costs of monitoring including investments costs are presented in Table 10.

Table 10: Environmental Monitoring Cost

Sl no	Activities	Estimated Cost (USD)
1	Compliance monitoring during construction	515,980
2	Compliance monitoring during construction	122,330
3	Investment Cost of Environmental Monitoring	1,340,000
4	Cost of Independent Monitor	813,780
	Total Cost of monitoring	**2,792,090**

1.12 Indirect Project Benefits and Measures Proposed Beyond Compliance

233. The proposed Project is designed as environmentally sound in comparison to the existing operation regime of Unit 4. Despite such design, the Project may have sensitivity to environment and thus measures to go beyond regulatory requirements are introduced in the EIA and EMP. Aspects such as GHG emission reduction, corporate social responsibility, extending support to use of condenser cooling water for irrigation, and measures such as, green belting of asbestos pit and neutralization pond are therefore proposed.

1.12.1 GHG Emission Reduction – An Indirect Project Benefit

234. Annual GHG emissions from the natural gas-fired, combined-cycle power plant (repowering) in comparison to the gas based steam-cycle generation (baseline) are estimated. It is found that 1,439,264 ton/y of CO_2 emission generates from the baseline scenario (steam cycle) and 901,868 ton/y of CO_2 emission will be produced from the repowering case for the same power (412 MW) generation, respectively. The net CO_2 emission benefit is estimated as 537,396 ton/y and a total of 13,434,904 ton in the entire project life (25 years). It is recommended that BPDB keeps track of GHG emission reductions on an annual basis and includes the actual figures realized in the form of a GHG Register.

1.12.2 Measures under corporate social responsibility

235. The following activities are proposed under corporate social responsibility under the repowering project:

- It is proposed to provide access to the existing health facility to the poor population around the GPS. Appropriate security measures may be taken;
- Construct three toilets in designated sites in Ghorashal municipality area following the guidelines for public toilet[3] and with the coordination of Ghorashal Municipal Administration to provide sanitation facilities. Management of these toilets may be based on lease system, so that it remains usable over a long run to a large number of people;
- Training of 200 local youths in semi-skilled electrical technician so that they can, in turn, be employed during project construction and GPS operation. There is a huge demand of such technicians in Middle East and South East Asian countries. The Project can facilitate capacity development of the local youths through relevant training programs using knowledge hub of the Ghorashal Power Station.
- Develop three socio-cultural facilities such as mosques, playgrounds and community centers for the community.

1.12.3 Use of cooling water discharge for irrigation – extending support for three years

236. Currently, Ghorashal Power Station is diverting about 7.79 m^3/s of water from the condenser cooling water discharge canal to an irrigation network for the benefits of local farmers. About 4,000 acres (1,619 ha) of farmland is cultivated using this water. At present, 6,152 ton of boro rice is produced per season using this water.

[3] WaterAid Bangladesh, 2006. Step by Step Implementation Guidelines for Public Toilet

237. Close cycle cooling is recommended for Unit 4 repowering. In addition, all future repowering projects may follow the same design, which will lead to less or no water available for irrigation. This is detrimental to the current irrigation practices in the project impact area. Under the close cycle cooling the water demand from Shitalakhya River will be significantly reduced and some of the pumps may become redundant. Considering the severance of the issue, local demand, and the significant benefits to the communities, it is recommended that one pump can be dedicated for the irrigation water for at least three years of project operation. GPS will coordinate with BADC to handover the pumps and watermain for irrigation services. The operation and maintenance costs after three years should be borne by BADC. Current annual operation and maintenance costs of one pump is about BDT 10 million, however, for irrigation purposes, operation cost will be significantly less.

1.12.4 Greenbelt Development

238. There will be about 25 trees of mahogany species, shrubs, and grasses that require clearing for the project footprint, which requires compensation by 3-5 times per tree felt to comply with DoE requirements. In addition, wildlife habitat especially bird species will be affected. To compensate, the trees and wildlife habitat loss, a plantation program by planting 400 saplings under the project is considered in terms of green belt development beyond compliance within the project boundary. The greenbelt will also minimize the noise generated from the power plant. As well as help attenuate the dust. Indigenous tree species that are pollution resistant and with thick foliage will be selected for green belt development. The saplings will be planted and maintained by GPS authority.

1.13 Institutional Arrangements and Capacity Building

1.13.1 Profile of Key Institutions

239. *Bangladesh Power Development Board*: The Bangladesh Power Development Board (BPDB) is responsible for planning and development of country's power generation and distribution infrastructures as well as operation of many of nation's power generation facilities. At present, the BPDB is the main agency responsible for generation and distribution of electricity mainly in urban areas of the country. The BPDB falls under the auspices of the Power Division, Ministry of Power, Energy and Mineral Resources, Government of Bangladesh.

240. *Project Implementation Unit:* For the implementation of Unit-4 repowering, the BPDB has created a project implementation unit (PIU), under the office of the Chief Engineer, Power Station Construction (PSC). The PIU consists of one Project Director (PD), one Executive Engineer, and an Assistant Director-cum- Accountant.

241. *Ghorashal Power Station (GPS):* Ghorashal Power Station is the largest power station in Bangladesh. The station started its operation in 1974. The station is headed by a Chief Engineer and four operation and maintenance managers.

242. *Owner's Engineer:* PIU will recruit an Owner's Engineer for supervision of EPC contractor involving in boiler decommissioning, civil works, erection of turbine and HRSG, including supervision and implementation of EMP. The Owner's Engineer will consist of an environmental unit with 2 international and 3 national environmental experts.

243. *External Monitor:* Besides internal monitoring and evaluation by the PIU/BPDB for environmental management and monitoring, independent external monitors will be retained by BPDB, to undertake monitoring of all compliance and effects monitoring components. These external monitors will carry out monitoring implementation of the different components

and submit an independent monitoring and appraisal report to the PIU, BPDB and to the World Bank.

244. *EPC Contractor:* Each Contractor procured under this Project (especially boiler decommissioning Contractor and EPC Contractor) will be recommended to be a compliant of ISO 14001 Environmental Management System (EMS) certification.

245. *Other relevant organizations* involved in the implementation of EMP are: (a) Department of Environment (DOE) oversee implementation of all development projects in the country verifying that the environmental requirements are fulfilled, government guidelines and procedures followed and environmental quality standards are maintained properly

1.13.2 Need for Institutional Strengthening

246. In order to implement the environmental management plan (EMP) as proposed in the EIA, an effective PIU with dedicated staff will be of crucial significance. Without qualified full time staff it would be nearly impossible to minimize and/or eliminate the effects of environmental hazards and risks and ensuring a safe working environment for the workers, staffs and staff family members, who are residing in the project compound.

1.13.3 Proposed Institutional Strengthening

247. *Strengthening of PIU:* Under a proposed DPP there is a request for additional 20 staff to strengthen the existing PIU. However, in the DPP no provisions have been made for dedicated staff to ensure compliance to EHS issues. For effective and meaningful implementation of the EMP, it is recommended that one Executive Engineer, with requisite training and practical experiences in implementing and/or monitoring environmental, health and safety issues pertaining to power sector are recruited. The executive engineer (EHS) will be supported by one Sub-Divisional Engineer (EHS), and two Assistant Engineers (one experienced in environmental management, and other in Occupational Health and Safety).

248. *Strengthening of EHSU Circle of GPS:* In order to comply with the EMP requirements that has been proposed in the EIA, an effective EHSU Circle with experienced and dedicated staffs are essential. After a careful review of the proposed organization of GPS, the Consultant made a proposal to strengthen the proposed organizational structure, which consists of of the following:

- Two deputy managers, one for environment and one for occupational health and safety;
- Two Sub-Division Engineers or Assistant Engineers with Environment background under deputy manager environment;
- Two Occupational health and safety officers under deputy manager occupational health and safety;
- Two chemists under deputy manager environment;
- Environment engineers and occupational health and safety officers must have qualifications in their relevant areas of expertise; and
- An EHS Consultant to support EHSU Circle in environmental, health, and safety aspects of the project implementation.

249. *Capacity Building Programs:* Capacity building training to strengthen the PIU and EHSU Circle of GPS staffs in the field of environmental management and occupational health and safety is proposed. Members of the EHSU Circle and PIU staffs responsible for supervision of environmental mitigation measures would be trained in environmental

management, environmental quality control, ecology, environmental awareness, participatory approach and occupational health and safety. The contractor will also be required to provide environmental and health and safety trainings to its staff, to ensure effective implementation of the EMP. A budget of USD 0.13 million has been earmarked for capacity building of PIU and GPS staffs.

250. *Grievance redress mechanism*: Two grievance redress committees (GRCs) will be formed: local grievance redress committee (LGRC); and project grievance redress committee (PGRC). Most of the grievances would be resolved at LGRC within 7 days of receipt of compliant, while a few might be forwarded to PGRC, which will take two weeks to resolve the complaint.

1.13.4 Cost Estimates for Institutional Strengthening

251. The cost estimates for all institutional strengthening measures proposed in the EIA is presented in Table 11. Total costs of institutional strengthening is estimated as USD 1.34 million.

Table 11: Proposed Budget for Institutional Strengthening and Capacity Building

Sl.	Strengthening/Capacity Building Measure	Amount, USD
1	Strengthening of EHSU Circle	445,112
2	EHS Consultants of Owner's Engineer	942,000
3	Capacity Building and Training	131,675
	Total	**1,518,787**

1.14 Public Consultation and Information Disclosure

252. In the EIA process public participation and consultation to assist BPDB and MoPEMR to achieve public acceptance of the Project were included. Public consultation is a regulatory process by which the public's input on matters affecting the community is involved and their suggestions solicited.

253. Public consultation is preferred for the EIA study of any development Project according to the DoE Guidelines of Environmental Assessments, 1997. The World Bank Operation Policy also requires that public consultations be included in the EIA process.

1.14.1 Details of Consultation Meetings

254. Various consultation meetings were conducted during the early stage of the EIA. The brief of the consultation meetings are presented below:-

- *Informal consultation:* A number of occupational groups and other relevant stakeholders were consulted informally. These consultations were made on spot when the team was visiting the project area. This was done to create awareness and clear any misunderstanding about the project and eventually obtain support from the local communities to conduct baseline environmental, ecological, fisheries, and socio-economic surveys.
- *Expert/Institution Consultation:* Experts and organizations with professional knowledge of EIA processes were consulted through individual and group meetings, during early stages of the study. The meetings were conducted with the objective to identify people to be consulted, to brief stakeholders about the project components, and to discuss potential environmental and social impacts of the Project. The outcomes of those consultations were used to identify valued environmental components, stakeholders for public consultation and institutional strengthening of BPDB to implement the EMP.

- *Focus Group Discussion:* FGDs were conducted at various stages with the affected communities, women groups, local traders, farmers, fishermen, etc. The purpose of the FGDs were to harness knowledge on issues, such as, how noise and air pollution are affecting the nearby communities (e.g., hearing difficulties, respiratory ailments and problems related with pregnancies), whether the discharge of hot water and effluents affecting the fishermen and farmers and whether the proposed project will aid in any socio-economic development or not; availability of construction materials close to the project site; availability of local labors; site safety and security; community involvement, and sustainable environmental management. The outcomes of these discussions were used to prioritize impacts and risks, and to structure the EMP.
- *Public Consultation:* A formal public consultation meeting was held at 10:00 am on 11th April, 2015 (Saturday) at Conference Room of Ghorashal Paurashava. Affected people were invited through an advertisement in locally published newspaper called *Dainik Grameen Dorpan*. Additionally, they communicated through the local representatives and leaders for ensuring their presence. A total of 61 participants had attended, which comprised of local government representatives, occupation groups, NGO representative, businessmen, etc.

1.14.2 Consultation Outcome

255. During consultations, concerns were raised in terms of the discharge of condenser cooling water and other pollutants into the Shitalakhya River, which greatly affects fish population. River water also gets highly polluted due to the release of ammonia gas from the fertilizer factory, which leaches into the river. Noise generated from the RMS and gas pipes also caused great disturbances to the residents living nearby, particularly during the night.

256. Outcome of expert and institution consultations were positive, such as, extending irrigation through condenser cooling water support for three years , increased electricity generation and greater employment opportunities, low NOx emission due to combined cycle technology and etc. The release of effluents and toxic wastes into the river further compounds the degradation of the river water quality, heavily impacting fish habitats and fish growth. Necessary mitigation actions are suggested by them and particular focus was made in arranging necessary advocacy measures in curbing the release of ammonia gas from the fertilizer factory into the Shitalakhya river, as it is very toxic to the aquatic species of the river.

257. Outcome of public consultation was positive and participants opined that the project will have a positive outlook in elevating the socio-economic status of the people in the region, generate further employment opportunities to local youths, and skilled and un-skilled labors due to development of new industries with augmented power generation. Noise and respiratory disease is, however, the main issue raised by the participants. Appropriate measures were also suggested such as, soundproofing of machineries and turbines, setting up dialogues to minimize ammonia release by the fertilizer factory and prohibiting child labour during construction stage. Mitigation measures are thus, suggested by the people to which BPDB assured various measures, such as, setting up of cooling water systems and appropriate effluent treatment plants to treat the water for toxic substances before being released into the river.

1.14.3 Disclosure

258. The EIA, documenting the mitigation measures and consultation process, will be made available for public review. The Executive Summary of the EIA will be available in both Bengali and English and published on BPDB, DOE, and the World Bank's websites. On the other, the full EIA will be made available through the World Bank and will also be accessible

in BPDB website. During the consultations, the affected people and the local communities expressed support for the Project as they clearly saw the benefit to the community as well as in country. Consultations and public disclosure of information will continue during project implementation through:

(i) The preparation and dissemination of a brochure in Bengali, explaining the affected peoples' entitlements and the procedures for obtaining compensation for the lost of trees, crops, and land and the procedure for recording grievances; and

(ii) Setting up of two grievance redress committees (GRCs): local grievance redress committee (LGRC); and project grievance redress committee (PGRC) with a representation from GPS, Ward Councilor, Member, women representative, representative of Civil Society, Owner's Engineer, and the Contractor in the project area to ensure participatory process and to allow voices of the affected communities in the grievance procedures.

259. The draft EIA will be shared with the stakeholders during a second public consultation in the project area and in a national workshop in Dhaka. Once finalized, the EIA will be submitted to the DoE for their review and clearance.