FEASIBILITY STUDY REPORT FOR GAZARIA 350(±10%) MW COAL FIRED THERMAL POWER PLANT PROJECT, MUNSHIGANJ, BANGLADESH.

VOLUME I: FEASIBILITY STUDY REPORT

SUBMITTED TO:

RURAL POWER COMPANY LIMITED

SUBMITTED BY:

O&M SOLUTIONS

O&M SOLUTIONS PRIVATE LIMITED, INDIA [LEAD]
O&M SOLUTIONS BANGLADESH LIMITED

FEBRUARY 2017

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PREFACE

We are confident that this prepared report will contribute to the power generation progress and economic development of Bangladesh and would be helpful to implement the project successfully.

We wish to express sincere appreciation to the concerned officials of the Government of Bangladesh and Rural Power Company Limited as well as the Project Team including the Feasibility Study Team for their cooperation extended to the study.

For and on behalf of: Joint Venture of O&M Solutions Private Limited, India and O&M Solutions Bangladesh Limited and Center for Environmental and Geographic Information Services, Bangladesh.

Debjeet Swain

Debjeet Swain
Executive Director
O&M Solutions Private Limited

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LETTER OF ACKNOWLEDGEMENT

The success of this feasibility study report would not have been achieved without the unwavering support received from the Management of RPCL. We thank all for continuing assistance and guidance to the study throughout the feasibility study period.

We are confident that this report will contribute to the power generation progress and economic development of Bangladesh and would be helpful to implement the project successfully.

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Mohan Sankar Deshpande
Director Technical and Team Leader
O&M Solutions Private Limited

Email: ms.deshpande@omsltd.net

LETTER OF TRANSMITTAL

We are pleased to submit herewith the Feasibility Study Report for the "Gazaria 350 (±10%) MW Coal Fired Thermal Power Plant Project at Gazaria, Bangladesh. This report is prepared by the Joint Venture of O&M Solutions Private Limited, India and O&M Solutions Bangladesh Limited and Center for Environmental and Geographic Information Services, Bangladesh. The report consists of the following parts:

Volume I: Feasibility Study Report
Volume II: Annexures (Part 1)
Volume II: Annexures (Part 2)

The report contains the advices and suggestions from Rural Power Company Limited. We would like to express our sincere gratitude to the Government of the People's Republic of the Bangladesh, Ministry of Power, Energy and Mineral Resources, Power Division and Rural Power Company Limited for providing the opportunity to conduct this Feasibility Study. We are grateful for the cooperation, guidance and assistance of the Project Director and the Steering Committee. We also appreciate the assistance of the team involved in this Project.

Yours Faithfully,

For and on behalf of: Joint Venture of O&M Solutions Private Limited, India and O&M Solutions Bangladesh Limited and Center for Environmental and Geographic Information Services, Bangladesh.

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Managing Director
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DISCLAIMER

This Feasibility Study Report is subject to the limitations and scope of services for the "Consultancy Services for Detail Feasibility Study, Initial Environmental Examination (IEE), Environmental Impact Assessment (EIA) & Social Impact Assessment (SIA) Study of Gazaria 350 (±10%) MW Coal Fired Thermal Power Plant at Gazaria, Munshiganj, Bangladesh", contained in the contract between the Rural Power Company Limited (The first Independent Power Producer of Bangladesh and the first non-Bangladesh Power Development Board Enterprise) (hereinafter referred as "RPCL" or "Client") and the Joint Venture of O&M Solutions Private Limited, India [Lead], O&M Solutions Bangladesh Ltd., Bangladesh and, Center for Environmental and Geographic Information Services, Bangladesh (hereinafter referred as "JV-OMS-CEGIS" or "Consultant"). JV-OMS-CEGIS is not in a position to, and does not, verify the accuracy of, or adopt as its own, the information and data supplied by others or any secondary source. This disclaimer must accompany every copy of this feasibility study document, which is an integral document and must be read in its entirety.

PROJECT SYNOPSIS

Project Title:	Gazaria 350 (±10%) MW Coal Fired Thermal Power Plant Project
Consultancy Services:	Consultancy Services for Feasibility Study of Gazaria 350 (±10%) MW Coal Fired Thermal Power Plant Project
Contract Reference:	PUR NO-019/2015-16 (RFP), Date - 31.01.2016
Location:	Gazaria, Munshiganj, Bangladesh
Country:	Bangladesh
Client:	Rural Power Company Limited (RPCL) House No. 19, Road No. 1/B, Sector No. 09, Uttara Model Town, Dhaka - 1230, Bangladesh Contact Person: **Executive Director (Engineering).** Address: Rural Power Company Limited, House No.-19, Road No.-1/B, Sector No.-09, Uttara Model Town, Dhaka- 1230. Bangladesh. **Project Director** Address: Rural Power Company Limited, House No.-19, Road No.-1/B, Sector No.-09, Uttara Model Town, Dhaka- 1230. Bangladesh.
Consultant:	Joint Venture of O&M Solutions Private Limited, India [Lead], O&M Solutions Bangladesh Ltd., Bangladesh and, Center for Environmental and Geographic Information Services, Bangladesh (JV-OMS-CEGIS) Contact Person(s): **Team Leader:** Mohan Sankar Deshpande Director Technical O&M Solutions Private Limited Cell Phone: +919881719361 Email: ms.deshpande@omsltd.net **Authorized Representative:** Tofael Ahmed Managing Director O&M Solutions Bangladesh Limited Cell: +8801819-239845 Email: tofael.ahmed@omsltd.net

Overall Objective:	The objective of the study is to provide Consulting Services for Detail Feasibility Study, Initial Environmental Examination (IEE), Environmental Impact Assessment (EIA) & Social Impact Assessment (SIA) Study of Gazaria 350 (±10%) MW Coal Fired Thermal Power Plant at Gazaria, Munshiganj, Bangladesh. The Consultant will conduct the Initial Environmental Examination (IEE), Environmental Impact Assessment (EIA) & Social Impact Assessment (SIA) as well as prepare a Table of Contents (TOC) for Feasibility Study of the same.
Reporting Requirements:	• Inception Report is to be prepared and submitted within 15 days from the date of commencement of the study; • Monthly progress report is to be prepared and submitted within 7 days of the next month; • Draft IEE Report is to be prepared and submitted at the end of 45 (forty five) days from the date of commencement of the study; • Draft EIA & SIA Report is to be prepared and submitted at the end of 120 (one hundred twenty) days from the date of commencement of the study; • Draft detail-feasibility study report, Coal Supply Agreement (CSA) and Power Purchase Agreement (PPA) are to be prepared and submitted at the end of 150 (one hundred fifty) days from the date of commencement of the study; • Final IEE Report is to be prepared and submitted at the end of 60 (sixty) days from the date of commencement of the study; • Final EIA & SIA Report are to be prepared and submitted at the end of 165 (one hundred sixty five) days from the date of commencement of the study; • Final detail-feasibility study report, Methodology of coal price determination and draft Coal Supply Agreement (CSA) and Power Purchase Agreement (PPA) are to be prepared and submitted at the end of 180 (one hundred eighty) days from the date of commencement of the study;
Service Start Date:	February 01, 2016 (Kick Off Meeting Date)
Service Duration:	The study is proposed to be commenced immediately and is scheduled for completion in maximum 6(Six) months.

ABBREVIATIONS

ACB	-	Air Circuit Breaker
AC	-	Alternating Current
ACI	-	American Concrete Institute
ACW	-	Auxiliary Cooling Water
ADB	-	As Dry Basis
AHP	-	Ash Handling Plant
APS	-	Automatic Plant Start
ARA	-	Amsterdam-Rotterdam-Antwerp
AISC	-	American Institute of Steel Construction
ANSI	-	American National Standards Institute
ARB	-	As Received Basis
ASCE	-	American Society of Civil Engineers
ASME	-	American Society of Mechanical Engineers
ASTM	-	American Society of Testing Materials
ATRS	-	Automatic Turbine Run-up System
ATT	-	Automatic Turbine Tester
AVR	-	Automatic Voltage Regulator
AVT	-	All-Volatile Treatment
BB	-	Bangladesh Bank
BDT	-	Bangladeshi Taka
BERC	-	Bangladesh Energy Regulatory Commission
BIWTA	-	Bangladesh Inland Transport Authority
BMD	-	Bangladesh Meteorological Department
BMS	-	Burner Management System
BNBC	-	Bangladesh National Building Code
BOI	-	Board of Investment
BOP	-	Balance of Plant
BPDB	-	Bangladesh Power Development Board
BS	-	British Standards
BTG	-	Boiler Turbine Generator
BTM	-	Bangladesh Transverse Mercator
BWDB	-	Bangladesh Water Development Board
C&I	-	Control And Instrumentation
CAAB	-	Civil Aviation Authority of Bangladesh
CAPP	-	Central Appalachian
CBM	-	Coal Based Methane
CBMS	-	Condition Based Maintenance System
CCCW	-	Closed Cycle Cooling Water
CCIE	-	Chief Controller of Import and Export
CCR	-	Central Control Room
CCTV	-	Closed Circuit Television
CD	-	Chart Datum
CDA	-	Chittagong Development Authority
CEGIS	-	Center for Environmental and Geographic Information Services
CEMS	-	Continuous Emission Monitoring System
CER	-	Central Electronics Room
CFB	-	Circulating Fluidized Bed
CFR	-	Cost and Freight
CGI	-	Corrugated Galvanized Iron
CHP	-	Coal Handling Plant
CI	-	Controller of Insurance
CIF	-	Cost, Insurance and Freight

CIFE	-	Chief Inspector of Factories and Establishment
CLCS	-	Closed Loop Control System
COA	-	Contract of Affreightment
COD	-	Commercial Operation Date
COP	-	Code of Practice
CPU	-	Condenser Polishing Unit
CRH	-	Cold Re-Heat
CS	-	Cadastral Survey
CT	-	Current Transformer
CW	-	Cooling Water
DAF	-	Dry Ash Free
DB	-	Dry Basis
DC	-	Direct Current, District Commissioner
DCS	-	Distributed Control System
DEHC	-	Digital Electro Hydraulic Turbine Control
DEM	-	Digital Elevation Model
DEQ	-	Delivered Ex Quay
DES	-	Delivered Ex Ship
DFSCD	-	Department of Fire Service & Civil Defense
DFT	-	Dry Film Thickness
DG	-	Diesel Generator
DIN	-	Deutschesinstitutfür Normung
DLRS	-	Directorate of Land Records And Survey
DM	-	De-Mineralized
DMO	-	Domestic Market Obligation
DOE	-	Department of Environment
DOEXP	-	Department of Explosives
DPHE	-	Department of Public Health Engineering
DWSA	-	Dhaka Water and Sewer Supply Authority
DWT	-	Dead Weight Ton
ECA	-	Environmental Conservation Act
EHV	-	Extra High Voltage
EIRR	-	Expected Internal Rate of Return
EMCR	-	Economic Maximum Continuous Rating
EMP	-	Environmental Management Plan
EOT	-	Electric Overhead Travelling (**Crane**)
EPABX	-	Electronic Private Automatic Branch Exchange
ESP	-	Electro-Static Precipitator
ETP	-	Effluent Treatment Plant
FAS	-	Free Along Side
FD	-	Forced Draft
FERA	-	Foreign Exchange Regulation Act 1947
FGD	-	Flue Gas De-Sulphurization
FOB	-	Free on Board
FOBT	-	Free on Board Trimmed
FS	-	Feasibility Study
FTS	-	Floating Transfer Station
GAR	-	Gross as Received
GCP	-	Ground Control Point
GCV	-	Gross Calorific Value
GDP	-	Gross Domestic Product
HCDS	-	High Concentration Slurry Disposal
HELE	-	High-Efficiency, Low Emissions
HMBD	-	Heat And Mass Balance Diagram

GIS	-	Geographical Information System
GL	-	Ground Level
GOB	-	Government of Bangladesh
GWH	-	Giga Watt Hour
HEI	-	Heat Exchange Institute
HFO	-	Heavy Fuel Oil
HGI	-	Hardgrove Grindability Index
HSD	-	High Speed Diesel
HT	-	High Tension
HP	-	High Pressure
ID	-	Induced Draft
IDC	-	Interest During Construction
IDT	-	Initial Deformation Temperature (For Coal Ash)
IDW	-	Inverse Distance Weighted
IEA	-	International Energy Agency
IEC	-	International Electromechanical Commission
IEEE	-	Institute of Electrical and Electronics Engineers
IESC	-	Important Environmental and Social Components
IGFC	-	Integrated Coal Gasification Fuel-Cell Combined Cycle
IP	-	Intermediate Pressure
IPW	-	In Partnership With
IS	-	Information System
ISO	-	International Organization for Standardization
IWFM	-	Institute of Water and Flood Management
IWM	-	Institute of Water Modeling
IWTA	-	Inland Water Transport Authority
LAD	-	Least Available Depth
LAN	-	Local Area Network
LCR	-	Local Control Room
LDC	-	Least Developed Country
LDO	-	Light Diesel Oil
LHV	-	Lower Heating Value
LILO	-	Loop In Loop Out
LNG	-	Liquefied Natural Gas
LP	-	Low Pressure
LV	-	Low Voltage
MCC	-	Motor Control Centre
MCR	-	Maximum Continuous Rating
MIS	-	Management Information System
MMI	-	Man-Machine Interface
MOC	-	Ministry of Commerce
MOF (ERD)	-	Ministry of Finance (Economic Relations Division)
MOF (IRD)	-	Ministry of Finance (Internal Resources Division)
MOHA	-	Ministry of Home Affairs
MOL	-	Ministry of Law
MOPEMR	-	Ministry of Power, Energy and Mineral Resources
MPO	-	Master Plan Organization
MPWD	-	Meter Public Works Datum
MS	-	Main Steam, Mild Steel
MTPA	-	Million Ton Per Annum
MU	-	Million Unit
MVA	-	Mega Volt Ampere
MW	-	Mega Watt
NAR	-	Net as Received

NBR	-	National Board of Revenue
NEC	-	National Electrical Code
NEMA	-	National Electrical Manufacturers Association
NFPA	-	National Fire Protection Association
NGO	-	Non-Government Organization
NSW	-	New South Wales
NTP	-	Notice to Proceed
NYMEX	-	New York Mercantile Exchange
OEACEI	-	Office of the Electrical Adviser and Chief Electric Inspector
OECD	-	Organization For Economic Co-Operation and Development
O&M	-	Operation and Maintenance
OFAF	-	Oil Forced Air Forced
OLCS	-	Open Loop Control System
OMS	-	O&M Solutions
ONAF	-	Oil Natural Air Forced
ONAN	-	Oil Natural Air Natural
OTC	-	Over-The-Counter (A Coal Trade Term)
OWT	-	Oxygenated Water Treatment
P&T	-	Posts and Telegraph
PA	-	Primary Air
PC	-	Pulverized Coal
PCC	-	Power Control Centre
PGCB	-	Power Grid Company of Bangladesh
PHE	-	Plate Heat Exchanger
PLC	-	Programmable Logic Control
PLF	-	Plant Load Factor
PMS	-	Performance Monitoring Sub-System
PRDS	-	(Steam) Pressure Reducing And De-Superheating Station
PSMP	-	Power System Master Plan
PT	-	Power Transformer
PVC	-	Poly Vinyl Chloride
PWD	-	Public Works Department
RCC	-	Reinforce Cement Concrete
RL	-	Reduced Level
RMS	-	Root Mean Square
RO	-	Reverse Osmosis
RPM	-	Revolution Per Minute
RS	-	Remote Sensing, Regional / Resettlement Survey, Revisional/ Revised Survey
SADC	-	Secondary Air Damper Control
SC	-	Super Critical
SCAPH	-	Steam Coil Air Pre-Heater
SER	-	Sequential Event Recorder
SG	-	Steam Generator
SGMCR	-	Steam Generator Maximum Continuous Rating
SPM	-	Suspended Particulate Matter
SPP	-	Steam Power Plant
SPT	-	Standard Penetration Test
SRDI	-	Soil Resource Development Institute
ST	-	Steam Turbine
STG	-	Steam Turbine Generator
SWOT	-	Strengths, Weaknesses, Opportunities, and Threats
TDS	-	Total Dissolved Solids

TG	-	Turbine Generator
TGMCR	-	Turbine Generator Maximum Continuous Rating
TIN	-	Triangulated Irregular Network
TMCR	-	Turbine Maximum Continuous Rating
TPD	-	Ton Per Day
TPES	-	Total Primary Energy Supply
TPH	-	Ton Per Hour
TS	-	Total Station
UCG	-	Underground Coal Gasification
UF	-	Ultra Filtration
UP	-	Union Parishad
UPS	-	Uninterruptible Power Supply
US	-	United States
USC	-	United States Cent
USC	-	Ultra Supercritical
UV	-	Ultra Violet
VFD	-	Variable Frequency Drive
VWO	-	Valve Wide Open
WL	-	Water Level

DEFINITIONS

Air Dry (ad): Coal quality data calculated to a basis in which only inherent moisture is associated with the sample. Inherent moisture is moisture held within the coal itself as opposed to surface moisture. For some ranks of coal such as subbituminous, air dry moistures can be below inherent.

Alluvium: Transported chiefly by water and is sorted.

Anchorage: Port charge relating to a vessel moored at approved anchorage site in a harbor.

Annual Flood: The highest peak discharge in a *water year.*

ARA: Antwerp/Rotterdam/Amsterdam. Major coal importing ports is in northwest Europe.

As Received (ar): Coal quality data calculated at a basis in which all moisture is associated with the sample. As received, analysis includes both inherent and surface moisture of the coal sample.

Ash: Residue remaining after burning coal or coke; also referred to as mineral mater in coal.

Average Discharge: In the annual series of the Geological Survey's reports on surface-water supply the arithmetic average of all completed water years of record whether or not they are consecutive. Average discharge is not published for less than 5 years of record. The term "average" is generally reserved for average of record and "mean" is used for averages of shorter periods, namely, daily mean discharge.

Bag houses: A generic name for air pollution equipment which uses a range of filter bags/fabric types to separate particulate (dust, ash, powders, etc.) from the exhausting air stream. Not only is this an essential process in order to recover the product being manufactured, it is also required by the Environmental Protection Agency (EPA) to ensure that all industrial exhaust gasses are particulate (dust) free, or at least comply with their particulate emission limits. The EPA is particularly concerned with particles that are 10 micrometers in diameter or smaller because those particles generally pass through throats and noses and enter lungs, causing serious health problems.

Bank: The margins of a *channel.* Banks are called right or left as viewed facing in the direction of the flow.

Barge: A large, flat-bottomed boat used to carry cargo from a port to shallow-draft waterways. Barges have no locomotion and are pushed by towboats. Barges carry dry bulk (grain, coal, lumber, gravel, etc.) and liquid bulk (petroleum, vegetable oils, molasses, etc.).

Basic Hydrologic Data: Includes inventories of features of land and water that vary only from place to place (topographic and geologic maps are examples), and records of processes that vary with both place and time. (Records of precipitation, streamflow, ground-water, and quality-of-water analyses are examples). Basic hydrologic information is a broader term that includes surveys of the water resources of particular areas and a study of their physical and related economic processes, interrelations and mechanisms.

Berth: Defines a specific location in a port or harbor where a vessel may moor, usually for loading or unloading.

Bill of Lading: A contract between a shipper and carrier listing the terms for moving freight between specified points.

Blending: The practice of mixing or combining coals with different properties to produce a coal product that optimizes desired characteristics is depending on the usage. Blending coal can reduce the cost of generation. Blending can occur at the mine, prep plant, during shipment, or at the generating station.

Boiler: A device found in power plants for generating steam for power, processing or heating purposes, or for producing hot water for heating purposes or hot water supply. Heat from an electrical combustion source is transmitted to a fluid contained within the tubes in the boiler shell. The fluid is delivered to an end-user at a desired pressure, temperature and quality. Boilers are often classified as steam or hot water, low pressure or high pressure, capable of burning one fuel or a number of fuels.

Bottom Ash: Agglomerated ash particles formed in pulverized coal furnaces too large to be carried by the flue gasses. Bottom ash is commonly used as an aggregate substitute.

Brown Coal: Generally, sub-bituminous and lignite rank coals.

Bulk Cargo: Loose cargo (dry or liquid) which is loaded (shoveled, scooped, forked, mechanically conveyed or pumped) in volume directly into a ship's hold (e.g., grain, coal and oil).

Buoys: Floats that warn of hazards such as rocks or shallow ground, to help ships maneuver through unfamiliar harbors.

Calorific Value (CV): Measure of the heating value of coal. Heat content is usually expressed in metric units of Kcal/ kg or English units of Btu/lb.

Capacity (Power Plant): Maximum rated output of electric power production equipment. Power unit capacities are expressed as nameplate capacity, net summer capacity and net winter capacity. The nameplate capacity is the unit's maximum output as designated by the manufacturer. The net summer capacity is the units output measured between June 1 and September 30 whereas the net winter capacity is measured between December 1 and March 31. In general, the net winter capacity is greater than the summer's because of the impact of air temperature and density. Generating units can intake a greater amount of cooler, dense "winter" air than comparably warm, less dense "summer" air increasing rated capacity.

Capesize: A ship of capacity more than 80,000 DWT. (A vessel which is too large to transit the Panama Canal and thus has to sail via Cape of Good Hope from Pacific to Atlantic and vice versa.)

Carbon Dioxide (CO2): A gaseous substance at standard conditions composed of one carbon atom and two oxygen atoms. CO2 is produced when fossil fuels are burned and is thought to be a major contributor to warmer global temperatures.

Cargo: The freight (goods, products) carried by a ship, barge, train, truck or plane.

Central Appalachian (CAPP): CAPP coal spot prices are the most widely referenced prices for eastern coal in the United States. Coal producers, electric utilities, merchant generators,

non-utility industrial coal users, and other energy marketers use CAPP spot prices as a benchmark in both physical and financial transactions for short-term and long-term contracts. Changes in CAPP spot prices can affect fuel procurement and power dispatch decisions.

Channel (watercourse): An open conduit either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of water. River, creek, run, branch, anabranch, and tributary are some of the terms used to describe natural channels. Natural channels may be single or braided. Canal and floodway are some of the terms used to describe artificial channels.

CIF (Cost, Insurance, Freight): The seller delivers the goods on board the vessel or procures the goods already so delivered. The risk of loss of or damage to the goods passes when the goods are on board the vessel. The seller must contract for and pay the costs and freight necessary to bring the goods to the named port of destination.

Clean Air Act: A federal law that defines EPA's responsibilities for protecting and improving the nation's air quality and the stratospheric ozone layer. The Clean Air Act Amendments of 1990 were the last major change in the law, enacted by Congress. Legislation passed since that time has made several minor changes.

Clean Coal Technologies: Processes designed to burn coal with little or fewer emissions, including coal with either high sulfur content or high ash content that might make it unattractive as a fuel.

Climate: The sum total of the meteorological elements that characterize the average and extreme condition of the atmosphere over a long period of time at any one place or region of the earth's surface. The collective state of the atmosphere is at a given place or over a given area within a specified period of time. (Landsberg, 1945, p. 928.)

COA: Contract of Affreightment - a Charter Party covering more than one voyage.

Coal: A combustible black or brownish- black sedimentary rock formed by the partial to complete decomposition of organic matter over millions of years. Coal is primarily composed of carbon, as well as other elements such as hydrogen, sulfur, oxygen, and nitrogen.

Coal Additive: A type of substance, either liquid, solid or gas, that is manually added to coal for some altering purpose. Some additives are used to even out coal, alter emissions, improve furnace operation and a variety of other purposes.

Coal Fired Power Plant: A fossil-fuel power station that burns fossil fuels such as coal, natural gas or petroleum (oil) to produce electricity. Central station fossil-fuel power plants are designed on a large scale for continuous operation. In many countries, such plants provide most of the electrical energy used. Fossil fueled power stations are major emitters of CO2, the most harmful greenhouse gas.

Coal Mine: An area of land and any structures or equipment used in extracting coal from its natural deposits in the Earth. This also includes the coal preparation Facilities.

Coal Washing: Coal Washing is the separation of impurities or undesirable material from coal, based on differential densities.

Coking Coal: Coking coal is an essential ingredient in steel production. It is different to thermal coal which is used to generate power. Coking coal, also known as metallurgic coal,

is heated in a coke oven which forces out impurities to produce coke, which is almost pure carbon.

Combustion: The process of retrieving energy from the burning of fuels in the most efficient way possible. To maximize combustion efficiency, it is necessary to burn all fuel material with the least amount of waste. The more efficiently fuels are burned and energy is gathered, the cheaper the combustion process becomes.

Contract Price: Price agreed to in a coal sales contact. The contract price may differ from the current market or spot price.

Correlation: The process of establishing a relation between a variable and one or more related variables. Correlation is simple if there is only one independent variable; multiple, if there is more than one independent variable. For gaging station records, the usual variables are the short-term gaging-station record and one or more long-term gaging-station records. (Searcy, 1960)

Datum: An arbitrary elevation from which all vertical measurements are taken in a design.

Deadweight Tonnage (DWT): The difference between loaded displacement and lightship, consisting of the total weight of cargo, fuel, fresh water, shores, and crew which a ship can carry when immersed to a particular load line.

Demurrage: Money paid by the charterer, shipper, or receiver for occupying port space beyond a specified period of time allowed in the charter party.

Depletion: The progressive withdrawal of water from surface- or ground-water reservoirs at a rate greater than that of replenishment.

Deposition: The terminus of erosion - the settling of particles.

Discharge: In its simplest concept discharge means outflow; therefore, the use of this term is not restricted as to course or location, and it can be applied to describe the flow of water from a pipe or from a drainage basin. If the discharge occurs in some course or channel, it is correct to speak of the discharge of a canal or of a river. It is also correct to speak of the discharge of a canal or stream into a lake, a stream, or an ocean.

Drainage Basin: A part of the surface of the earth that is occupied by a drainage system, which consists of a surface stream or a body of impounded surface water together with all tributary surface streams and bodies of impounded surface water.

Draught (or Draft): The vertical distance measure from the waterline to the lowest submerged part of a vessel.

Dredge: (Noun): A waterborne machine that removes unwanted silt accumulations from the bottom of a waterway. (Verb): The process of removing sediment from harbor or river bottoms for safety purposes and to allow for deeper vessels.

Dry Ash Free (DAF): Basis of reporting and assessing coal quality similar to the dry basis, however in addition to assuming zero moisture content the ash content is also unaccounted for.

Dry Basis (DB): Basis of reporting and assessing coal quality in which no moisture is associated with the sample. The sample is free of both surface or inherent moisture and moisture associated with the coal itself.

Dry Bulk: Minerals or grains stored in loose piles moving without mark or count.

Duty: A government tax on imported merchandise.

Electrostatic Precipitator: An electrostatic precipitator (ESP), or electrostatic air cleaner, is a pollution control device that removes particles from a flowing gas (such as air) using the force of an induced electrostatic charge. ESPs are highly efficient filtration devices that minimally impede the flow of gases through the device, and can easily remove fine particulate matter, such as dust and smoke, from the air stream. In contrast to wet scrubbers, which apply energy directly to the flowing fluid medium, an ESP applies energy only to the particulate matter being collected and therefore is very efficient in its consumption of energy (in the form of electricity).

Elevation: Measure of vertical length relative to a datum.

Emissions: Substances that are released into the air from power generating plants among other sources. Major emissions that are regulated by the federal government are nitrogen oxide, sulfur dioxide and mercury. Carbon dioxide is also a major emission, but is not regulated. Emissions from power plants and their byproducts form particulate matter, ozone smog and air toxins. These pollutants are associated with a vast array of health concerns such as respiratory hospitalizations, lost school days due to asthma attacks, low birth weight, stunted lung growth and infant death.

Erosion: The process by which particles of rock and soil are loosened, as by weathering, and then transported elsewhere, as by wind, water, ice, or gravity.

Fixed Carbon: The amount of carbon left in coal after the volatiles are driven off. Measurement is used to estimate the amount of coke that will be yielded from a sample of coal.

Flood: An overflow or inundation that comes from a river or other body of water (Barrows, 1948, p. 4), and causes or threatens damage. Any relatively high streamflow is overtopping the natural or artificial banks in any reach of a stream. (Leopold and Maddock, 1954, p. 249-251.). A relatively high flow as measured by either gage height or discharge quantity. (Jarvis and others, 1936, p. 463.)

Flood Plain: A strip of relatively smooth land bordering a stream, built of sediment carried by the stream and dropped in the slack water beyond the influence of the swiftest current. It is called a living flood plain if it is overflowed in times of highwater; but a fossil flood plain if it is beyond the reach of the highest flood. (Bryan, 1922, p. 88.). The lowland is that borders a river, usually dry but subject to flooding. (Hoyt and Langbein, 1955, p. 12.).

Flood Profile: A graph of elevation of the water surface of a river in flood, plotted as ordinate, against distance, measured in the downstream direction, plotted as abscissa. A flood profile may be drawn to show elevation at a given time, crests during a particular flood, or to show stages of concordant flows.

Flood-Prone Area: A relatively flat lowland that borders a stream and is covered by its waters at flood stage of twice the maximum bankfull depth.

Flue Gas: A gas that exits into the atmosphere via a flue, which is a pipe or channel for conveying exhaust gases from a fireplace, oven, furnace, boiler or steam generator. Quite often, it refers to the combustion exhaust gas produced at power plants. Its composition depends on what is being burned, but it will usually consist of mostly nitrogen (typically more than two-thirds) derived from the combustion air, carbon dioxide (CO2) and water vapor as well as excess oxygen (also derived from the combustion air). It further contains a small percentage of pollutants such as particulate matter, carbon monoxide, nitrogen oxide and sulfur oxide.

Flue Gas Desulfurization (FGD): A process that removes sulfur compounds formed during coal combustion. The devices, commonly called "scrubbers," combine the sulfur from gaseous emissions with another chemical medium, forming waste, which must then be removed for disposal.

Fly Ash: A product of burning pulverized coal in a boiler, removed from the exhaust gases by electrostatic precipitators and/ or baghouses. Some classes of fly ash have pozzolanic, or cementitious, properties and are commonly used in cement and concrete applications.

FOBT - free On board trimmed - as for FOB, but including trimming of cargo after loading.

Force Majeure - circumstances beyond reasonable control of the party/parties.

Fossil Fuel: Ancient organic remains (fossils) in sediments which over eons became sedimentary rock, giving rise to solid, liquid and gaseous fuels such as coal, crude oil, and natural gas. Coal is derived from vegetable matter altered by pressure, whereas crude oil and natural gas are derived from animal and vegetable matter altered by pressure and heat. Essentially, all fossil fuels are highly concentrated forms of far-ancient sunlight trapped in organic cells. They have been the primary energy source for human societies since the industrial revolution (mid-19th century to early 20th century), are non-renewable and are considered to be a primary source of global warming.

Free on Board (FOB): The seller delivers the goods on board the vessel nominated by the buyer at the named port of shipment or procures the goods already so delivered. The risk of loss of or damage to the goods passes when the goods are on board the vessel, and the buyer bears all costs from that moment onwards.

Freight: Merchandise hauled by transportation lines.

Gage Height: The water-surface elevation referred to some arbitrary gage datum. Gage height is often used interchangeably with the more general term *stage* although gage height is more appropriate when used with a reading on a gage.

Gaging Station: A particular site is on a stream, canal, lake, or reservoir where systematic observations of *gage height* or *discharge* are obtained

Gantry Crane: Track-mounted, shore side crane utilized in the loading and unloading of breakbulk cargo, containers and heavy lift cargo.

Gearless: A ship without means on board for the loading/unloading of cargo.

Gross as Received (GAR): The heat content of coal is under laboratory conditions where the impact of the coals moisture on reducing heat content is removed. GAR, also known as high heating values, is the standard in American reporting.

Harbor: A port of haven where ships may anchor.

Hardgrove Grindability Index (HGI): Quality measure of the hardness of coal, used to measure the ease of pulverization. The higher the HGI value the softer the coal.

Handymax: Inexact term, but normally taken to mean a vessel of about 40-60,000 DWT.

Handysize: Inexact term, but normally taken to mean a vessel of about 10-40,000 DWT.

Hazardous Air Pollutants: (Also known as air toxins) Chemicals that are known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects. Listed hazardous air pollutants include benzene, found in gasoline; perchlorethlyene, emitted from some dry cleaning facilities; and methylene chloride, used as a solvent and paint stripper in industry; as well as dioxin, asbestos, toluene, and metals such as cadmium, mercury, chromium and lead compounds.

Heat Rate: The amount of heat required to generate one unit of power. Primary measure of an electric generating unit's efficiency usually expressed as Btu/kWh.

Heavy Lift: Very heavy cargoes that require specialized equipment to move the products to and from ship/truck/rail/barge and terminals. This "heavy lift" machinery may be installed aboard a ship designed just for such transport. Shore cranes, floating cranes and lift trucks may also adapted for such heavy lifts.

Inherent Moisture: Moisture found within coal. The term is usually referenced in the coal sampling and testing process.

ISO: International Organization for Standardization. Worldwide organization formed to promote development of standards to facilitate the international carriage and exchange of goods and services. It governs construction specifications for ISO containers.

Kilocalorie (kcal): Amount of energy required to increase the temperature of 1 kilogram of water by 1°C. The unit is used to measure the heat content of coal, expressed in kcal/kg.

Landforms: Natural features of a land surface

Length Overall (LOA): Linear measurement of a vessel from bow to stern.

Lift On-Lift Off (LO/LO): Cargo handling technique involving transfer of commodities to and from the ship using shore side cranes or ship's gear.

Lignite: Sometimes referred to as brown coal, lignite is the lowest rank of coal and is characterized by high moisture and low calorific content. Lignite is most commonly used for steam generation in power plants. It is also a feedstock for activated carbon used to capture mercury in coal fired utility flue gas emission streams.

Load Factor: The ratio of the average load to peak load during a specified time interval.

Maritime: (adjective) Located on or near the sea. Commerce or navigation by sea. The maritime industry includes people working for transportation (ship, rail, truck and towboat/barge) companies, freight forwarders and customs brokers; stevedoring companies;

labor unions; chandlers; warehouses; ship building and repair firms; importers/exporters; pilot associations, etc.

Megawatt (MW): A unit of electrical power equal to one million watts or one thousand kilowatts.

Mercury: A metallic element that is toxic to human beings whose emission into the environment has come under increasingly tight restrictions. In 1988 it was estimated that 24 million pounds per year of mercury were released into the air, land and water worldwide as the result of human activities.

Metallurgical or Met or Coking Coal: Coal that has the unique ability to soften, transition through a plastic phase before re-solidifying into a porous substance called coke. This transition occurs in a temperature range between 300°C to 550°C in the absence of air.

Metric Ton (t): 1,000 kg or 2,204.6 lbs.

Mooring Dolphin: A cluster of pilings to which a boat or barge ties up.

Motor Ship (MS) or Motor Vessel (MV): A ship propelled by internal-combustion engines.

Net as Received (NAR): The heat content of coal is under laboratory conditions where the absorbed water in the coal is included. Net calorific values, also known as low heating values are standard in European reporting.

Nitrogen Oxide: A pollutant released into the air when coal is burned. It refers specifically to NOx (NO and NO2). Nitrogen oxides, or NOx, are the generic terms for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts. Many of the nitrogen oxides are colorless and odorless. However, one common pollutant, nitrogen dioxide (NO2) along with particles in the air, can often be seen as a reddish-brown layer over many urban areas. Nitrogen oxide forms when fuel is burned at high temperatures, as in a combustion process. The primary sources of NOx are motor vehicles, electric utilities, and other industrial, commercial, and residential sources that burn fuels.

Ocean Carrier: Diesel-fueled vessels have replaced the old steamships of the past, although many people still refer to modern diesel ships as steamships. Likewise, the person who represents the ship in port is still often called a steamship agent.

Panamax Vessel: The maximum size vessel that can transit the Panama Canal typically 60-80,000 DWT.

Particulate Matter: Fine particles or soot that is tiny subdivisions of solid matter suspended in a gas or liquid. Sources of particulate matter can be man-made or natural. Some particulates occur naturally, originating from volcanoes, forest and grassland fire, for example. Human activities, such as the burning of fossil fuels in vehicles, power plants and various industrial processes, also generate significant amounts of aerosols. Increased levels of fine particles in the air are linked to health hazards such as heart disease, altered lung function and lung cancer.

Pier: A structure which just out into a waterway from the shore, for mooring vessels and cargo handling. Sometimes it is called a finger pier.

Pilot: A licensed navigational guide with thorough knowledge of a particular section of a waterway whose occupation is to steep ships along a coast or into and out of a harbor. Local pilots board the ship to advise the captain and navigator of local navigation conditions (difficult currents; hidden wrecks, etc.).

Port: This term is used both for the harbor area where ships are docked and for the agency (port authority), which administers use of public wharves and port properties.

Power: Energy flow or energy divided by time.

Proximate Analysis: A physical, or nonchemical test of the composition of coal or coke; an assay of the moisture, ash, volatile matter and fixed carbon and may also include calorific and sulfur determinations. It provides a determination of commercial value rather than preciseness.

Quay: A wharf, which parallels the waterline.

Recoverable Reserves: The portion of reserves that can be economically and physically mined using current techniques after allowing for normal mining losses.

Reserves: The quantity of coal that is economically and physically recoverable using current mining techniques.

Scrubber: An apparatus that cleans the gases passing through a stack prior to being emitted. Scrubber systems are a diverse group of air pollution control devices that can be used to remove some particulates and/or gases from industrial exhaust streams. Traditionally, the term "scrubber" has referred to pollution control devices that use liquid to wash unwanted pollutants from a gas stream. They are often used at coal-burning power plants as a pollution control device. Recently, the term is also used to describe systems that inject a dry reagent or slurry into a dirty exhaust stream to "wash out" acid gases. Scrubbers are one of the primary devices that control gaseous emissions, especially acid gases. Scrubbers can also be used for heat recovery from hot gases by flue gas condensation.

Sediment: Fragmental material that originates from weathering of rocks and is transported by, suspended in, or deposited by water or air or is accumulated in beds by other natural agencies. (Colby, Hembree, and Jochens, 1953, p. 24.)

Sediment Discharge: The rate at which dry weight of sediment passes a section of a stream or is the quantity of sediment, as measured by dry weight, or by volume, that is discharged in a given time. (Colby, Hembree, and Jochens, 1953, p. 24.)

Selective Catalytic Reduction (SCR): A means of converting nitrogen oxide (NOx) with the aid of a catalyst into diatomic nitrogen (N2), and water (H2O). A gaseous reluctant, typically anhydrous ammonia, aqueous ammonia or urea, is added to a stream of flue or exhaust gas and is absorbed onto a catalyst. Carbon dioxide (CO2) is a reaction product when urea is used as the reductant. Commercial selective catalytic reduction systems are typically found on large utility boilers, industrial boilers, and municipal solid waste boilers and have been shown to reduce NOx by 70 to 95 percent.

Short Ton: A short ton equals 2,000. Lifting capacity and cargo measurements are designated in short tons.

Slagging: The glass-like mass left as a residue by the smelting of metallic ore.

Slurry: A thin mixture of a liquid, especially water, and any of several finely divided substances, such as cement, plaster of Paris or clay particles.

Sorbents: Insoluble materials or mixtures of materials capable of adsorption (attracting and holding substances upon its surface [e.g., charcoal]) and absorption (sucking in and holding a substance within a porous material [e.g., sponges]). Sorbents have been used to clean up oil spills and have also been applied in the combustion process in coal-fired plants to remove chemicals. Sorbents can be divided into three basic categories: natural organic, natural inorganic and synthetic.

Steam or Thermal coal: Coal which is burned, producing heat that is used to generate steam. The steam expands through a turbine, which in turn spins a generator, producing electricity. All ranks of coal can be used for steam generation, however the varying heat content between ranks impact the volume of coal necessary to produce equivalent amounts of steam.

Stevedores: Labor management companies that provide equipment and hire workers to transfer cargo between ships and docks. Stevedore companies may also serve as terminal operators. The laborers hired by the stevedoring firms are called stevedores or longshoremen.

Stream: A body of water found on the Earth's surface and confined to a narrow topographic depression, down which it flows and transports rock particles, sediment, and dissolved particles. Rivers, creeks, brooks, and runs are all streams.

Sub-bituminous Coal: Has a heating value between bituminous and lignite. It has low fixed carbon and high percentages of volatile matter and moisture.

Sulfur: Naturally occurring element found in varying concentrations in fossil fuels. When fossil fuels are combusted the sulfur forms sulfur dioxides which contribute to air pollution. Coal contains varying amounts of sulfur with lower sulfur coals of similar rank demanding premium prices. Coal plants are able to reduce sulfur emissions by implementing scrubbers allowing them to meet federal emissions standards.

Sulfur Dioxide: Also known as SO2, is a pollutant that is released into air through industrial uses including when coal is burned. SO2 has been linked to a number of adverse effects on the human respiratory system including chronic bronchitis and emphysema. Physically, it is a colorless, extremely irritating gas or liquid.

Terminal: The place where cargo is handled is called a terminal (or a wharf).

Thalweg: Longitudinal outline/trace/survey of a deepest part of riverbed from source to mouth (upstream/downstream). Line of steepest is descent along the stream.

Thermal Coal: See Steam coal.

Time Charter - fixture whereby charterer hires vessel for a specified period; payment made on a daily basis and includes fuel used, port costs etc.

Towboat: A snub-nosed boat with push knees used for pushing barges. A small towboat (called a **push boat**) may push one or two barges around the harbor. A large towboat is used to push from 5 to 40 barges in a tow is called a **line boat**. From the Port of New

Orleans, line boats deliver cargo to Mid-America via the 14,500-mile waterway system flowing through the Crescent City. (See also tug boat)

Transshipment: The unloading of cargo at a port or point where it is then reloaded, sometimes into another mode of transportation, for transfer to a final destination.

Trend: A statistical term referring to the direction or rate of increase or decrease in magnitude of the individual members of a time series of data when random fluctuations of individual members are disregarded.

Tugboat: Strong v-hull shaped boat used for maneuvering ships into and out of port and to carry supplies. A ship is too powerful to pull up to the wharf on its own. It cuts power and lets the tug nudge it in. Generally barges are pushed by **towboats**, not tugs.

Ultimate Analysis: Precise determination, by chemical means, of the elements and compounds in coal.

Vessel: A ship or large boat.

Vessel Operator: A firm that charters vessels for its service requirements, which are handled by their own offices or appointed agents at ports of call. Vessel operators also handle the operation of vessels on behalf of owners.

Volatile Matter: Constituent of coal, not including moisture, that is given off as vapor when coal is combusted. Volatile matter is measured by heating the coal in laboratory conditions. After heating, the weight loss of the coal, excluding moisture, is measured. Volatiles are a key indicator of the quality of coking coals.

Voyage Charter: fixture whereby the charterer pays a rate per ton loaded or on a lump sum basis.

Water Table: The upper surface of a zone of saturation. No water table exists where that surface is formed by an impermeable body. (Meinzer, 1923, p.22.)

Watershed: The divide separating one *drainage basin* from another and in the past has been generally used to convey this meaning. However, over the years, use of the term to signify drainage basin or catchment area has come to predominate, although drainage basin is preferred. *Drainage divide*, or just divide, is used to denote the boundary between one drainage area and another. Used alone, the term "watershed" is ambiguous and should not be used unless the intended meaning is made clear.

Watt: A unit of power which is equivalent to one joule per second.

Withdrawal Use of Water: The water removed from the ground or diverted from a stream or lake for use. (MacKichan, 1957, p. 2.)

UNITS AND CONVERSIONS

• Exchange Rates

1 USD = 80 BDT
1 m BDT = 0.0125 m USD

• Units:

amp	-	Ampere
Btu/lb	-	British Thermal Units per pound
c/sec	-	Cubic Feet per Second
deg. C	-	Degree centigrade
ft	-	Feet
HHV	-	Higher heating Value
kcal/kg	-	Kilocalories per kilogram
kg/sec	-	Kilogram per second
kV	-	Kilovolt
KW	-	Kilowatt
m/sec	-	Meter per Second
M^3/min	-	Cubic meter per minute
m3/day	-	Cubic meter per day
m3/ hr	-	Cubic meter per hour
mg/l	-	Milligram/liter
ml	-	Milli liter
Mm	-	Mili meter
MMCF	-	Million Cubic Feet
mm Hg	-	Milimeter mercury
MJ/kg	-	Megajoules per kilogram [1 MJ/kg = 1 Gigajoule/Tonne (GJ/t)]
mKWh	-	Mega kilo watt hour
Mt	-	million tonnes
Mtoe	-	million tonnes of oil equivalent
MVA	-	Mega Volt Ampere
MWh	-	Megawatt hour
N/m^2	-	Newton per square meter
psi		Pounds per square inch
rpm	-	Revoulation per minute
sq.meter	-	Square meter
Tk/kWh	-	Taka per kilowatt hour
ton/hr	-	Ton per hour

• Conversion of Units

1 bar	=	10^5 Pa
1 Btu/lb	=	0.002326 MJ/kg
100 BTU/SCF	=	37.26 MJ/m^3
1 cc/sec	=	0.0283 m^3/sec
1 ft^3	=	0.0283 m^3
1 Long Ton (lt)	=	1016.05 kilograms
1 Long Ton (lt)	=	2240 lb

1 m	=	1000 mm
1 m^3/h	=	0.588578 ft^3/min
1 MCF	=	103 CF
1 MCF	=	28.32 m^3
1 Metric Ton	=	1 Tonne
1 Metric Ton	=	2204.6 lb
1 Metric Ton	=	1000 kg
1 MJ/kg	=	238.8 kcal/kg
1 MJ/kg	=	429.9 Btu/lb
1 Mpa	=	1000 kpa
1 MWh	=	3600 MJ
1 MW	=	1 MJ/s
1 MW (thermal power) [MWth]	=	approx 1000 kg steam/hour
1 MW	=	1000 W
1 MW	=	1000 kJ/s
1 Short (US) Ton (st)	=	907.19 kilograms
1 Short (US) Ton (st)	=	2000 lb
1 kcal	=	4.184 kJ
1 kcal/kg	=	0.004187 MJ/kg
1 kcal/kg	=	1.800 Btu/lb
1 kg/sec	=	0.0031 mmcfd
1 km	=	1000 m
1 kPa	=	1000 Pa

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EXECUTIVE SUMMARY

CHAPTER: EXECUTIVE SUMMARY

In view of the power generation capacity of the country by the year 2030 and the corresponding demand scenario, the demand for electricity is expected to surpass the available generation capacity. With view of this impending scenario, Rural Power Company Limited (RPCL), upon Government directives has taken up initiatives to set up an import based coal power project at Gazaria, Munshiganj, Bangladesh (Gazaria 350 (±10%) MW Coal Fired Thermal Power Plant Project) on the bank of mighty Meghna River.

In this context, the Joint Venture of O&M Solutions Private Limited, India [Lead], O&M Solutions Bangladesh Ltd., Bangladesh and, Center for Environmental and Geographic Information Services, Bangladesh (JV-OMS-CEGIS), has been engaged by Rural Power Company Limited (RPCL) to carry out the Detail Feasibility Study, Environmental Impact Assessment, Social Impact Assessment and prepare the required reports for the project. The purpose of this report is to highlight the techno-economic details of the proposed installation of Gazaria 1 x 350 (±10%) MW Supercritical Coal Fired Power Plant on import based coal as fuel with the provision of future extension of another identical unit.

This report provides details of the selected site; availability of required land with minimum resettlement, supply and transportation of coal to the plant site, availability and use of water, technical features of the main plant equipment, raw and cooling water system, coal and ash handling systems, electrical systems, plans for evacuation of power, control & instrumentation system, environmental aspects, estimates of project cost, schedule for project implementation and organization structure for construction and operation and maintenance period of the project.

This report would be the base document for seeking support and clearances for the project from various authorities such as Government of Bangladesh (GOB) and Department of Environment (DOE), etc. Moreover, financial institutions can evaluate this report as the preliminary basis for financing for the Project.

The objective of the study is to provide consulting services for Detail Feasibility Study, Environmental Impact Assessment, Social Impact Assessment and Resettlement Action Plan for the project for the proposed installation of Gazaria 1 x 350 (±10%) MW Supercritical Coal Fired Power Plant on import based coal as fuel with the provision of future extension of another identical unit at Gazaria in Munshiganj District. The Consultant has conducted the Initial Environmental Examination (IEE) for 'Environmental Site Clearance' from DOE as a part of the Detail Feasibility Study. The study included the followings:

- Detail Feasibility Study for developing a 1 X 350 (±10%) MW Supercritical coal fired power plant based on import coal as fuel with the provision of future extension of another identical unit.

- Initial Environmental Examination to identify possible Environmental and Socio-economic Impacts with subsequent EIA & SIA Study for possible mitigation measures and a tentative Environmental Management Plan and Social Impact Assessment study.

SITE LOCATION

1. The proposed project site is located in Gazaria Upazila under Munshiganj District on the eastern bank of river Meghna within two Mouza namely, Daulatpur (at north) and Sholo Ani (at south) of Imampur Union. A Canal locally known as Pangashia Khal passes through the proposed project site from upper region to the Meghna River. The project site is surrounded by Andharmanik, Imampur and Karim Kha Mouza in East, Kalipur Mouza in South, Meghna River in West and Daulatpur Mouza in North.

2. The site is approximately 35 Km south-east of capital city Dhaka and 10 km from Gazaria Upazila headquarter by road. It is approachable by an existing road network which is connected to the Dhaka – Chittagong highway at Bhoberchar Bazar. The project site is also approachable by waterway through the Meghna River from the Bay of Bengal. Heavy equipment and construction materials, machinery can be transported through water route.

LAND

1. RPCL is in the process of acquiring project area of 330.60 acres (based on the approval of ECNEC of GOB for 350 Acres of Land and subsequently advised by Munshiganj DC office). Proposed power plant area will cover 314.10 acres out of the 330.60 acres.

2. The total land area is adequate for installing the power plant major equipment and its auxiliaries, plant water systems, coal stock pile, ash pond area, green belt and other ancillary infrastructure inside the plant boundary and a provision of around 16 acres of land is considered near the jetty at the bank of Meghna River for compliance of River Act & Regulations, Movement of ship, Ship Landing Station, Coal Handling Purpose, Ash Disposal Corridor, Material handling etc. purpose.

3. All maps digitized and geo-referenced using satellite image. Survey team carried out physical features survey, land use survey and topographic survey at the site area.

4. All structures according to their uses are agricultural, residential, commercial, education, religious, and community facilities, roads, water bodies, etc. There is about 2 km of natural khal network within the project area.

Table: List of RS mouza maps covering the proposed power plant project area

Serial	Mouza	JL No	Sheet No	Coverage
1	Doulatpur	69	01	Partial
2	Soloani	70	01	Partial

Source: Compiled by the Consultants, 2016

Table: Existing Land Use of the Project Area

Land Use Category	Area in Acres	Percentage (%)
Agriculture	308.78	93.40
Water body	16.79	5.08
Settlement Area	5.02	1.52
Total	330.60	100.00

Source: Land Use Survey by the Consultants, 2016

5. As there is some small number of habitations at the proposed site, the Resettlement and Rehabilitation (R&R) issues are envisaged in the proposed project.

6. The proposed land for the project has an average elevation of 3.08 mPWD. The highest flood level is 6.83 m PWD in 100 years return period. The maximum land is cultivable particularly in the winter season and basically silt-loam and clay.

RIVER HYDROLOGICAL AND MORPHOLOGICAL STUDY

1. Cooling Water requirement for the power plant has been estimated as 69,600 m^3/hr (considering once through cooling systems) or 1190 m^3/hr (considering closed circuit cooling systems as a make up water for cooling tower system). The water availability of the Meghna River at the project site is as below:

Month	Monthly Average Flow (m^3/s)*	Available Flow (m^3/s) = 50% of Monthly Average Flow
Jan	2,287	1,144
Feb	2,125	1,062
Mar	2,344	1,172
Apr	3,179	1,590
May	4,165	2,082
Jun	6,776	3,388
Jul	13,700	6,850
Aug	15,607	7,804
Sep	14,402	7,201
Oct	9,734	4,867
Nov	3,910	1,955
Dec	2,840	1,420

*The flow estimation was based on absolute values of 'tide in (flood)' and 'tide out (ebb)' flow

2. Considering the minimum available flow in the month of February, which is 1,062 in the above table, percentage of withdrawal for cooling water (considering once through cooling systems) is 1.8% and 0.9% of the monthly average (2,125 m^3/s) of the Meghna River water flow.

3. Water availability analysis shows that the river carries sufficient amount of water, and the availability of the water should not be a problem for this proposed coal-fired power plant.

4. The Average, 10, 50 and 100 years return period flood level at the project site is 5.24, 6.08, 6.64 and 6.83 mPWD, respectively.

5. The Average, 10, 50 and 100 years return period low water level at the project site is 1.01, 0.81, 0.70 and 0.67 mPWD, respectively.

6. The proposed power plant site is located in a flood prone area A major part of the project site as well as surrounding areas go under the water during peak flood time. Flood maps prepared using water levels of the Upper Meghna River show that the power plant may not increase the overall flooding problem of the area. However, it may trigger some water logging problem in nearby surroundings during post-project condition due to the obstruction of the natural drainage system. To avoid such problem, necessary measures should be taken appropriately so that the project may not create any obstruction for the flood water recession from surrounding areas.

7. The depth of the river bed at the project site varies 2 to 5 m in general with few deep pockets of 5 to 10 m deep. The surveyed river cross section analysis shows that the Eastern bank of the river where project site is located is considerably shallower than the opposite bank of the river. Particularly the river bed within 150 m from the middle of the project bank and within 300-400 m from the south end of the project bank to 2 km downstream, the depth of the river bed varies from 2 to 5 m (please refer to Ch. 4). Therefore, if a total depth of around 4.7 m (3.7 m draft + 1.0 m clearance from bottom of the vessel to river bed) is required for a safe navigation of the coal-carrying vessel for this proposed power plant then the river bed at the project site's immediate surroundings needs to be dredged.

SOURCING AND SPECIFICATION OF COAL

1. Derived from SWOT analysis for 4 countries such as Australia, Indonesia, South Africa, and Mozambique, and based on reserves, coal region, cost of mining, coal quality, infrastructure, tax regime, political stability and proximity to Bangladesh:

    - Indonesia has been prioritized for the source of coal,
    - Second option has been recommended for Mozambique/South Africa.

2. Coal mines can be leased for long term supply, stability of cost and quality. Sub-Bituminous thermal coal will be used for the power plant. In the Feasibility Report, a number of coal specifications have been studied. Following are the specifications of the probable coal requirement for the proposed Power Plant:

Table: Specification of Indonesian Coal (5000 Kcal/kg)

Specifications		Standard
GAR		5,000 Kcal/kg (more or less)
NAR		4,700 Kcal/kg (more or less)
Total Moisture	ARB	26 to 28%
Inherent Moisture	ADB	10 to 15 %
Ash Content	ARB	8 to 10%
Volatile Matter	ARB	35 to 42%
Fixed Carbon	ARB	5 to 21%
Total Sulfur	ARB	Up to 0.7%
HGI		40 to 60%
Size 0 to 50mm		85 to 90%
Capacity / Month		671,000 MT
Origin		Kalimantan, Indonesia

Table: Specification of Steam Coal (5000 Kcal/kg)

Specifications	Standard
Total Moisture	47
Inherent Moisture	(ADB) 0.09% Below
Ash	(ADB) 15.7%
Volatile Matter	(ADB) 3.3%
Fixed Carbon	(ADB) 36.4%
Total Sulphur	(ADB) 0.44%
Gross Calorific Value	(ADB) 5199 cal / g
HGI	(ARB) 16%-30%
Size	0-50 mm

After studying the specifications for different coal, it may be summarized that the recommended coal for Gazaria Power Plant will have calorific value 5000 Kcal/kg with the maximum Ash content 15% and carbon content around 40%

3. Low Sulphur content will ensure permissible SO_2 emission at the power plant and eliminates Flue Gas Desulphurization (FGD) plant and associated operation and maintenance costs in the power plant. However, required space provision for FGD in plot plan and design ducting to join FGD ducts is kept. This will help Project Company to avoid the risk of not having guaranteed supply of coal with low Sulphur content all the time during 30 years plant design life time.

4. CIF price of coal at Chittagong Port from Indonesian Kalimantan sea port is calculated USD 89.87 / ton (considering reference coal price 4.3 USD /GJ and calorific value 5000 Kcal/kg). Additional inland transportation charge up to power plant site is USD 19.5 / ton. Then total cost of coal per ton stands at Gazaria plant site is USD 109.37/ ton, which is approximately USD 110 / ton.

COAL AND OTHER FUEL

1. The requirement of coal (being 1.11 mTPA @ 80% PLF for 350 (±10%) MW coal fired supercritical power plant will be met by importing coal from Indonesia, Mozambique or South Africa. Daily maximum coal requirement for the 350 (±10%) MW Supercritical plant is maximum 3,800 ton.

2. The coal would be imported using Handymax Ships having requisite coal carrying capacities. It is estimated that one ship load would be required every 15 days by the project and the turnaround time of the ship from the loading port in Indonesia or Mozambique to Bangladesh and back shall be from 26 to 36 days.

3. A dedicated jetty for unloading of coal and loading/unloading of heavy mechinary will be constructed on the Meghna River bank adjoining to project site. The jetty would have a draught of 5 meter and river draughtt of 3.9 meter, hence, coal is proposed to be received by carrying out lighter age Vessel operations. The coal would be unloaded from the ships by cranes with grab and bucket to barges and transported by the barges of 2,500 ton capacities to the project site jetty. The coal would be unloaded at the jetty using onshore grab and bucket cranes and other equipments from the barges directly into the track hopper which would transfer the coal straight to a tube conveyor. The tube conveyor (2x100%) running for approximately 1 km would transport to the coal storage yard and the plant site from the jetty. Coal transportation logistics shall be finalized keeping in view of the bathymetric data at the river close to the project site.

4. Heavy Fuel Oil (HFO) would be used for start-up and flame stabilization at low loads and Light Diesel Oil (LDO) will be used for light up and warm up of unit.

MARINE TRANSPORTATION OF COAL

1. Based on the preliminary study, 50,000 ton capacity ship can be moved to the outer anchorage (A-Anchorage) of Chittagong port. A-Anchorage has a draught of 10 to 13 meters. Tidal window will be used to cross the low draught part of Bay of Bengal between Kutubdia to Chittagong C-Anchorage to reach and anchor at A-Anchorage. At this A-Anchorage area the mother vessels (Handymax) will be anchored and unload coal to Cargo Vessel.

2. It has been assumed that Indonesia – Chittagong – Indonesia route will take approximately 7.5x2= 15 day's voyage time by the mother vessel. Loading in Indonesia takes approximately 5 days, unloading at Chittagong will take 7 days. So a turnaround time will be 27 days.

3. A continuous supply chain will be maintained for uninterrupted supply of coal.

COAL TRANSSHIPMENT FROM MOTHER VESSEL TO CARGO VESSEL

1. The transshipment concept with primary function of intermediating storage smoothes out the discontinuity between maritime, land and barging transport, making it the perfect solution.

2. These concepts provide among other options, the availability of on-board buffer storage in the range of 6,000 to 16,000 tons of cargo as the case may require. A Floating Terminal Station (FTS), besides having the flexibility of floating crane, has the great advantage of floating terminal as well.

3. Coal will be transshipped directly by crane mounted grab unloader mounted with the Handymax Ship to the cargo vessels or to the FTS. Cargo vessels will be moored at the side of ship at deep sea A-Anchorage and tied with the mother vessel / FTS. Normally these ships have two cranes and can load two cargo vessels at a time.

4. There are sufficient lightering spaces in the A-Anchorage for unloading from mother vessel to the cargo vessels. The length of A-Anchorage is approximately 10 – 12 km and width 3 – 4 km.

5. During rough weather conditions if the lighter vessel fastened alongside the mother vessel experiences heavy rolling and pitching causing hard scarping, bending and indentation to the mother vessel railing and hull. In this situation, the cargo vessel will move from alongside the mother vessel and anchor to a safe position. As soon as the weather condition improves, it again moored alongside the mother vessel and start loading.

6. Coal will be unloaded at Chittagong at a rate 7,500 tons per day. Each cargo vessel capacity 2,500 tons. This is the highest capacity vessel operating in the Class-I route in Bangladesh river system, which is the highest draught route. In average, 3 cargo vessels will be loaded per day.

7. During April to October weather conditions become inclement for maximum 3 – 8 days continuously and occurs normally once in a month. Coal transshipment from mother vessel to cargo vessel will not be possible during these days. But design of higher transshipping capacity (7,500 ton per day) and higher unloading capacity at plant jetty (7,500 ton per day) will recover this shortage of coal storage at site.

8. Government has planned to develop Central Coal Terminal for buffer coal storage facility at the Deep Sea Port at Sonadia, and at Matarbari Island, Cox's Bazar and at Payra Port, Patuakhali. When these Coal Terminals will be implemented and functional, coal will be unloaded directly from mother vessel to the coal terminals. Coal will be transported to the Gazaria power plant site by cargo vessels after getting loaded from central coal terminals as and when required. This will substitute the FTS system as mentioned above.

9. At the project site, coal storage facility for 60 days will be kept as per requirements and guidelines of Government agencies (RPCL/BPDB).

RIVER TRANSPORTATION OF COAL

1. Distance from Chittagong outer anchorage to Gazaria, Munshiganj project site is around 250km. It will take 17 hours to reach the project site from Chittagong A-Anchorage after filling up the cargo vessels. This time includes the waiting time for high tide to cross the Sandwip Channel. Cargo vessels need to use the tidal window during high tide to cross the low draught part of Sandwip Channel.

2. The whole route is Class-I as charted by BIWTA and draught is maintained at 3.9 meters. Except at few locations at Sandwip Channel in this route where draught becomes 2.1 to 2.5 meters at low tide. BIWTA provides monthly river notices mentioning the lowest draught at Sandwip Channel for convenience of navigation for the vessels. Moreover, BIWTA maintains buoys, beacons, etc. for the day and night navigation in the whole route.

3. For the 3.9 m draught the maximum available cargo vessel capacity is 2,500 tons. Total river transportation has been designed on the basis of 2,500 tons cargo vessel capacity.

4. 2,500 tons capacity size of cargo vessels is available in Bangladesh and those are transporting bulk cargoes like cement clinker. The cargo vessel will be self propelled and can be moored at the side of mother vessel and controlled during the inclement weather conditions. Naval Architecture and Marine Engineering Department of Bangladesh

University of Engineering and Technology (BUET) has also authenticated the maximum size of the self propelled cargo vessel as 2,500 tons. The design of this cargo vessel has been provided and they are covered with hatches to protect dispersion of coal dusts in the atmosphere. Currently in Bangladesh, there are number of sufficient Cargo vessels which have capacity of more than or equal 2,500 tons and regularly plying in this Class-1 Route.

TECHNOLOGY OPTIONS

1. Following two different technology has been discussed for selection of the suitable boiler design:

   Supercritical (SC) – Improved metallurgy, very high steam temperature and pressure, comparatively more expensive to build, decreased emissions, requires highly experienced and trained operating staff.

   Ultra Supercritical (USC) – Construction team should be familiar with welding techniques and have the capacity to construct using exotic metals and techniques require to ensure safe construction, produce huge efficiencies and reduces use of fuel, improvement in reduction of emissions.

2. The primary factors which govern the steam cycle selection are - efficiency, flexibility to operate in variable load environment, equipment cost and the fuel price. With higher steam parameters, the investment cost goes up on account of increase in the cost of boiler and turbine island equipment. However, on account of higher plant efficiency, the incremental investment cost is expected to be recovered within the initial years of operation. However, it is required to strike balance between increased capital cost and fuel savings due to increased efficiency while deciding for selection of steam parameters.

3. In view of the cost benefit and environment related analysis developers are now considering adoption of supercritical steam parameters; and the project would also adopt supercritical steam parameters. Presently in Bangladesh, there are no supercritical thermal power plants in operation. However, globally, supercritical technology is used extensively and hence the technology, as such, is proven. Supercritical technology is mature and ultra-supercritical technology is being inducted and developed for higher capacity units. Hence, Supercritical (SC) technology, with 350 (±10%) MW size single unit has been selected for the proposed power plant.

4. The plant would be designed for base load operation and will have the capability to operate under cyclic load variation mode. The plant design life would be 30 years but the plant will be operated for PPA tenure of 25 years.

SUPERCRITICAL TECHNOLOGY FOR STEAM GENERATOR

1. The Steam Generator (SG) or Boiler shall be once through, water tube, pulverized coal (PC) fired, top supported, balanced draft furnace, single reheat, natural circulation, radiant type, dry bottom type, suitable for outdoor installation. The gas path arrangement shall be two pass types.

2. The main parameters at 100% SGMCR will be as follows:

    - Pressure at super heater outlet - about 24 MPa
    - Temperature at SG outlet– about 566 °C

STEAM GENERATOR DESIGN REQUIREMENTS

1. It is proposed to install high efficiency electrostatic precipitators (ESP) having an efficiency that limits the outlet emission to 50 mg/Nm³ (maximum 100 mg/Nm³).

2. Maximum NO_x emission from the unit will not be more than 510 mg / m^3.

3. Boiler will meet the requirement of sustained high efficiency and availability, high efficiency at part load, flexibility to burn coal within the range specified, and quick start up and two shift operations.

STEAM TURBINE DESIGN CONSIDERATIONS

1. The Steam Turbine shall be tandem compound, single reheat, regenerative, condensing, multi cylinder design with separate or combined HP-IP and separate LP casings, nozzle/ throttle governing and directly coupled with the generator suitable for indoor installation.

2. The plant would be designed to operate as a base load station. The turbine design shall cover adequate provision for quick start-up and loading of the unit to full load at a fast rate.

PROJECT COSTS

1. The capital cost of the project has been estimated to be USD 650.59 million. The cost includes all the equipment cost, civil cost for pump intake pump house, outfall facilities, jetty, civil foundation for coal conveyor and coal storage yard. All the soft costs like interest during construction, financing charges and working capital margin, etc., are also

included in the total capital cost. Land purchase, land development and resettlement cost are included in the capital cost.

2. The project would be executed preferably through an EPC (Engineering, Procurement & Construction) contract, which is to be awarded to a reputed contractor selected through competitive bidding procedure. The procurement of steam turbine generators and steam generators has been kept within the scope of the EPC contract. Steam generators and steam turbine generators would be procured from reputed manufacturers. The EPC Contractor would undertake to execute all civil works and the erection of all plant and machinery at site. Responsibility for overall site management would rest with the EPC contractor.

3. Land development of the Project site will be executed by RPCL under separate contract.

4. The Commercial Operation Date (COD) of the supercritical unit is envisaged in 36 months reckoned from the effective date giving the NTP to the contractors. This is estimated on the basis of expected deliveries of major equipment and estimated time durations for design, engineering, construction and commissioning.

COAL HANDLING

1. Transportation through conveyor system with a minimum capacity of 7000-8000 ton per day (TPD). This meets the requirement of coal for the power plant.

2. The design criteria for coal unloading, reclaiming and conveying is based on the following functional requirements and assumptions:

   - A coal feed rate of 180 TPH,
   - Space for stocking of coal for a period of 60 days,
   - Coal would be received with unloading hopper,
   - For continuous loading and unloading, end looping will be done,
   - The conveyor system used would be a tube conveyor to avoid spillages of coal.

DUST CONTROL DURING COAL HANDLING

1. Dust generated during unloading of coal from the buckets into unloading hoppers would be suppressed by spraying chemical solution (an array of agents, binders, foams, and antioxidants).

2. Crusher house, junction towers, feed points below reclaim hopper would be provided with dry type dust extraction system comprising bag filters.

3. Dust suppression sprinklers would be provided all around the stockpile to suppress dust generation and to keep dust nuisance to the minimum.

4. Sprinklers would also be provided all along and on either side of the track just before the track hopper as well as track hopper to suppress the dust generated while unloading coal into track hopper.

5. Bunker ventilation system would be provided with bag filters to trap the dust generated while loading coal into bunkers and vent out dust free gases/air.

CIVIL DESIGN ASPECTS – RIVER BANK PROTECTION

1. Average width of Meghna River close to the project site is more than 1000 m. Jetty and water intake facility will be built on Meghna River bank.

3. During high flood, project inside Khal (canal) might be affected by Meghna River. Therefore, bank protection will be required along the bank of the Meghna River of the project area. Also bank protection of both sides of the canal has to be implemented.

4. At the eastern, southern and northern side of the project area, earth embankment will be needed by CC block and geo-textile sufficiently enough to prevent erosion.

5. Land filling and development of the project will be required in whole project area except at ash pond and jetty.

6. Elevation of land filing will be around 8.03 m PWD. Land filling materials should be collected by dredging of Meghna River. The proposed land for the project has an average elevation of 3.08 m PWD.

7. Cost of land development has been assumed at Taka 150 crore (18.75 m USD) which includes bank protection, land filling including earth embankment and other related cost.

PLANT WATER SYSTEM

1. The river water will be used for condenser cooling, cooling of SG and Turbine Generator, auxiliaries and various other requirements like SG makeup, service and potable water, fire protection system, etc.

2. Both cooling systems – once through and cooling tower has been discussed in the Study; the technology will be finally selected after due consideration of complying Environmental regulations relevant to the power plant emissions.

3. In once through system, the water from the river will be brought to the site by construction of a vertical pump at the jetty and a pipeline for a distance of approximately 1.3 km running along with coal conveyer system. The discharge water pipeline shall be

discharged to an open channel parallel to the existing canal at the north side of the site and mixed to the canal when temperature drops to the canal water temperature which ultimately mixed at approximately 1.5 km downstream of the water intake.

4. Water tapped off from inlet cooling water pipe from river will be supplied to clarified clarifier which would be located close to the pre-treatment plant.

5. Clarified water from the clarifiers would be filtered in the second stage of filtration consisting of dual media filters of 3 x 50 % capacity RO plant supply pumps followed by Ultra Filtration (UF) media. The treated water from the RO plant will be further used in DM plant make up and other sweet water requirement.

6. A DM plant of total 30 m^3/hr capacity is envisaged to ensure make-up requirement of heat cycle at the rate of 1 % of the SGMCR steam flow, make up to closed circuit auxiliary cooling water system, hydrogen generation plant (if applicable) and periodic DM plant regeneration water requirement and considering future extension of identical unit

7. The waste water would be treated and then reused to the maximum extent possible.

8. Once through cooling system is cost effective and gives highly efficient cooling system and hardly affect generation due to condenser's performance also need quite less maintenance during plant life. Discharge temperature is only disadvantage looking presently but with latest engineering practices discharge system is so designed to have minimal adverse effect on Flora & Fauna, aquatic species, etc. due to discharge temperature.
   If cooling tower alternative is suggested,
   a. Land requirement need to be considered.
   b. Capital cost will be higher in both NDCT and Forced Draft cooling tower.
   c. Cooling tower performance depends on dry bulb, wet bulb temperature, wind velocity, and other weather condition which will have direct effect on plant generation capacity.
   d. Cooling tower drift may affect the humidity in surrounding as forced draft cooling tower air discharge is at low level.

9. Cooling towers need higher maintenance and due down time plant availability gets affected also O&M cost increases to maintenance.

10. Compliance of Environmental regulations relevant to the power plant emissions can be strictly followed in case of cooling towers, where ST condenser circulating cooling water sourced from Cooling towers basin.

POWER EVACUATION

1. Power evacuation is planned considering the nearest 230 kV transmission systems, connected from Meghnaghat 230 kV substation to Comilla 230 kV substation.

2. Power generated from the plant unit will be evacuated through a 230 KV outdoor switchyard which will be connected by 230 KV double circuit transmission lines to the nearby 230 kV line with loop in loop out (LILO) system. The length of the transmission line from power station switchyard to the connection point is 10 km.

3. Start up power will be drawn from the grid through the station transformer.

4. The 230 kV Switchyard shall be designed for one and half breaker scheme. All necessary protections for bus, line feeders, and transformer will be provided in the 230kV switchyard.

5. The power plant will be operated for meeting the requirement of Bangladesh Grid Code.

6. Power will be dispatched as per the dispatch schedule of the National Load Dispatch Centre (NLDC)

ENERGY ABSORPTION PLAN

1. The average yearly gross electrical generation from the 350 (±10%) MW SC unit of the power plant is estimated to be at a PLF of 80% which is typical for this type of generating plant. Auxiliary power consumption is considered approximately 7% of gross plant output, which is typical for the power plant of this size.

PLANT OPERATIONAL CONTROL AND INSTRUMENTATION

1. Distributed Control System:

    - The instrument and control system provided with a microprocessor-based Distributed Control System (DCS) with state of art Man-Machine Interface (MMI) and other analog instruments and control devices.

    - It will perform the functions of monitoring, control, alarm, protection and interlock, diagnosing, and maintenance guidance, event recording of steam generator and auxiliaries, steam turbine generator and auxiliaries and the balance of plant systems with a hierarchically distributed structure to meet all requirements at various operational conditions.

2. Operation Philosophy:

- The main plant system like boiler, turbine, generator and auxiliaries, will be operated through the operator consoles in the Central Control Room (CCR).

- With the exception of auxiliary systems like coal handling plant, waste water treatment, chlorination and ac & ventilation all drives will be remotely operable from the operator's console in the central control room.

3. Control Philosophy:

Mode of plant operation	:	**Centralized**
Type of control	:	Automatic
Mode of control system	:	Distributed control system
System controlled and monitored by DCS	:	Steam generator and its auxiliaries
System controlled and monitored by Dedicated control system with DCS	:	Steam turbine generator (STG) system (Control & Auxiliaries)
Interface for monitoring Purpose only		
Standalone control system with critical systems	:	1. Cooling Water system signals interfaced to DCS for monitoring
		2. Electrostatic Precipitator
		3. Ash handling system
		4. Coal handling system
		5. Firefighting system
		6. Ash water recycling System
		7. Switchyard
		8. DM Plant

OTHER SYSTEMS OF THE PLANT

1. Fuel Oil System

- The steam generator will be designed for 100% coal firing.
- LDO/HFO will be used for hot start-up and for flame stabilization at low loads.
- For cold start-up, warm-up purposes and for start-up / commissioning activities, LDO will be used.
- The steam generator will require fuel oil flame support when coal is fired below 40% SGMCR.

2. Other Systems are:

- Compressed air system
- Fire protection system
- Hydrogen generation & storage- Generator rotor & stator winding cooling
- Air conditioning & ventilation system
- Cranes, hoists & elevators

ASH HANDLING, UTILIZATION AND DISPOSAL

1. Ash generated per day is about 570 ton for 350 (±10%) MW SC unit. The ash handling / disposal system will be designed to meet the above ash generation.

2. The ash handling system will be designed and constructed for dust free operation.

3. Fugitive dust emission at any area will not exceed 5 mg/m^3 for all solid sizes. Ash handling will be fully automated.

4. Fly ash is collected in ESP hoppers, AHP, economizer hoppers and chimney hopper.

5. The main ash silos are located within the plant boundaries near jetty to enable easy loading of Fly Ash on barges.

6. The slurry is pumped to the ash pond by multistage ash slurry pumps of non-clog type.

7. The ash pond will be constructed such that a dyke is formed to contain the ash slurry. After settlement of ash slurry the water will over flow in to a collection well / settling tank from where the water will be pumped back to the ash water pump house located in the main plant area.

8. The fly ash generated in thermal power stations has commercial value because of its usage in cement and construction industries in various forms.

9. Fly ash generated from the proposed power plant would be commercially utilized in the cement factories in vicinity to the proposed power plant.

PROJECT EXECUTION

1. It is envisaged to synchronize the unit and put into commercial operation in 36 months, reckoned from the zero date of the Project construction (i.e. handing over developed site to EPC contractor and contract effectiveness).

2. A single Turn-key contract for completion of the project for BTG and BOP, civil contract, engineering service contract and construction & erection contracts.

3. The contracts will cover complete mechanical, electrical, instrumentation and associated civil works.

4. The site development and approach roads will be outside the EPC contracts and will be carried out by separate civil contractors. However, compactness of the Road as

necessary for transportation of Heavy Equipment/Machinery inside the Project area is bestowed on the EPC Contractor's scope.

OPERATIONAL SETUP

1. O&M Organization: As there is no similar power plant in Bangladesh, the key operation and maintenance people can be outsourced through an experienced O&M contractor in similar technology and capacity.

2. Operation Philosophy: Plant would be operated in accordance with dispatch schedule, and grid code provisions. Sliding pressure operating regime would be utilized for achieving better heat rate at part load operations.

3. Maintenance: The maintenance plan would focus on plant performance, improvement of reliability, reduction of operation and maintenance costs, relationship of operating mode with operation and maintenance costs and remaining plant and component life.

4. Training: Training would be provided on plant system/equipment specifically on safe integrated operation and maintenance procedures, adopting best health & safety procedures etc.

OCCUPATIONAL HEALTH AND SAFETY

1. Occupational Health

   - Occupational health needs sincere attention both during construction & erection and operation & maintenance phases.

2. Safety Plan:

   - Safety of both men and materials during construction and operation phases is of major concern.
   - The preparedness of an industry for the occurrence of probable disasters is known as emergency plan. The disaster in the plant is possible due to leakage of hazardous chemicals, collapse of structures and fire/explosion etc.

   - Keeping in view the safety requirement during construction, operation and maintenance phases, power plant has to formulate safety policy with regulations.

   - Safety Organization shall be maintained during construction phase, operation & maintenance phase for compliance of safety policies regarding procedures, accident / hazard prevention, periodic safety audit & meeting, mitigation measures.

PERMITS AND CLEARANCES

1. Certain permits and clearances are required to be obtained by the project developer from different Government and statutory agencies at various stages of development phase of the project:

    - Government authorizations before financial closing, and
    - Government authorizations after financial closing

LEGAL ASPECTS

1. Following Laws have been reviewed and considered during the study of the proposed project:

    - Laws regulating of Environmental in Bangladesh
    - Laws relating to Health and Safety
    - Regulation of Power Generation
    - Coal Sourcing and Technology
    - Coal Transportation
    - Fishery
    - Water resources
    - Land use, administration and management
    - Rural and urban planning and protection
    - Wild life
    - Energy and mineral resources
    - Local Government Laws
    - Other miscellaneous laws and procedures
    - International maritime conventions, protocol and agreements

ENVIRONMENTAL ISSUES

1. The environmental impact of the proposed power station covering the following aspects is discussed in this clause

    - Air pollution
    - Water pollution
    - Sewage disposal
    - Thermal pollution
    - Noise pollution
    - Pollution monitoring and surveillance systems
    - Waste Water (liquid effluent) treatment and recycling.

2. The Air pollutants from the proposed unit are:

    - Dust particulates from fly ash in flue gas
    - Sulphur dioxide in flue gas
    - Nitrogen oxides in flue gas
    - Coal dust particles during storage/handling
    - Ash dust

3. Stack height requirement for SO_2 control is 220 meter, based on the Environmental Conservation Rule, 1997, Schedule–11, for coal based power plant less than 500 MW published by the Department of Environment, Bangladesh and Environmental Health and Safety Guidelines for Thermal Power Plants by World Bank Group published in December, 2008.

4. DOE requirement: Standard particulate emission for power plant with capacity more than 200 MW, 150 µg/Nm^3 for average period of 24-hour. However, the power plant will maintain the emission standards as per World Bank Group guideline as mentioned below:

Table 1.1.1: WHO Ambient Air Quality Guidelines[7,8]

	Averaging Period	Guideline value in µg/m³
Sulfur dioxide (SO_2)	24-hour	125 (Interim target-1) 50 (Interim target-2) 20 (guideline)
	10 minute	500 (guideline)
Nitrogen dioxide (NO_2)	1-year	40 (guideline)
	1-hour	200 (guideline)
Particulate Matter PM_{10}	1-year	70 (Interim target-1) 50 (Interim target-2) 30 (Interim target-3) 20 (guideline)
	24-hour	150 (Interim target-1) 100 (Interim target-2) 75 (Interim target-3) 50 (guideline)
Particulate Matter $PM_{2.5}$	1-year	35 (Interim target-1) 25 (Interim target-2) 15 (Interim target-3) 10 (guideline)
	24-hour	75 (Interim target-1) 50 (Interim target-2) 37.5 (Interim target-3) 25 (guideline)
Ozone	8-hour daily maximum	160 (Interim target-1) 100 (guideline)

[12] US EPA Prevention of Significant Deterioration Increments Limits applicable to non-degraded airsheds.

(Source: Air Emissions and Ambient Air Quality in General EHS Guidelines: Environmental published by World Bank Group)

5. ESP will be designed for outlet dust concentration of maximum 100 mg/Nm^3

6. NO_X & SO_X Emissions:

   - Boiler is designed for maximum of 510 mg/m^3 with provision of low NO_x burners.
   - SO_2 concentration will be sufficiently below permissible limit based on the Sulphur content of the coal. Additionally modern technology will be adopted to control emission well under international guidelines.

7. Dust control:

   - Dusts due to Coal handling would be minimized by providing suitable dust suppression/extraction systems at crusher house, junction towers, etc.
   - For coal stockyard, dust suppression system would be provided.
   - Boiler bunkers would be provided with ventilation system with bag filters to trap the dust in the bunker

ECONOMIC AND FINANCIAL ANALYSIS

1. Economic aspects of the proposed project have been evaluated regarding contribution to GDP, creating employment opportunities, social desirability, agricultural production loss, and political and environmental issues.

2. The proposed project is close to the load centre, and thus contributes to the economy by supplying reliable power to the industries and commercial institutions of the country.

PROJECT COST ESTIMATE & TARIFF

1. The total estimated project cost of the proposed 350 (±10%) MW supercritical power plant is USD 650.59 million. The levelized Tariff is calculated as US Cents 8.92/kWh (7.14 Tk/kWh) considering Coal Price 110 USD/ton, Plant Load Factor 80%, Discount Factor 12%, Exchange Rate 1 USD = 80 BDT, for the Term 25 years, Net Capacity 350 (±10%) MW.

2. Tariff has three components; (1) Return on Investment (ROI), (2) Fuel Cost and (3) Operation & Maintenance Cost.

3. The Fuel (coal) cost has been assumed based on imported coal (USD 110 per ton, including marine and river transport and delivery).

4. The operating and maintenance cost includes all the costs for operation and maintenance of the power generation plant and, in particular, the cost of labor, the day-to-day maintenance, the cost for spare parts and so on. The O&M costs will include:

- Fixed Operating Costs: Salary, administrative expenses, Salary, allowances, utilities, travel, transportation, Operating labor, Long Term Service Agreement (LTSA) expenses, Maintenance labor and materials, support labor etc.

- Variable, Non-fuel Operating Costs: Spares, Chemicals, Limestone, Consumables, HFO/LDO for startup, Waste disposal and other operating costs.

CONCLUSION

1. Based on the feasibility study of the 350 (±10%) MW coal fired power plant at Gazaria, Munshiganj in Bangladesh, **the location of the project is suitable** for a single unit of 350 (±10%) MW supercritical coal fired power plant with the provision of future extension of another identical unit, considering the navigability of Meghna River for imported coal carrying vessels and heavy equipments, proximity to the load center (Dhaka) and existing 230 kV power evacuation facilities, river hydrological and morphological studies and environmental impact on emissions.

2. Considering the technology selected, the study revealed that, for the 350 (±10%) MW supercritical power plant **the area of 330.60 acres is suitable** (power plant area will cover 314.10 acres and remaining area is left vacant to satisfy the River Acts and Environmental Aspects as the land is situated on the bank of the Meghna River) considering single unit of boiler and turbine, one chimney, keeping space for extension of another identical unit in future, probable addition of FGD, single natural draft / force draft cooling tower, jetty for coal unloading facility for two barges at a time, river water intake system, coal handling system, coal storage facility, ash pond, water treatment and Effluent treatment plant, workshop and warehouse, administrative building, lay down and construction yard and a dormitory for plant operation and maintenance people.

3. The proposed power plant has been considered to be built based on imported coal. There are countries like Indonesia, Mozambique and South Africa from where coal can be purchased for the power plant. Long term contract with the coal mine is suitable for the stable price and quality of coal. Coal will be transported by 50,000 ton capacity mother vessel, which can be anchored at the A-Anchorage of Chittagong off-shore area. Coal can be transshipped throughout the year except few days in a month during April to October when the weather condition become rough in Bay of Bengal. As there is 60 days coal storage at site, the shortage of coal at site for this interruption in coal transportation will be recovered shortly. However, for a smooth transportation of coal to site this study report recommends a central coal terminal at Matarbari or at Payra port facilitating buffer stock of coal to be implemented by the Government of Bangladesh. Coal will be transported by 2,500 ton capacity cargo vessel or barge from the unloading point at A-Anchorage to the project site at Gazaria, Munshiganj. This route from Chittagong to Munshiganj is under the Class-I route charted by BIWTA, which maintains 3.9 meters of draught. However, there are limitations at Sandwip Channel where river draught becomes 2.1 to 2.2 m during dry season. The cargo vessels need to use high tide to cross this part of Sandwip Channel.

The present feasibility study considered all the issues of marine transportation, transshipment and river transportation to site, interruptions of coal transportation due to inclement weather condition in Bay of Bengal, coal unloading capacity from mother vessel, power plant maximum coal demand and concluded that **a single unit of 350 (±10%) MW supercritical with future extension of another identical coal fired power plant unit is feasible to implement**.

4. The power plant has to be designed technically to meet all the environmental emission requirements including the guidelines set forth by World Bank Group and DOE, Bangladesh. All coal conveying and handling system will be designed to **meet nearly "zero emission" requirement**.

5. Economic and financial analysis of the proposed power project has been done considering some basic assumptions like project cost for the 350 (±10%) MW supercritical power plant at 650.59 m USD, Debt quantity will be 85% of EPC Cost as a result Debt Equity Ratio stands at 72:28, Interest rate 4.65% on USD borrowing, expected IRR on Equity 12%, Coal price USD 4.3 /GJ, Inland coal transportation Cost USD 20 /Ton, Coal calorific value 5000 Kcal/Kg, O&M cost 1.15 US Cents/KWh, Plant factor at 80%. Based on these assumptions Levelized Tariff is derived at USC 8.92/kWh (7.14 Tk/kWh).

In view of the foregoing discussions, it can be concluded that 350 (±10%) MW supercritical coal fired power plants are technically viable & feasible to implement on the basis of this study.

Evaluating the economic and financial analysis in the Feasibility study, it can be concluded that the project is economically and financially feasible.

RECOMMENDATIONS

1. The Feasibility study for the implementation of 350 (±10%) MW supercritical coal fired power plant at Gazaria, Munshiganj, Bangladesh has been performed and found technically viable, economically and financially feasible.

2. Based on the results of this study following issues are also recommended in view of the implementation of the power plant project including its future extension:

Construction of central coal terminal at Matarbari and Payra (near deep sea) for coal unloading and a buffer stock of coal:

During April to October there are few days' interruptions in every month due to inclement weather conditions at the Bay of Bengal. Considering a 60 days stock of coal at the site these interruptions will be compensated within short time. However, to make an uninterrupted and reliable supply of coal to the power plant, construction of a deep sea coal terminal with buffer stock is recommended to build at Matarbari Island or Payra Port location by the Government of Bangladesh.

3. **Necessary permits, clearances, studies and surveys:**

In order to ensure timely completion of the project, it is recommended that early action on the following activities be initiated:

- Initiate proceedings for obtaining the Environment Clearance for the Project.
- Apply to get permission from BIWTA as well as port authority to set up the captive jetty at river coast attached to proposed power plant boundary.
- Application for obtaining consent for establishment under air and water pollution related Acts from Government of Bangladesh.
- Approval of chimney height from the Civil Aviation authority of Bangladesh.
- Pursue other project clearances from statutory authorities and concerned government agencies.
- Conduct the route survey and alignment studies for electrical transmission lines i.e. from proposed power plant to the existing 230 KV national grid.

CHAPTER 01:
INTRODUCTION

CHAPTER 01: INTRODUCTION

1.1 BACKGROUND

At present 62% of total power generation depends on natural gas resources of the country. As there remains scarcity in the supply of gas, implementation of natural gas based power plants in future may not be possible. To increase the fuel security and fuel diversification, Ministry of Power has been working to reduce the dependency on natural gas and providing due importance on the use of other fuel category. Government of Bangladesh has taken up initiatives to meet the ever increasing demand for power and launched short, medium and long term programs to increase power supply through introduction of fuel mix (gas, coal, liquid fuel, LNG, nuclear energy and renewable), demand side management, energy efficiency and conservation.

The power system in Bangladesh requires an optimum mix of 'Base' load and 'Peak' load plants to provide electricity at a reasonably least cost. The power system master plan study emphasized low cost 'Base' load plants. According to the 'Power System Master Plan' (PSMP) study conducted by Power Division, Ministry of Power Energy & Mineral Resources (MPEMR), Government has planned to enhance the electricity generation of the country to 39,000 MW by the year 2030, out of which 50% Power generation would be of coal-based fuel (domestic & import), 25% on gas fuel (Natural gas & LNG), 20% on Nuclear, Renewable, hydro, cross border and 5% on liquid fuel.

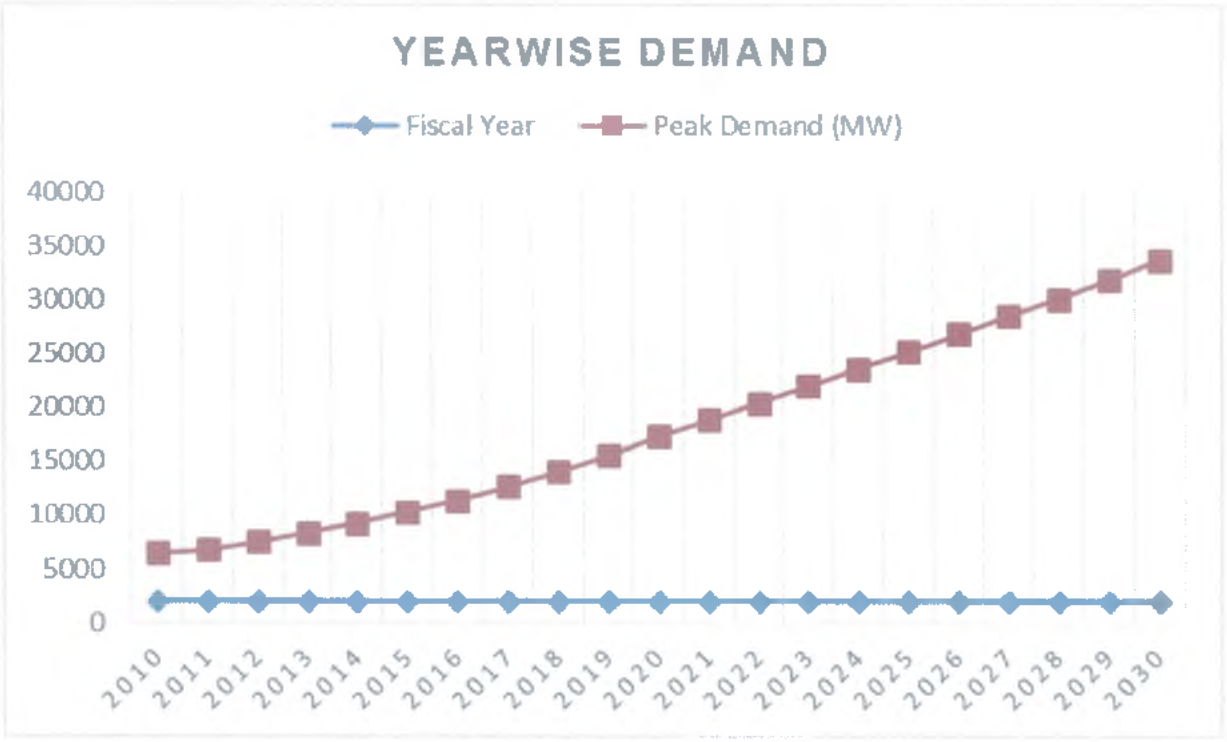
The Power System Master Plan – 2010 (PSMP-2010) of Government of Bangladesh (GOB) prioritizes the use of domestic primary energy sources. However, in the event of domestic energy supplies are not enough to fulfill the rapid demand growth for electricity, it will be necessary to tap into other fuel sources from outside the Bangladesh. Achieving the best mix of energy supply including imported resources, it would facilitate sustainable, economical and stable power generation or supply system of the country complying environmental regulations and protection measures. Especially coal will be an important resource as the primary energy supply in Bangladesh hereafter, due to, (i) its price stability and lower volatility compared with oil and natural gas, (ii) longer reserve to production ratio compared with oil and natural gas, and (iii) its wide spread availability throughout the world and is expected to be supplied stably. In the PSMP-2010 demand forecast was made based on 7% GDP growth rate. The electricity development is required to be accelerated to increase access and attain economic development. The desirable economic growth rate would be about 7% per annum. According to PSMP-2010 Study year-wise peak demand forecast is given below.

Table1.1: Demand Forecast as per PSMP-2010

Fiscal Year	Peak Demand (MW)	Fiscal Year	Peak Demand (MW)
2010	6,454	2021	18,838
2011	6,765	2022	20,443
2012	7,518	2023	21,993
2013	8,349	2024	23,581
2014	**9,268**	2025	25,199
2015	10,283	2026	26,838
2016	11,405	2027	28,487
2017	12,644	2028	30,134
2018	14,014	2029	31,873
2019	15,527	2030	33,708
2020	17,304		

Source: Power System Master Plan 2010

Figure1.1: Demand Forecast as per PSMP-2010 presented graphically



From the historical record of installed and derated capacity of power sector of Bangladesh from FY 1974-75 to FY 2013-14, it is known that the installed capacity was only 667 MW in FY 1974-75 which has been increased to 10,416 MW in FY 2013-14. Moreover, GOB is always behind to meet the demand and not to utilize the installed capacity properly.

Table1.2: Historical Installed & Derated Capacity

Fiscal Year	Installed Capacity (MW)	Derated Capacity (MW)	Fiscal Year	Installed Capacity (MW)	Derated Capacity (MW)
1974-75	**667**	490	1995-96	2,908	2,105
1975-76	766	606	1996-97	2,908	2,148
1976-77	767	571	1997-98	3,091	2,320
1977-78	752	557	1998-99	3,603	2,850
1978-79	718	571	1999-00	3,711	3,549
1979-80	822	625	2000-01	4,005	3,830
1980-81	813	707	2001-02	4,234	3,883
1981-82	857	712	2002-03	4,680	4,368
1982-83	919	810	2003-04	4,680	4,315
1983-84	1,121	998	2004-05	4,995	4,364
1984-85	1,141	1,018	2005-06	5,245	4,614
1985-86	1,171	1,016	2006-07	5,202	4,623
1986-87	1,607	1,442	2007-08	5,305	4,776
1987-88	2,146	1,859	2008-09	5,719	5,166
1988-89	2,365	1,936	2009-10	5,823	5,271
1989-90	2,352	1,834	2010-11	7,264	6,639
1990-91	2,350	1,719	2011-12	8,716	8,100
1991-92	2,398	1,724	2012-13	9,151	8,537
1992-93	2,608	1,918	**2013-14**	10416	9,821
1993-94	2,608	1,881	**2014-15**		
1994-95	2,908	2,133	**2015-16**		

Source: Bangladesh Power Development Board

The installed capacity of electricity by fuel type from FY 1997 to FY 2014 is as shown in the following table. Natural gas is the primary fuel source having contribution of 62.16 % in total installed capacity in FY 2013-14. The coal based power plant has come into existence in 2006 and its capacity is 250 MW which is only 2.4% of total installed capacity. There is only one hydro power plant in Bangladesh with a capacity of 230 MW (2 units of 40MW and 3 units of 50 MW) and it is located in the southern part of Bangladesh in Chittagong hill tracts. In recent years, the installed capacity of liquid fuel based power plant is increasing gradually. The total installed capacity of liquid fuel (HFO, HSD) based power plant was 503 MW in FY 1996-97 which has increased to 2,961 MW in FY 2013-14. An increase of 1,039 MW in installed capacity of HFO based power plant from 802 MW to 1,841 MW can be noticed in FY 2011-12. This is due to the fact that the availability of natural gas fuel has been decreasing gradually over the last few years.

Table1.3: Historical Installed Capacity by Fuel Type

Year	Hydro	Natural Gas	HFO	HSD	Coal	Import	Total
1996-97	230	2,175	242	261	0		2,908
1997-98	230	2,365	242	254	0		3,091
1998-99	230	2575	462	336	0		3,603
1999-00	230	2,675	462	344	0		3,711
2000-01	230	3,281	346	149	0		4006
2001-02	230	3,513	342	149	0		4,234
2002-03	230	3,956	340	155	0		4681
2003-04	230	3,956	336	158	0		4,680
2004-05	230	4,271	342	152	0		4,995
2005-06	230	4,271	342	152	250		5,245
2006-07	230	4,228	339	155	250		5,202
2007-08	230	4,354	283	188	250		5,305
2008-09	230	4,768	283	188	250		5,719
2009-10	230	4,822	335	186	250		5,823
2010-11	230	5,301	802	681	250		7,264
2011-12	230	5,862	1,841	533	250		8,716
2012-13	230	6,175	1,963	533	250	500	9,651
2013-14	230	6,475	2,107	854	250	500	10,416

Source: Bangladesh Power Development Board

Power plants with the total capacity of 8,613 MW will be dismantled by 2040, among which 4,843 MW from the public sector and 3,770 MW from the private sector. The 3,770 MW from the private sector will go into retirement by 2026. The following Table is the retirement schedule of power plants from FY 2012 to FY 2040:

Table 1.4: Retirement Schedule of Power Plants from FY 2012 to 2040

FY	Retired Derated Capacity (MW)			FY	Retired Derated Capacity (MW)		
	Public	Private	Total		Public	Private	Total
2013	0	53	53	2027	104	0	104
2014	81	110	191	2028	0	0	0
2015	185	0	185	2029	190	0	190
2016	72	33	105	2030	105	0	105
2017	188	0	188	2031	203	0	203
2018	0	525	525	2032	538	0	538
2019	118	643	761	2033	177	0	177
2020	0	0	0	2034	0	0	0
2021	280	405	685	2035	150	0	150
2022	611	501	1112	2036	210	0	210
2023	206	21	227	2037	142	0	142
2024	180	472	652	2038	313	0	313
2025	0	197	197	2039	0	0	0
2026	570	810	1380	2040	220	0	220

Source: Bangladesh Power Development Board

The power sector of Bangladesh is highly dependent on natural gas and the dependency is increasing. A sharp increase in gas consumption can be noticed after the FY 1998-99 and till 2012-13. Very recently the gas consumption in power sector is noticed to be decreasing. It is assumed that from FY 2013-14, the gas consumption in power sector started declining and to continue unless Bangladesh is blessed with new gas field exploration and imported LNG supply to the national gas grid. As, the natural gas being in low producing, Bangladesh is looking for alternative sources of power generation in the future. Coal, Nuclear and Renewable Energy sources are holding the key to the puzzling situation. These facts prompt the GOB to plan for the diversification of fuel. By the year 2030, the fuel source for power generation will look as follows.

Figure 1.2: Fuel diversification, 2030

To meet the increasing demand of this country and according to the PSMP-2010 of GOB, BPDB has taken initiatives and planned to generate 24,000 MW up to 2021 and 39,000 MW up to 2030. Therefore, Rural Power Company Limited (RPCL) intend to build 1,670 MW coal based power plant(s) at Patuakhali or Munshiganj District of Bangladesh within 2021. With this objective of fuel diversification for sustainable power generation and reliable electricity supply, RPCL has initially planned to install a 350MW coal fired thermal power plant at Gazaria, Munshiganj. Accordingly, a committee formed with the members from RPCL officials to select a probable location at Gazaria Union in Munshiganj District with a view to set up the new coal based power plant. The entity shall also select Consultants for the detail Feasibility Study (Technical and Financial Study) for developing a 350MW coal based power plant and to conduct the Initial Environmental Examination (IEE), Environmental Impact Assessment (EIA) and Social Impact Assessment (SIA) to identify possible Environmental and socio-economic impacts with possible mitigation measures and a tentative Environmental Management Plan.

1.2 FLOW OF THE STUDY

With the essence of the Project, RPCL engaged Consultants for a Detail Feasibility Study and took initiatives to justify the Project at the proposed site area based on the Feasibility Study as well as Environmental Impact Assessment.

The main objective of this study is to prepare a Feasibility Study Report to make the decision and to take further steps to implement the Project. Therefore, this study includes a comprehensive study where the study of the fundamental conditions or parameters for the Project (land survey, hydrological and morphological study of the adjacent river, ground water modeling of surrounding area, inland waterways, coal sourcing, availability and coal transportation, heavy equipment transportation, efficient technology, power evacuation, legal aspects, environmental issues, and so on) are added. In addition, the consultant shall carry out economic and financial analysis in order to take decision that the Project is commercially feasible or not.

1.3 STUDY TEAM

The study team or study executor body is consisting of two teams, one is RPCL Team from the Client's side and another is Consultants' Team.

Client	Consultant
Rural Power Company Limited	Joint Venture of O&M Solutions Private Limited, India [Lead], O&M Solutions Bangladesh Ltd., Bangladesh and, Center for Environmental and Geographic Information Services, Bangladesh

Study Executing Body

RPCL Team	Consultant Team
Executive Director (Engineering)	Team Leader
Chief Engineer (P&D)	Deputy Team Leader
Project Director & Superintending Engineer (P&D)	Other Consultants

According to the Terms of Reference provided by RPCL, a multidisciplinary team has been formed for the Feasibility Study and Environmental Assessment. The team members with their positions are presented in the table below.

Table 1.5: Consultant Team

Serial	Name of Professional	Proposed Position
1	Mohan Shankar Deshpande	Team Leader
2	Subhendu Beura	Electrical Engineer
3	Debjeet Swain	Mechanical Engineer
4	Md. Sayedul Hoque Khan	Maritime Engineer
5	Md. Maqbul-E-Elahi	Coal Expert
6	Abu Syed Md. Shykul Islam	Economist/ Financial Expert
7	Sultan Ahmed Chowdhury	Transportation and Transshipment (Coal)
8	Jogesh Chandra Shee	Coal Handling Expert including Jetty
9	Md. Nuruzzaman	Legal Adviser
10	Md. Korban Ali	Civil Engineer
11	Dr. Mehedi Ahmed Ansary	Geotechnical Specialist
12	Hasan Mahmud	Hydrologist and Navigation Expert
13	Khan Md. Wahid Palash	Hydraulic and Hydrodynamic Modeler
14	Abu Musa Md. Abdullah	GIS and AutoCAD Specialist
15	Dr. Mollah Md. Awlad Hossain	RS Specialist
16	Kazi Md. Noor Newaz	Environmental Expert
17	Md. Sarfaraz Wahed	Water Resources Engineer
18	Dr. Maminul Haque Sarker	Morphologist
19	Md. Amanat Ullah	Ecologist
20	Dr. Dilruba Ahmed	Socio Economist
21	Mohammed Mukteruzzaman	Fisheries Specialist (Biologist)
22	Taslima Islam	Environmental Law Specialist
23	Mujibul Hoque	Soil and Agricultural Specialist
24	Tofael Ahmed	Coal Power Tariff Expert
25	Mohammad Nazrul Islam	Chemical Engineer

The following staffs have been engaged to support the Consultant Team during the feasibility study for the smooth and on time execution of the deliverables.

Serial	Name of Professional	Proposed Position
1	Zahid Uddin Ahmed	Deputy Team Leader
2	Tarique Saifullah	Project Coordinator
3	Anwarul Kabir	Mechanical Engineer
4	Abdullah Bin Hossain	Electrical Engineer
5	Kamrul Hasan	Mechanical Engineer
6	Tahsin Ahmed	Electrical Engineer
7	Debashish Saha	Civil Engineer

1.4 SCOPE OF SERVICES

The scope of services of the Consultant is to evaluate the study area with necessary discussions and analysis in coordination with the Client. In the feasibility study level, the area has been surveyed and necessary data and information have been collected to analyze and to determine whether the project is suitable to implement or not, considering the marine and river coal transportation, power evacuation systems, availability of water, technical and environmental considerations, etc.

Finally, a detailed feasibility study report will be submitted which will cover both technical and financial aspects including methodology of coal price determination, draft coal supply agreement (CSA), draft power purchase agreement (PPA) and draft tender documents.

Moreover, Initial Environmental Examination (IEE), Environmental Impact Assessment (EIA), Social Impact Assessment (SIA) and Resettlement Action Plan (RAP) of the proposed Gazaria 350MW Coal Fired Thermal Power Plant Project are in progress simultaneously with the Feasibility Study.

The site of the proposed power plant project has been selected by RPCL in the area of Gazaria, Munshiganj, Bangladesh upon in-house study of RPCL. The Consultant is to evaluate the selection of the site for the proposed Gazaria 350 (±10%) MW Coal Fired Thermal Power Plant Project at Gazaria, Munshiganj, Bangladesh with the provision of future expansion is based on the following issues (scope of services) but not limited to:

(1) Availability of sufficient area for a 350MW Coal Fired Thermal Power Plant Project with possible future expansion, considering the standard practice for the area required for each individual items such as main power plant area including boiler-turbine generator building, water treatment plant, cooling tower (if technologically is suitable) or once

through cooling systems, coal unloading jetty, cooling water intake facility, coal storage facility, ash pond, flue gas desulfurization systems, workshop and warehouse, administrative building, residential area, etc.

(2) In any part of Bangladesh, it is not apparently possible to get a considerable area of land without human habitation. However, during the evaluation of the selected site, it is to be considered to avoid as much as possible to minimum number of settlements.

(3) The main fuel of the power plant is to be imported coal. The evaluation is to be justifiable for economic and reliable transportation of coal to the power plant during operation. This will also ensure the availability of water during construction and operation of the coal fired power plant.

(4) A preliminary data and information is to be collected for the draught of the river through the possible coal transportation route. More authentic information might be collected from bathymetric survey data or river chart prepared by other government or non-government organizations (BIWTA, Bangladesh Navy, etc.).

(5) The river flow maps found from the available maps, maps prepared by Survey of Bangladesh (SOB), and using google-maps has been considered. This provides a recent map of the rivers which shows any sharp change of flow direction. This observation of the nature of change of flow direction of the river will allow identifying and understanding the trends of erosion prone area of certain location.

(6) Vulnerability to natural disasters has been considered in evaluation of the selected site.

(7) Suitability of road transportation facility is under consideration so that during the project development, construction and operation stages, the site could be easily accessible.

(8) The availability of 400kV/ 230kV power evacuation facilities for the proposed 350MW coal fired thermal power plant, 400kV/ 230kV grid sub-station and associated transmission system to the district town or upazila town close to the proposed power plant site of RPCL is under study by the Consultant in close contact / discussion with PGCB to connect to the national power grid systems.

(9) Environmental issues are under consideration in evaluation of the proposed project site.

(10) Legal issues relating to the power plant has been considered in evaluation of the proposed project site.

(11) Financial and Economic analysis of the Project will be included in the detail feasibility study report.

1.5 SECONDARY DATA AND DOCUMENTS

The Consultant has collected and purchased all the necessary information, data and documents (basically, historical data, detailed survey data, planning and development information, map and route, charts etc. related to the project and site) from the following government organizations of Bangladesh (not limited to):

- Bangladesh Power Development Board (BPDB)
- Rural Electrification Board (REB)
- Power Grid Company of Bangladesh Ltd. (PGCB)
- Bangladesh Inland Water Transport Authority (BIWTA)
- Bangladesh Water Development Board (BWDB)
- Institute of Water Modelling (IWM)
- Soil Resource Development Institute (SRDI)
- Water Resources Planning Organization (WARPO)
- Bangladesh Meteorological Department (BMD)
- Department of Environment (DOE)
- Bangladesh Forest Department (BFD)
- Roads and Highway Department (RHD)
- Directorate of Land Records and Surveys (DLRS)
- Local Government Engineering Department (LGED)
- Department of Public Health Engineering (DPHE)
- Bangladesh Bureau of Statistics (BBS)
- Survey of Bangladesh (SOB)
- Public Works Department (PWD)
- Deputy Commissioner's Office (DC Office) of Munshiganj District
- Munshiganj Sadar Upazila Agriculture Office
- Munshiganj Sadar Upazila Fisheries Office
- Chittagong Port Authority (CPA)
- Bangladesh Navy Hydrographic and Oceanographic Centre (BNHOC)
- Bangladesh Bridge Authority (BBA)

1.6 ENTITY BACKGROUND

Rural Power Company Limited, hereinafter referred as "RPCL" or "Client", is a state owned Power Generation Facility of Bangladesh. Rural Power Company Limited is registered as a public limited company under company ACT 1913, was incorporated on 31st December, 1994 under the company laws for enhancement of Power generation facilities with business philosophy and principles fulfilling national benefits.

Rural Power Company Limited is committed to reliable power generation for Rural Development and also to take part in social & economic development for rural people of the country.

Rural Power Company Limited has opened a new dimension of power generation in Power sector of Bangladesh, because the 100% investment is mobilized locally for implementation of 2x35 MW GT under Phase-II except the 2x35 MW GT under Phase-I of Mymensingh 210 MW CCPP which was partially financed by ADB. This is absolutely a National Company in the private sector. This will raise the confidence of investors in the Power Generation Sector.

RPCL has implemented successfully three (03) nos. of Power Plant located at Mymensingh, Gazipur and Chittagong district of Bangladesh having a total Capacity of 287 MW. The Mymensingh 210MW Gas based Combined Cycle Power Plant was commissioned in 1999 as Open Cycle and started it's Combined Cycle operation on 2007. The Gazipur 52MW Dual Fuel Power Plant (HFO/ Gas), presently operated in HFO and commissioned in 2012. The Raozan 25MW Dual Fuel Power Plant (HFO/ Gas), presently operated in HFO and commissioned in 2013. Moreover RPCL has implemented its 150MW Dual Fuel Power Plant at Kadda, Gazipur on Joint Venture basis with Bangladesh Power Development Board (BPDB). All the generated power is sold to BPDB under individual Power Purchase Agreement.

RPCL has taken an intensive plan in order to extend its New Generation Capacity of 2730 MW under the direction of Power Division. Proposed Gazaria 350 (±10%) MW Coal Fired Thermal Power Plant Project is a part of this planning.

The following Four (04) are the completed Project of RPCL:

Mymensingh 210 MW Combine Cycle Power Plant Project

Project Location	:	**Mymensingh, Bangladesh**
Executive Agency	:	Rural Power Company Ltd.
Phase I	:	
Configuration	:	2 X 35 MW Gas Turbine (GEEPE, France, PG6551B)
Total Cost	:	BDT 2359.00 Million
Gas Turbine Model	:	Type PG6551B & PG6561B (GE, France)
Generator Model	:	Type T600C(ALSTOM, France)
Commercial Operation Date	:	November 1999
Phase II	:	
Configuration	:	2 X 35 MW Gas Turbine (GEEPE, France, PG6561B)
Total Cost	:	BDT 1673.00 Million
Gas Turbine Model	:	Type PG6551B & PG6561B (GE, France)
Generator Model	:	Type T600C(ALSTOM, France)
Commercial Operation Date	:	December 2000
Phase III	:	
Configuration	:	1 X 70 MW Steam Turbine (Siemens, Germany, NK 90/3.2)
Total Cost	:	BDT 11046 Million
Steam Turbine Model	:	NK 90/3.2 (Siemens, Germany)
Generator Model	:	TLRI 100/36 (Siemens, Germany)
Commercial Operation Date	:	July 2007

150MW Duel Fuel Power Plant Project

Project Location	:	**Kadda, Gazipur Sadar, Gazipur**
Executive Agency	:	Rural Power Company Ltd.
EPC Contractor	:	M/S CCCE-ETERN-FEPEC JOINT VENTRUE (M/S. CEF JV.China)
EPC Cost	:	BDT 13098.00 Million
Total Project Cost	:	BDT 13789.00 Million
Fuel Type	:	Dual Fuel (Gas/HFO)
Manufacturer of Engine	:	MAN Diesel & Turbo SE. Germany
EPC Contract Signing Date	:	03 January, 2013
Commercial Operation Date	:	February, 2015

Gazipur 52 MW Dual Fuel Power Plant Project

Project Location	:	Kadda, Gazipur Sadar, Gazipur
Executive Agency	:	Rural Power Company Ltd.
EPC Contractor	:	Concord Pragatee Consortium Ltd.
EPC Cost	:	BDT 3060.66 Million
Fuel Type	:	Dual Fuel (HFO/Gas)
Engine	:	6 X 8.924 MW Engine WARTSILA, Finland, W20V32GD
Commercial Operation Date	:	July, 2012

Raozan 25 MW Dual Fuel Power Plant Project

Project Location	:	**Raozan, Chittagong**
Executive Agency	:	Rural Power Company Ltd.
EPC Contractor	:	Concord Pragatee Consortium Ltd.
EPC Cost	:	BDT 1878.732 Million
Fuel Type	:	Dual Fuel (HFO/Gas)
Engine	:	3 X 8.924 MW Engine WARTSILA, Finland, W20V32GD
Commercial Operation Date	:	May, 2013

FUTURE PROJECTS OF RPCL UNDER PLANNING:

No.	Name of Power Plant Project	Capacity (MW)	Fuel Type	Expected Date of Completion	Remarks
1.	Patuakhali 1320 MW Coal Based Thermal Power Plant	1320	Coal	30.06.2021	Site Selection Study completed, Finall selected site is Kalapara, Patuakhali, Feasibility Study including EIA and SIA is going on.
2.	Gazipur 450 (±15%) MW Combined Cycle Power Plant	450	Gas/ LNG	30.06.2021	PDPP approved by Power Division. The project will be implemented upon receiving Gas supply consent from Petrobangla. Proposal submitted to Power Division for Dual Fuel CCPP instead of Gas/LNG based CCPP
3.	Mymensingh 360(±10%) MW Combined Cycle Power Plant	360	Gas/ LNG	30.06.2021	PDPP approved by Power Division. The project will be implemented upon receiving Gas supply consent from Petrobangla. Proposal submitted to Power Division for Dual Fuel CCPP instead of Gas/LNG based CCPP
4.	Mollahat 100 (±10%) MW Solar PV Power Plant	100	Solar	30.06.2018	Site has been selected at Mollahat, Bagerhat. Detail Feasibility Study has to be conducted
5.	200 MW Wind Power Plant Project	200	Wind	100 MW within 2020 & 100 MW within 2030	Wind Mapping Project is going on, after completion of wind mapping in December 2017 suitable site will be selected for implementation

6.	Madargonj 100 MW Solar PV Power Plant	100	Solar	31.12.2019	Site has been selected at Madargonj. Detail Feasibility Study has to be conducted
7.	Boda 30 MW Solar PV Power Plant	30	Soalr	30.06.2019	Site has been selected at Boda. Detail Feasibility Study has to be conducted
	Total Capacity	**2560**			

FUTRE PLANNED PROJECTS OF RPCL:

Station Name	Fuel Type	Type	Installed Capacity (MW)	In Service FY	Retirement FY
Gazaria 350 (±10%) MW Coal Fired Power Plant, Unit 2	Coal-New	ST	350	2025	2050
Patuakhali 1320 MW Coal Fired Power Plant, Unit 2	Coal-New	ST	1320	2025	2050
Total Capacity			**1670**		

1.7 BASIC INFORMATION FOR APPRAISAL

Particulars	Remarks
Project	Gazaria 350 (±10%) MW Coal Fired Thermal Power Plant Project
Project Proponents	Rural Power Company Limited House No. 19, Road No. 1/B, Sector No. 09, Uttara Model Town, Dhaka -1230, Bangladesh
Consultant	Joint Venture of O&M Solutions Private Limited, India [Lead], O&M Solutions Bangladesh Ltd., Bangladesh and, Center for Environmental and Geographic Information Services, Bangladesh (JV-OMS-CEGIS). Flat # B1, House # CEN (D) 3, Road # 95, Gulshan - 2, Dhaka – 1212, Bangladesh.
Location	Gazaria, Munshiganj, Bangladesh
Capacity	350 (±10%) MW
Configuration	The power plant shall consist of 1 Steam Turbine Generator (STG) set, of 350 (±10%) MW capacity and 1 Super Critical Pulverized Boiler (SCPB) and the Balance of Plant (BOP) comprising of coal & ash handling plant, water treatment plant, flue gas desulphurization, compressed air system, electrical systems, instrumentation and control, power evacuation system, infrastructure facilities, chimney, jetty etc.
Basis of Selection of Identified Site	• Vicinity/ Proximity of the site is near to the capital city and load center of the country. • Availability of sufficient area for a 350MW Coal Fired Thermal Power Plant Project with possible future expansion, considering the standard practice for the area required for each individual items such as main power plant area including boiler-turbine generator building, water treatment plant, cooling tower (if technologically is suitable) or once through cooling systems, coal unloading jetty, cooling water intake facility, coal storage facility, ash pond, flue gas desulfurization systems, workshop and warehouse, administrative building, residential area, etc. • Considering the marine and river coal transportation, power evacuation systems, transportation of heavy equipment, availability of water, technical and environmental considerations, etc.
Land Use Pattern	Vacant land and cultivated land under seasonal crop production.

Broad Description of Site Location	The proposed site is located within two Mouza namely, Daulatpur (north) and Sholoani (south) of Imampur union in Gazaria Upazila under Munshiganj district. Daulatpur and Sholoani Mouza has been transected by a small river locally named as Uttar Khal which has been reached to the mighty river Meghna from East. The project site is surrounded by Mandartoli Mouza at East, Kalipur Mouza at South, river Meghna at West and Daulatpur Mouza at North.
Area of the Land Proposed	Acquired Land 330.60 Acres (Project Area Covers 314.10 Acres excluding Jetty Area)
Government Land/ Private Land	Mostly privately owned Land. To be acquired by Rural Power Company of Bangladesh
Topographical Features	• Reference Level = 5.76 mPWD (SOB Bench Mark No. 3469) • Average Height of Land = 3.08 mPWD • Lowest Height of Land = 1.88 mPWD • Highest Height of Land = 3.66 mPWD • Highest Flood Level = 6.83 mPWD (100 years return period, simulated) • Designed Elevation = 8.03mPWD
Nature of Soil	Silty Clay
Distance From Nearest Town	Narayanganj City is about 15km north-west of the Project Site
Distance From Water Source	On the Bank of the Mighty Meghna River
Area of Forest Land	No Natural Forest near Site.
Distance of Nearest Reserve/ Wild Life from Site	There is no reserve forest or wild life sanctuary near the site.
Nearest Notified Historical Place	Sonargaon Archeological Site (Panam City)
Details of Major Industries, Power Plants, Mines etc. near site	Meghnaghat Power Generation Complex, Cement Industries at Narayanganj and Munshiganj
Transportation Facility	Approach Road: 10 km via Village Road from Dhaka-Chittagong Highway Railway Station: Narayanganj. Airport: Hazrat Shahjalal International Airport, 56 km from project site. River port: Narayanganj.
Source of Fuel	Imported Coal
Transportation of Fuel	Marine and Inland waterways.
Capacity of Mother Vessel	40,000-60,000 DWT (Handymax)
Capacity of Cargo Vessel	2,500 tons

Water Sources and Availability	From Meghna River.	
Noise Emission	Turbine Room Noise Data: 85 - 90 db (A) Plant approximately > 65 db Plant boundary approximately < 60 db.	
Air Emissions	Number of Stack	No of Stack: 1; Bi-flue mechanism if expansion of second unit is planned. Height: 220m and Diameter: Internal Exit Diameter of Flue 4.5 m.
	Gas Exit Velocity	Approximately 23 m/sec
	Temperature of Exhaust Gas	140 ^{0}C
	Density of Exhaust Gas	0.86 kg/m^3
	Stack discharge pressure	0.992 kg/cm^2 at exit
	Exhaust Gas Flow	396 kg/sec
	Exhaust Gas Composition	- CO_2 13.550 % - O_2 4.780 % - SO_2 0.032 % - N_2 73.500 % - H_2O 7.258 % - Ar 0.8841%
Efficiency of FGD, Low NOx burner or SCR/SNCR, Electro Static Precipitator	99% efficiency (It can achieve 95% Sulphur dioxide removal without additives and 99% (+) removals with additives) 99% efficiency for Others	
Fuel Handling	Coal Unloading Jetty and Coal Handling Systems.	
Power Evacuation	Through Comilla-Meghnaghat 230kV National Grid Systems under PGCB.	
Project Schedule	36 Months (1095 Days)	

CHAPTER 03:
LOCATION OF THE PROJECT

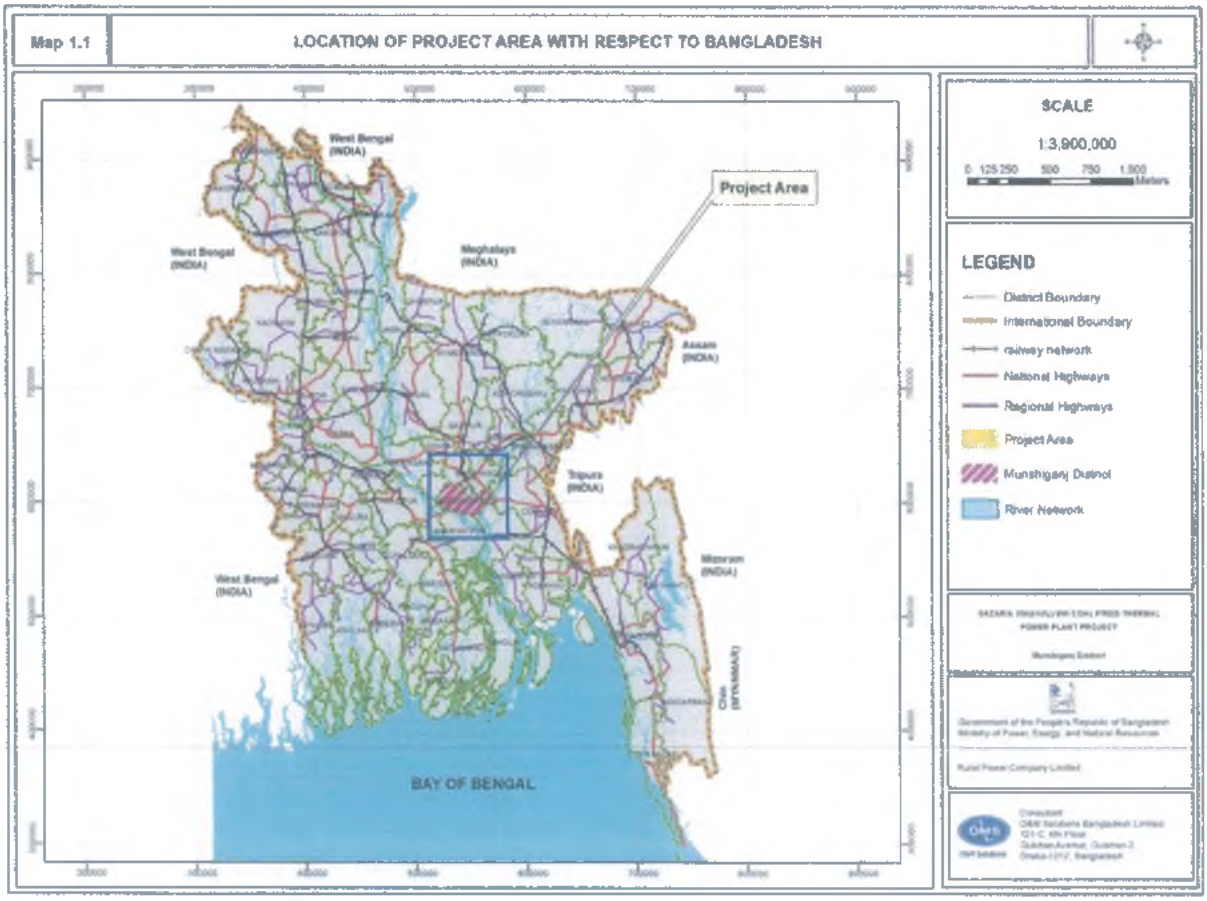
CHAPTER 03: DETAILS OF THE PROJECT SITE

3.1 PROJECT LOCATION

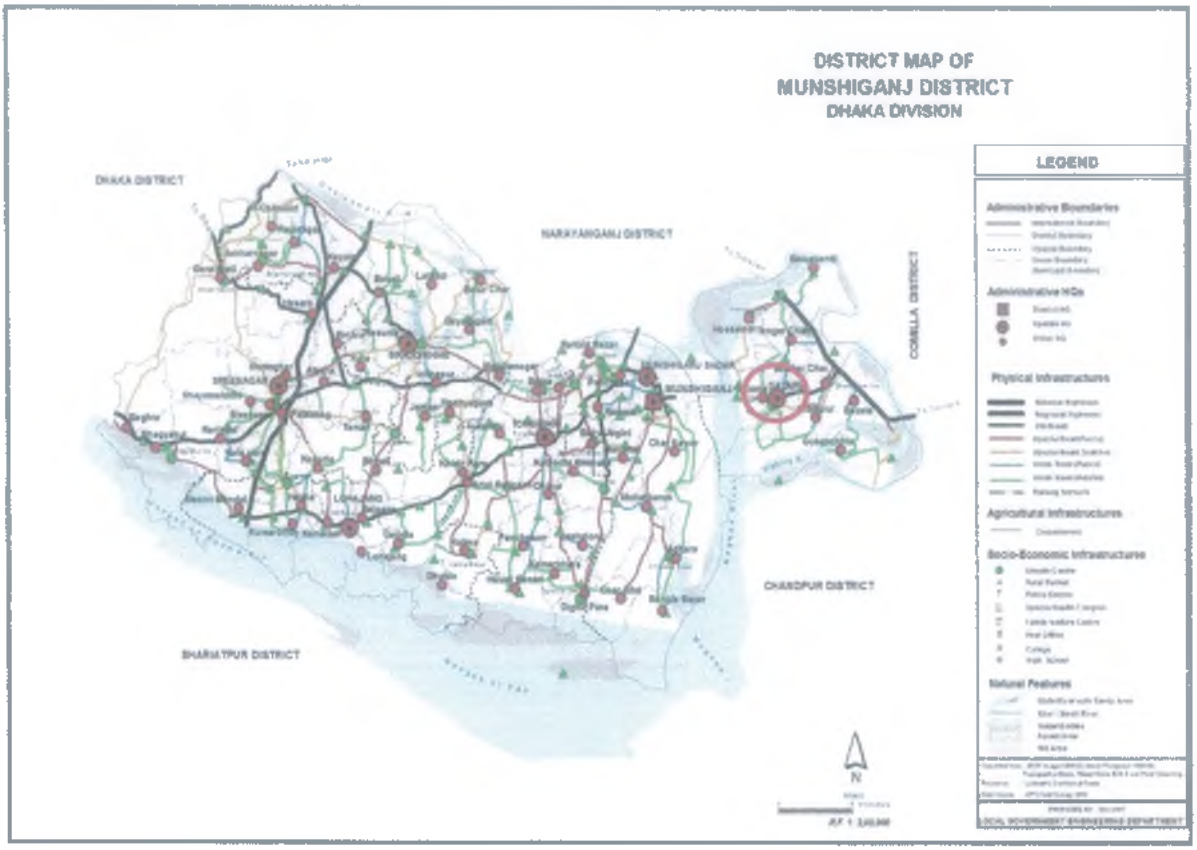
The proposed project site is located within two Mouza namely, Daulatpur (at north) and Sholo Ani (at south) of Imampur Union in Gazaria Upazila under Munshiganj District on the eastern bank of river Meghna. RPCL is in the process of acquiring project area of 330.60 acres out of which proposed power plant area will cover 314.10 acres. A Canal locally known as Pangashia Khal passes through the proposed project site from upper region to the Meghna River. The project site is surrounded by Andharmanik, Imampur and Karim Kha Mouza in East, Kalipur Mouza in South, Meghna River in West and Daulatpur Mouza in North.

The site is approximately 10 km from Gazaria Upazila head-quarter by road. It is approachable by an existing road network which is connected to the Dhaka – Chittagong highway at Bhoberchar Bazar. The project site is also approachable by waterway through the Meghna River from the Bay of Bengal. Heavy equipment and construction materials, machineries can be transported through water route.

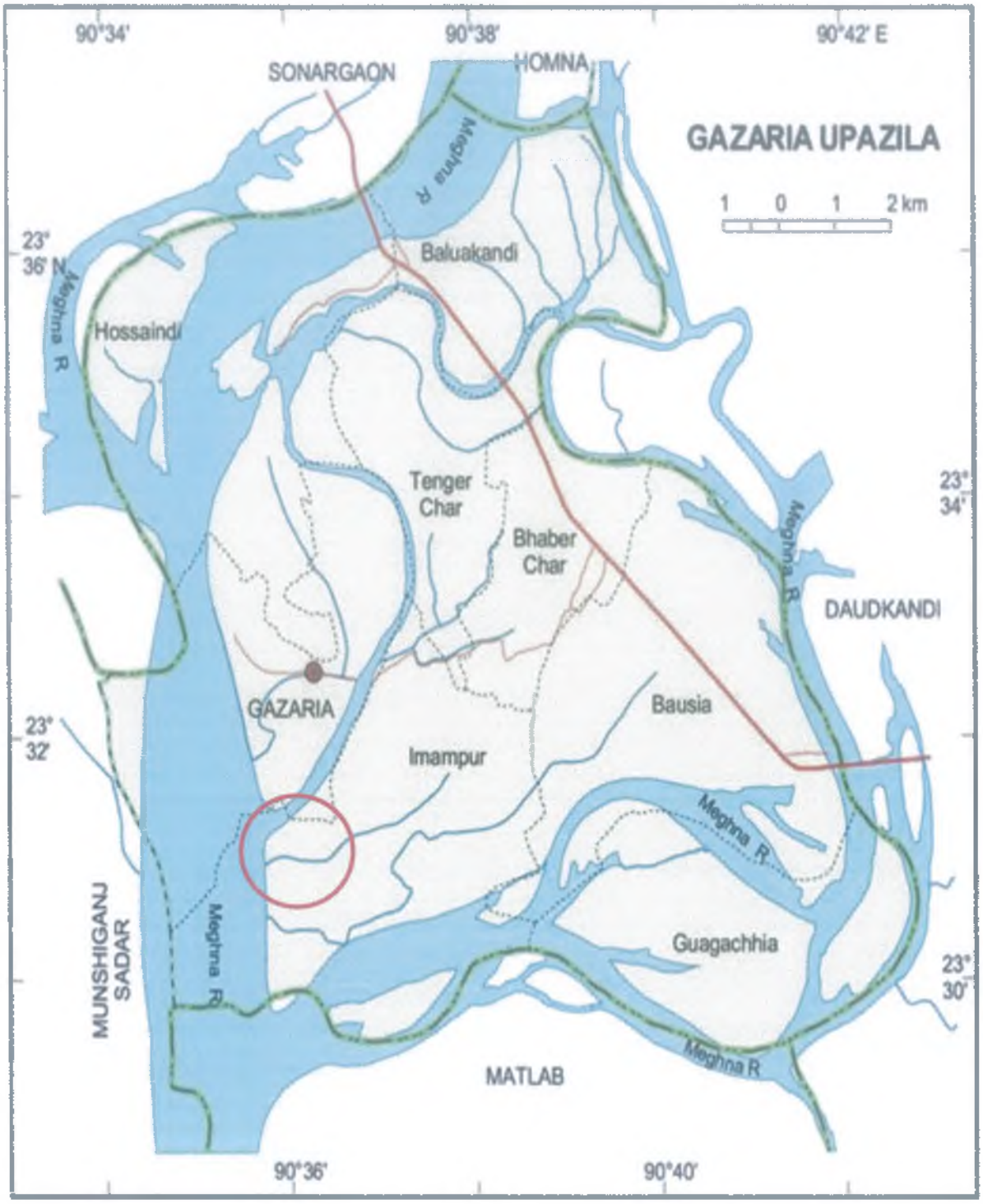
Map 3.1: Location of the Project Site with respect to Bangladesh



Map 3.2: Location of the Project Site with respect to Munshiganj District



Map 3.3: Location of the Project Site with respect to Gazaria Upazila



Map 3.4: Location of the Project Site in Google Map (earth view)

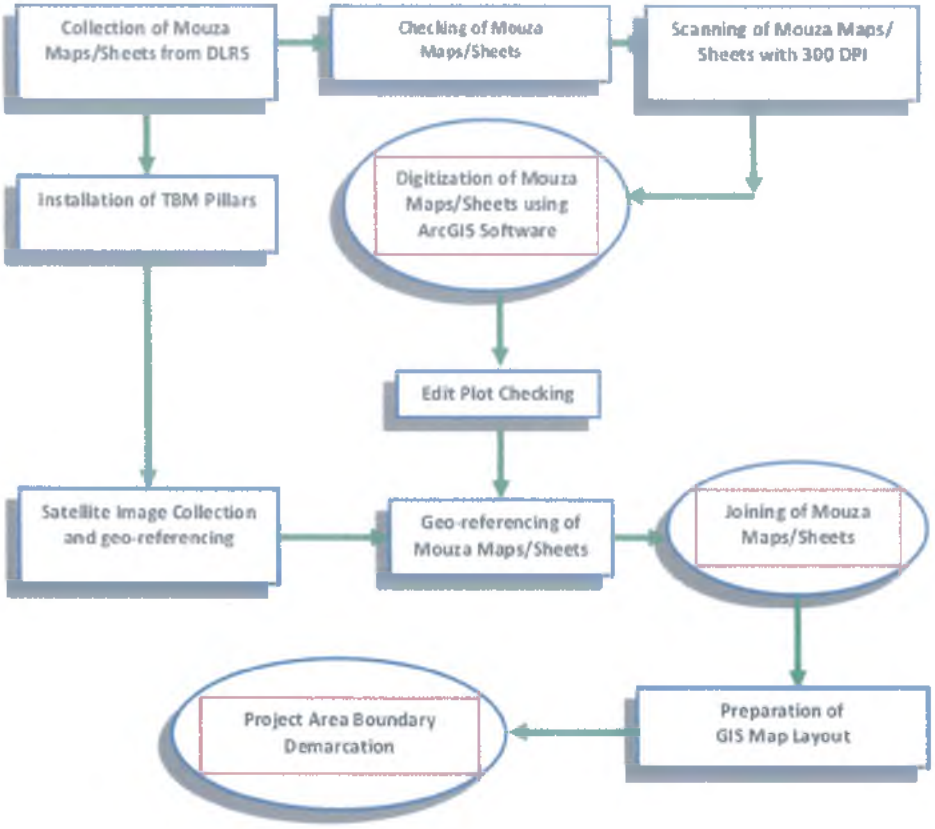
Map 3.5: Location of the Project Site in Google Map (map view)

3.2 BOUNDARY DEMARCATION PROCESS

Introduction

Preparation, compilation of base map and boundary demarcation contains lots of activities from collection of mouza maps/ sheets to mosaic maps/ sheets with geo-referencing. The sequential activities undertaken to prepare and compile base map are as follows:

Figure 3.1: Boundary Demarcation Process Flow Chart



Collection of Mouza Maps

Two RS (Revisional/ Revised Survey) mouza sheets have been collected from DLRS Office for the project area. Proposed power plant area is comprised of two mouza maps and these are presented in the Table 3.1.

Table 3.1: List of RS mouza maps covering the proposed power plant project area

Serial	Mouza	JL No	Sheet No	Coverage
1	Doulatpur	69	01	Partial
2	Soloani	70	01	Partial

Source: Compiled by the Consultants, 2016

Scanning of Mouza Maps/Sheets

Scanning of all the mouza maps/sheets started immediately after the collection from DLRS Office. The scanning was done with 300 DPI to obtain good quality image and saved as JPG format to be used later on for screen digitization.

Digitization of Mouza Maps/Sheets

The mouza maps/ sheets have been digitized as shape file through on screen digitization process using GIS based ArcGIS 10.0 software, having the scanned image on the background. During the digitization process, the view properties has been set as Map Unit = Inch and Distance Unit = Inch to get 1:1 map scale and zoom it into 1:50 scale for maintaining maximum accracy level. All the features of mouza maps/sheets are classified in three classes and they are digitized in three separate shape files as Line, Poly and Point.

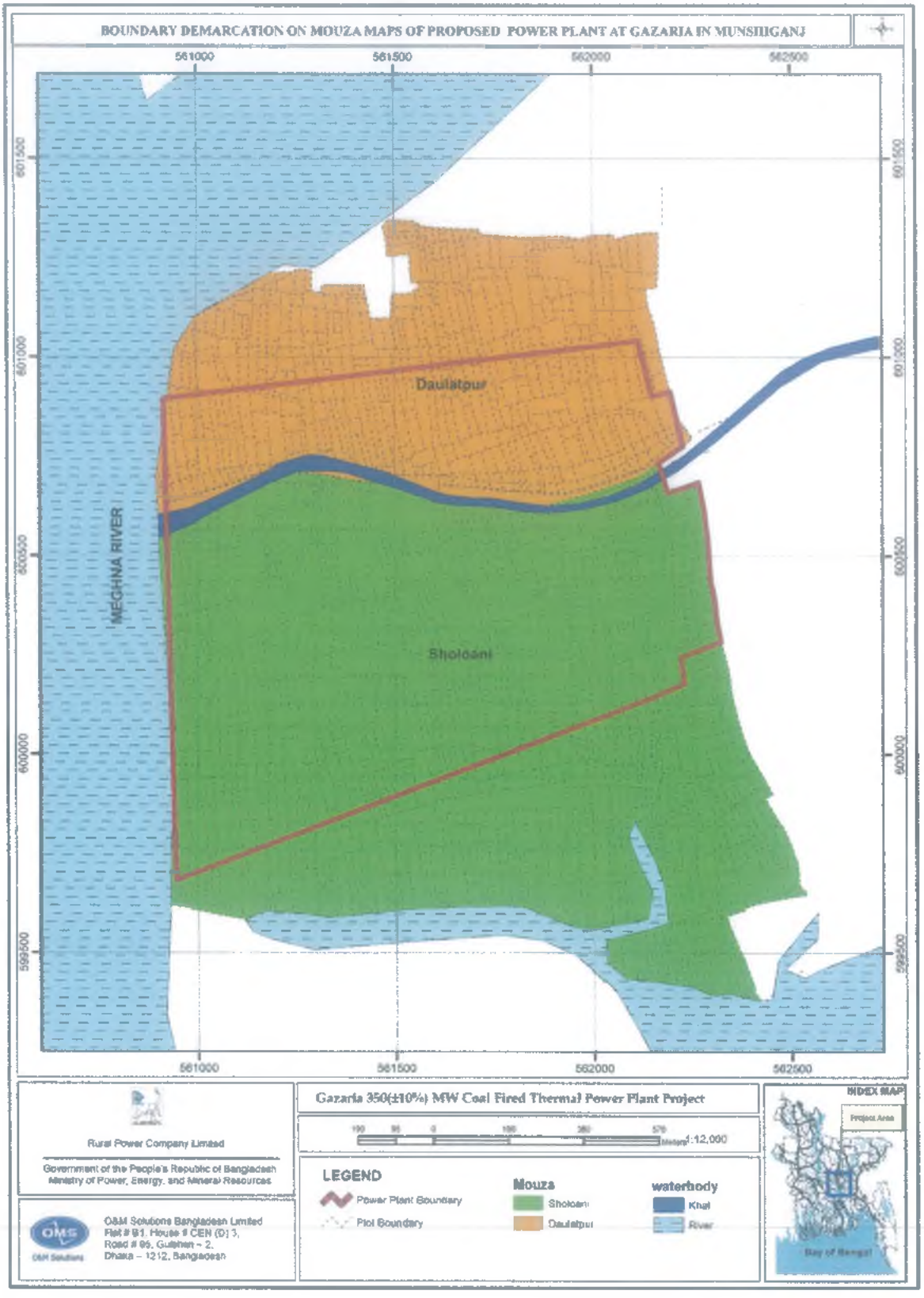
Geo-Referencing of the Mouza Sheets using Satellite Image

Map projection is the converting data from geographical location (latitude and longitude) on a sphere or spheroid to a representative location (two dimensional coordinates such as northing and casting) on a flat surface. A mathematical conversion used to create a flat map from the spherical surface of earth. This mathematical conversion or transformation of three-dimensional earth surface into a two dimensional flat map is called 'Projection'. Geo-referencing of digitized mouza sheets/maps is the projection of mouza maps from digitized unit to real world coordinate units or transformation of coverage from digitized units to projected units. It is mentioned that, all spatial data and maps have been prepared in Bangladesh Transverse Mercator (BTM) projection system. Latest Satellite images were collected and geo-referenced using above mentioned BTM parameter. After that individual digitized mouza sheets have been transformed on these combined referenced Satellite images. Same procedure has been applied for the referencing of all mouza sheets.

Joining of Mouza Maps/ Sheets and Demarcating the Study Area/ Boundary

After geo-referencing all digitized mouza maps, they are merged or joined using ArcGIS software. And thus a compiled base map has been prepared for the Project area. Boundary of the Project area has been demarcated on this prepared base map and after field verification; the boundary of the project area has been finalized.

Map 3.6: Boundary Demarcation on Mouza Maps of the Proposed Power Plant Area



3.3 SURVEY ACTIVITIES

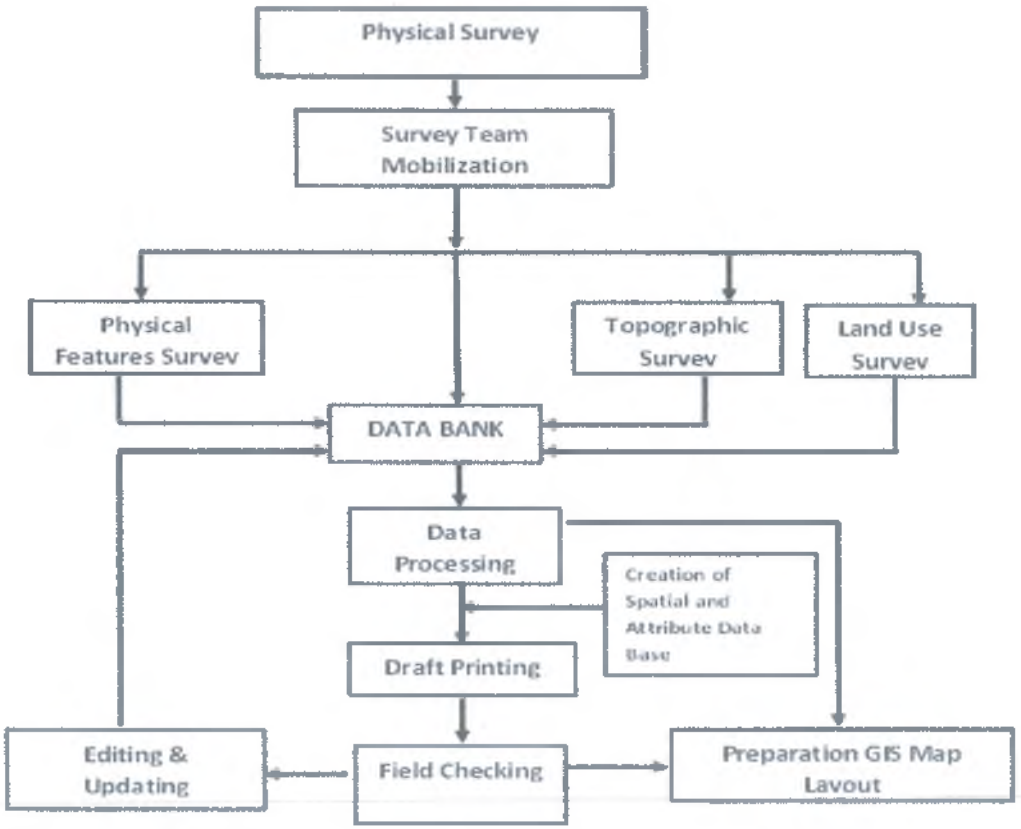
Introduction

Conducting of topographic and physical feature survey is the prime requisite for the successful accomplishment of the Power Plant Project under RPCL. As instructed, all the surveys have been carried out as per TOR requirement and suggestion of Project Director. GPS and Total Station (TS) based advanced survey techniques were used for conducting topographic and physical feature and land use surveys. GIS technique was used for data processing and preparing all type of survey maps.

Methodology

Methodologies applied for conducting topographic and physical feature survey for Project Area are presented in the following chart and details have been given on the later in this chapter.

Figure 3.2: Methodological Flowchart of Physical Survey



The survey operations were carried out in phases as described below.

Phase 1: Survey Team Mobilization

In Phase 1 the survey team was mobilized. The team leader of the survey team visited the site to have a reconnaissance view of the area and get introduced with the concerned authorities

Phase 2: Setting up of BM Pillars

Value of Reduced Level (RL) was collected from SOB reference BM which is located at Harganga Degree College in Munshiganj Sadar. This collected RL has been used during setting up Temporary Benchmark (TBM) for the project area.

Phase 3: Topographical Survey

The Phase 3 started after determination of BM pillar, when topographic survey was carried out with the help of total station. GPS was used to find x, y values needed for geo-referencing maps. Spot levels were taken as per TOR direction to draw contour map of the project area.

Phase 4: Physical Feature and Land Use Survey

In Phase 4 physical feature and land use surveys were carried out. Each and every structure including type of construction, storey, vegetation, road, bridge/ culvert, and all other features on the surface of the earth were picked up. Attribute database was created for polygon, point and line features. Based on the attribute and spatial features on map a preliminary existing land use map was created. Several verifications and corrections were made before finalization of the land use map. Extensive use of satellite imagery was made to quicken and authentication of the physical feature and land use map.

3.4 SURVEY FINDINGS

General Topographic Condition of Project Area

The spot levels are denser, where the undulation of project land is frequent. The contours have been drawn from the spot level data with an interval of 0.5 mPWD and the grid interval was 5 m. As per specified interval of spot level survey, heights (value) of 779 spots have been collected from the field level survey. The lowest spot height is 3.070 mPWD while the highest spot height is found 4.970 mPWD within the Project area. Average land height of the

project area is 3.08 mPWD. Details have been presented in the Table 3.2 below. The representative height is between 3.00 mPWD to 3.50 mPWD, which comprises about 39.79% of the spots surveyed (Table-3.3). Map 3.10 shows the elevation of land surface and Map 3.11 shows the contours in the Project area.

Table 3.2: Unit wise spot height in the project area

Spot unit	Value (mPWD)
Total Spot Number	779
Mean	3.0863555841
Maximum Height	4.9700000000
Minimum Height	0.3070000000
Variance	0.4463583425
Standard Deviation	0.6681005482

Source: Topographic Survey by the Consultants, 2016

Table 3.3: Percent distribution of spot according the height interval

Spot interval	Spot number (Frequency)	Percentage
Below 1.0	15	1.93
1.00 - 1.50	16	2.05
1.50 –2.00	28	3.59
2.00 –2.50	57	7.32
2.50 –3.00	129	16.56
3.00 – 3.50	310	39.79
3.50 - more	224	28.75

Source: Topographic Survey by the Consultants, 2016

Land Use Survey

It is clearly evident that agricultural land use is seasonal. During Moonsoon time no appreciable utilization of the land for agriculture purpose was observed. With about 93% of the share of total land uses cover the study area. Agriculture land use includes all types of cultivated land/ barren land.

Table 3.4: Existing Land Use of the Project Area

Land Use Category	Area in Acres	Percentage (%)
Agriculture	308.78	93.40
Water body	16.79	5.08
Settlement Area	5.02	1.52
Total	**330.60**	**100.00**

Source: Land Use Survey by the Consultants, 2016

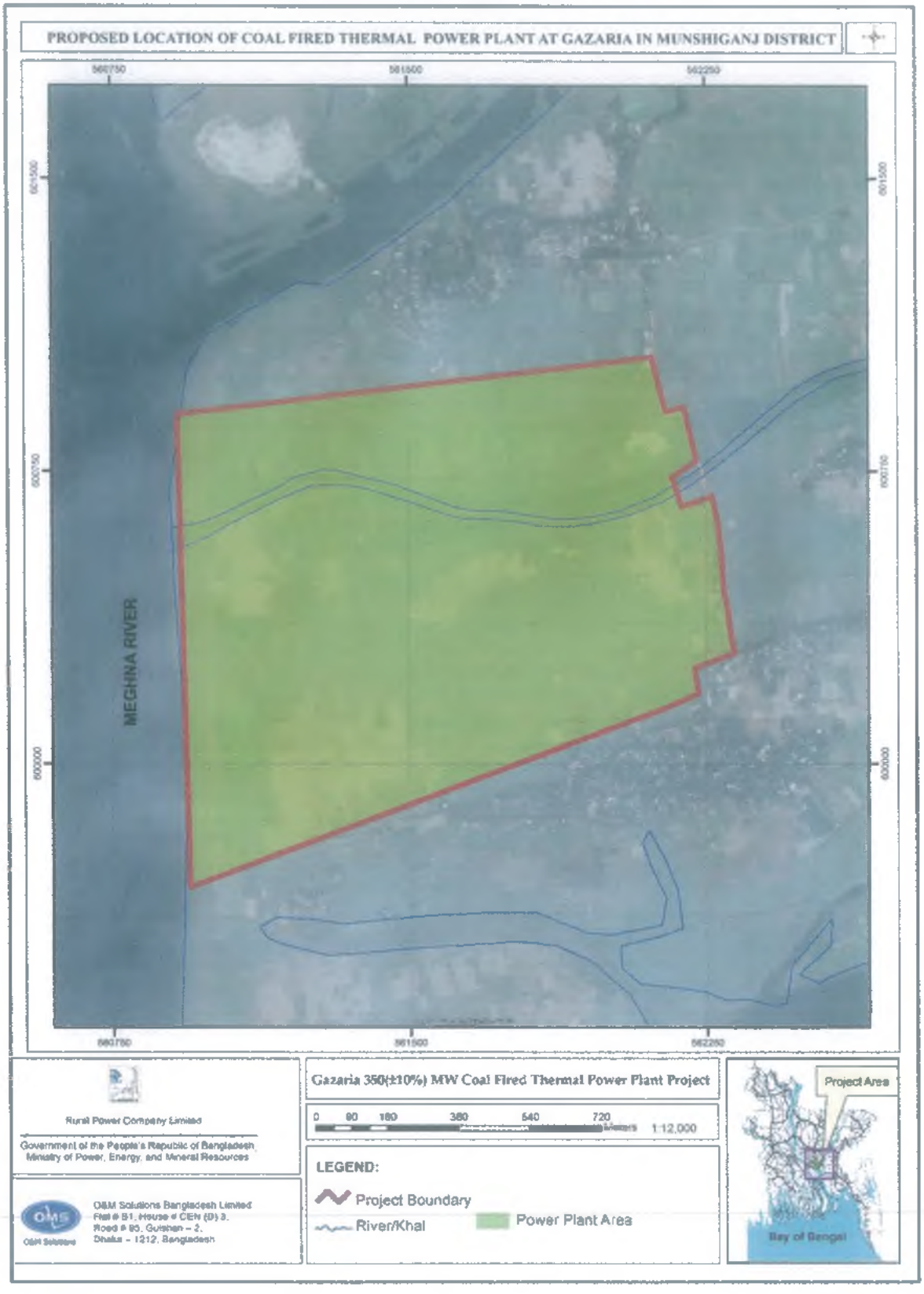
In the entire Project area the major land use goes to Agriculture that constitute 316.43 acres which is 93.40% of the total Project area. The second major land use is waterbody that occupy 5.08% (17.19 acres) of the project area. Details about land use have been provided in Table 3.4 and generalized land use pattern of Project area has been presented in Map 3.9.

Physical Feature Survey

The findings of physical feature survey consist of all structures according to their uses as residential, commercial, education, religious, and community facilities, roads, waterbodies, etc.

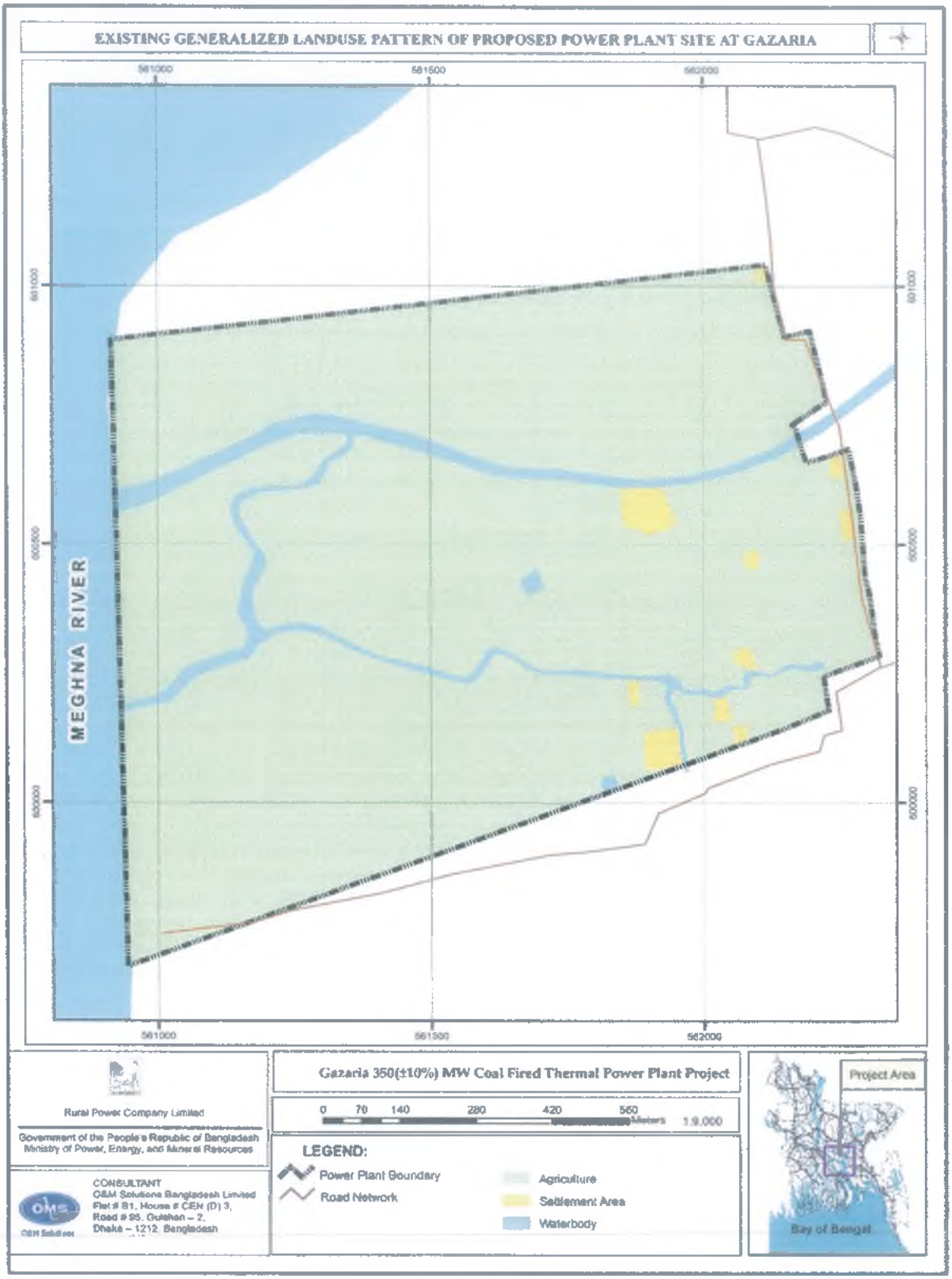
It has been found from physical feature survey that there exist only 24 number settlements within the proposed project area. The existing structures are mostly katcha and semi-pucca in nature. It has been also found that all the existing structures are single storied residential structures within the project area.

Map 3.7: Location of the Project Site beside Meghna River

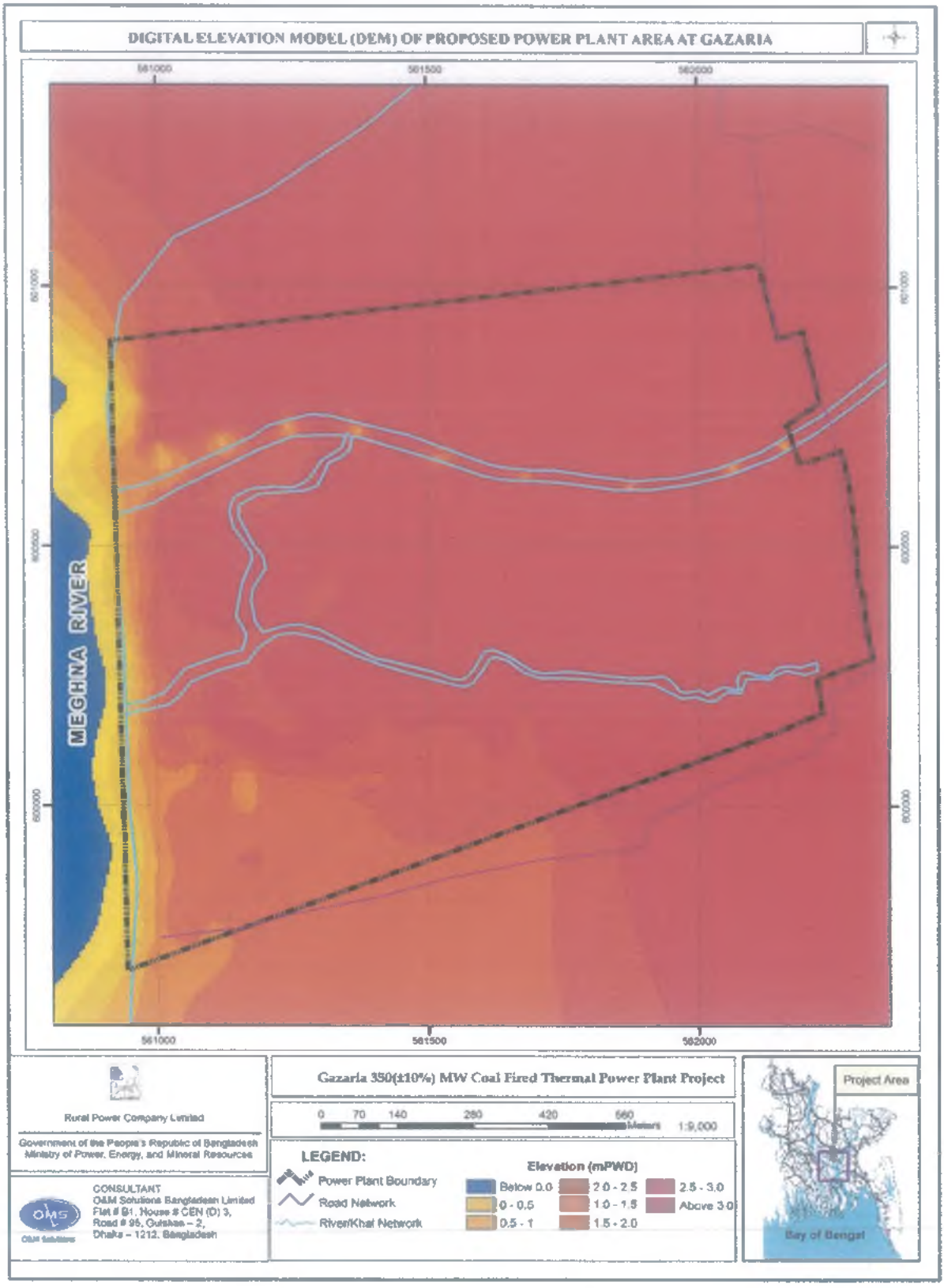


Map 3.8: Location of the Project Site with Coordinates

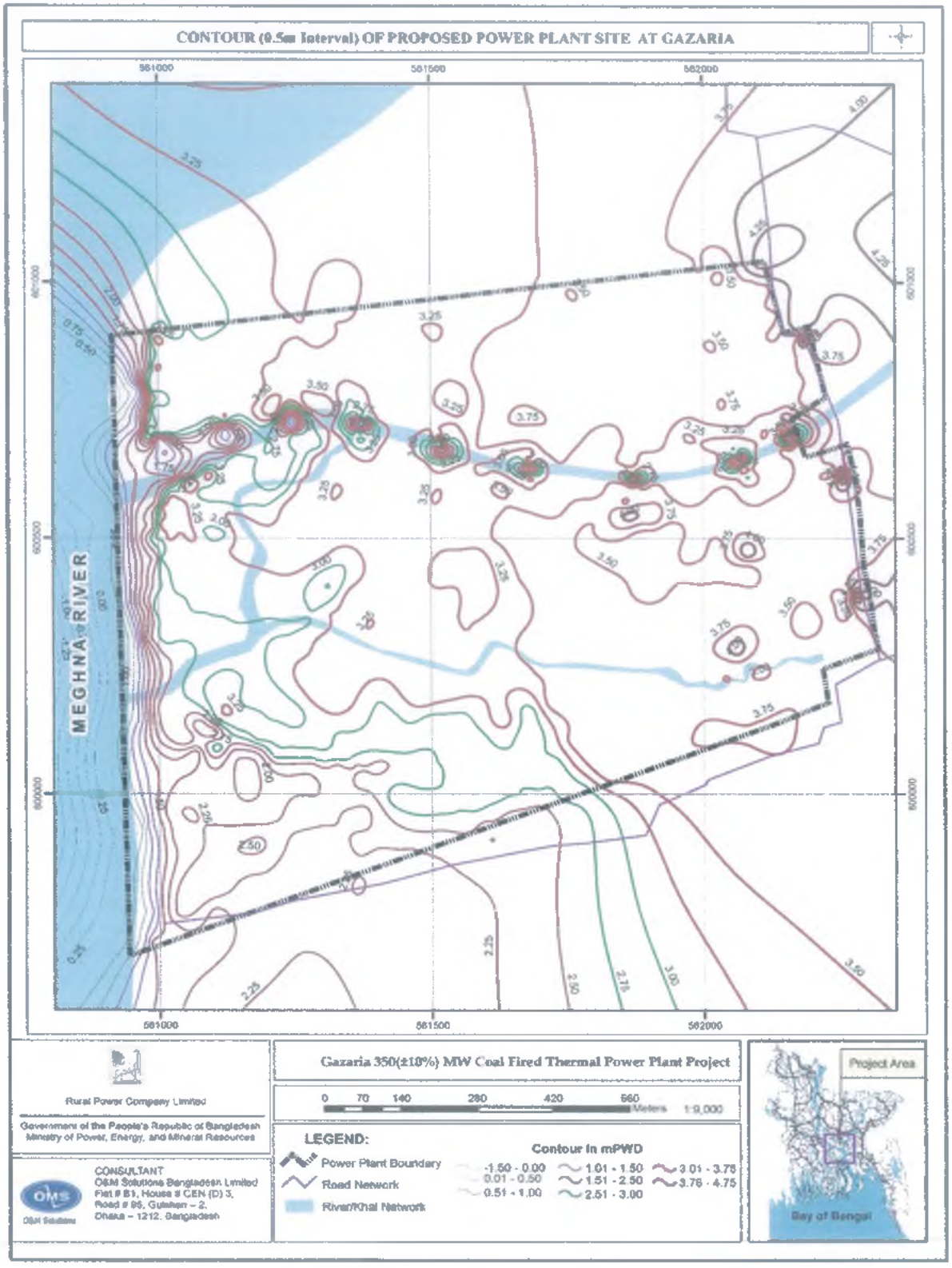
Map 3.9: Existing Land Use Pattern of the Proposed Power Plant at Gazaria



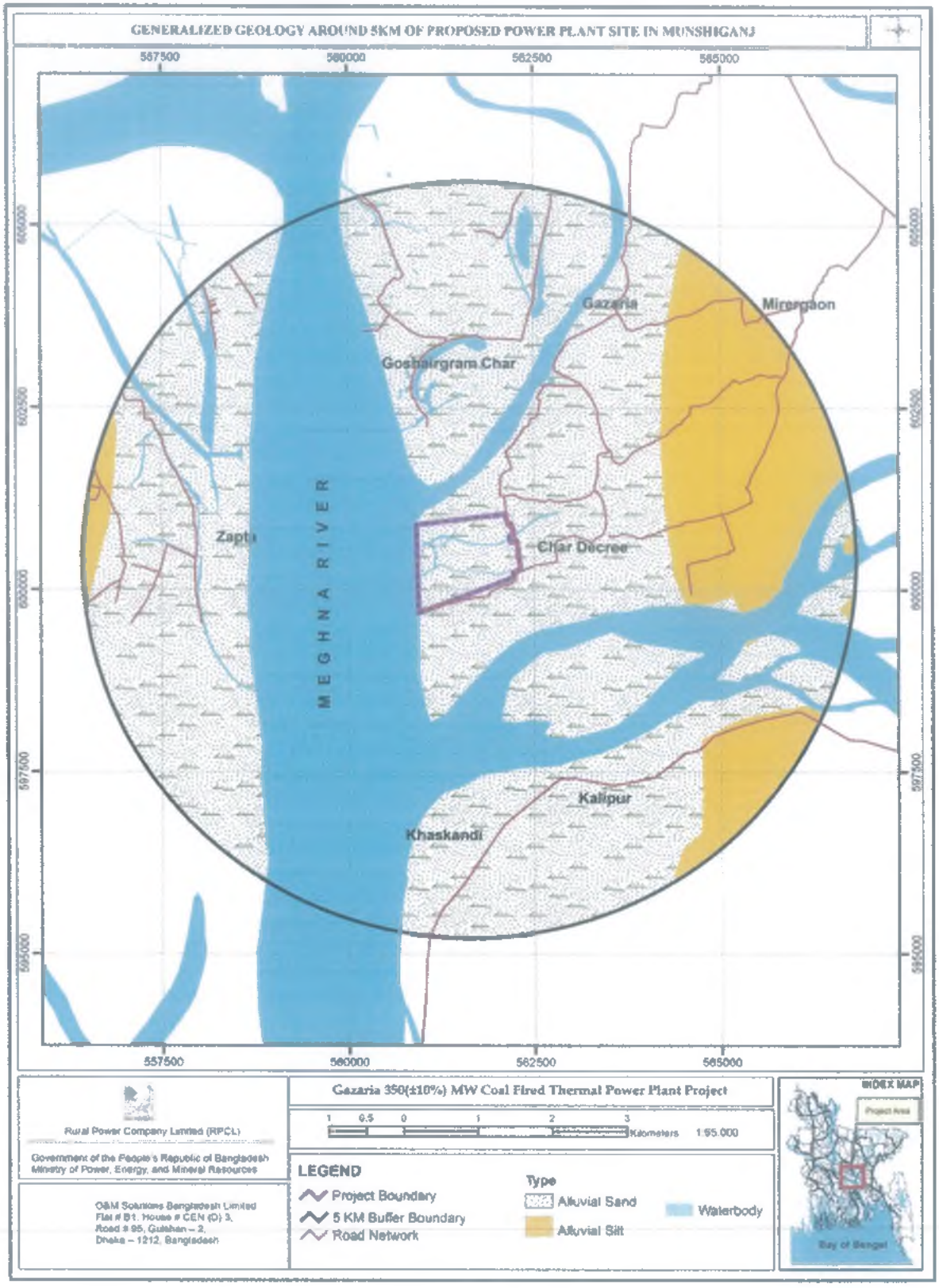
Map 3.10: Digital Elevation Model of Proposed Project Site at Gazaria



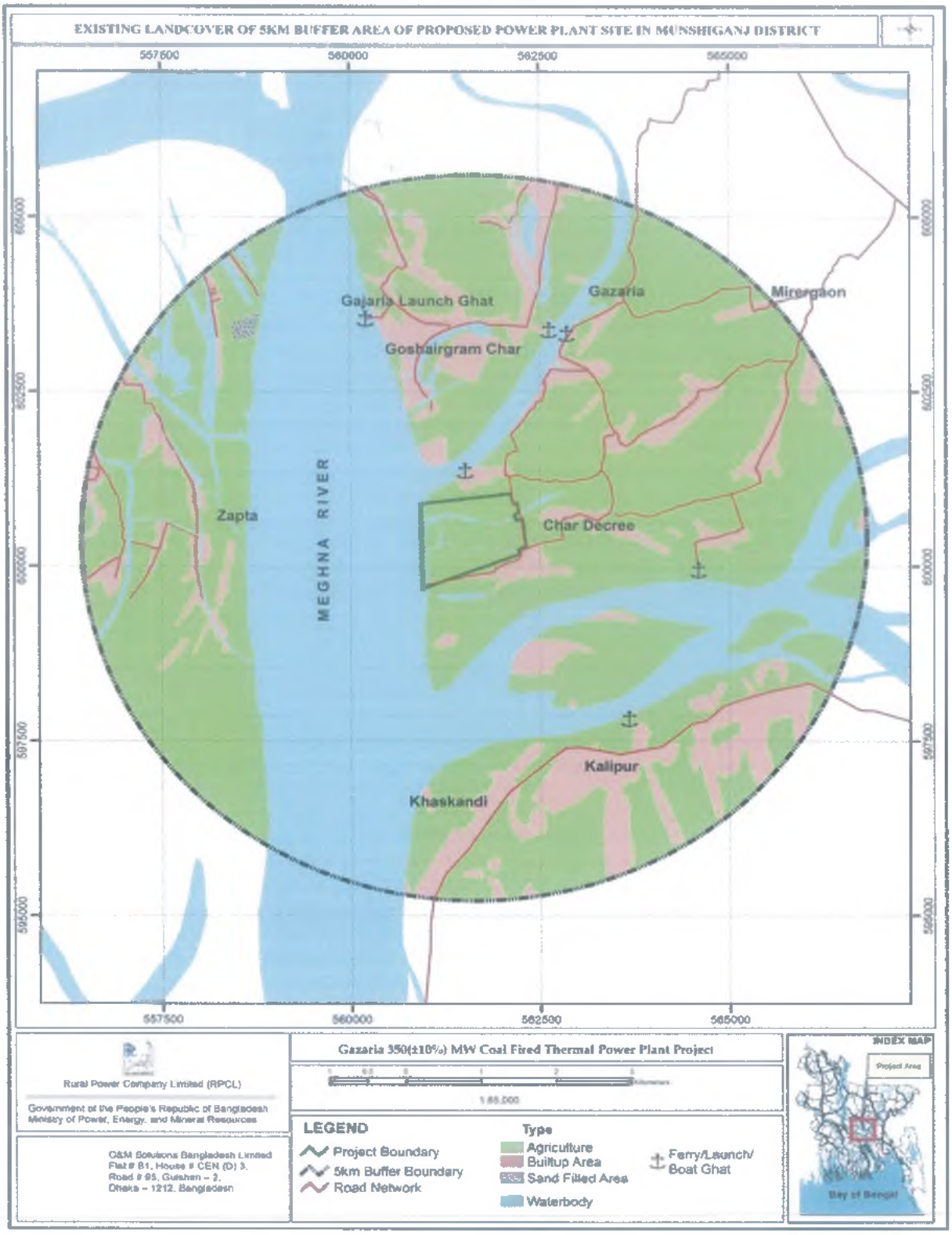
Map 3.11: Contour Map of Proposed Project Site at Gazaria



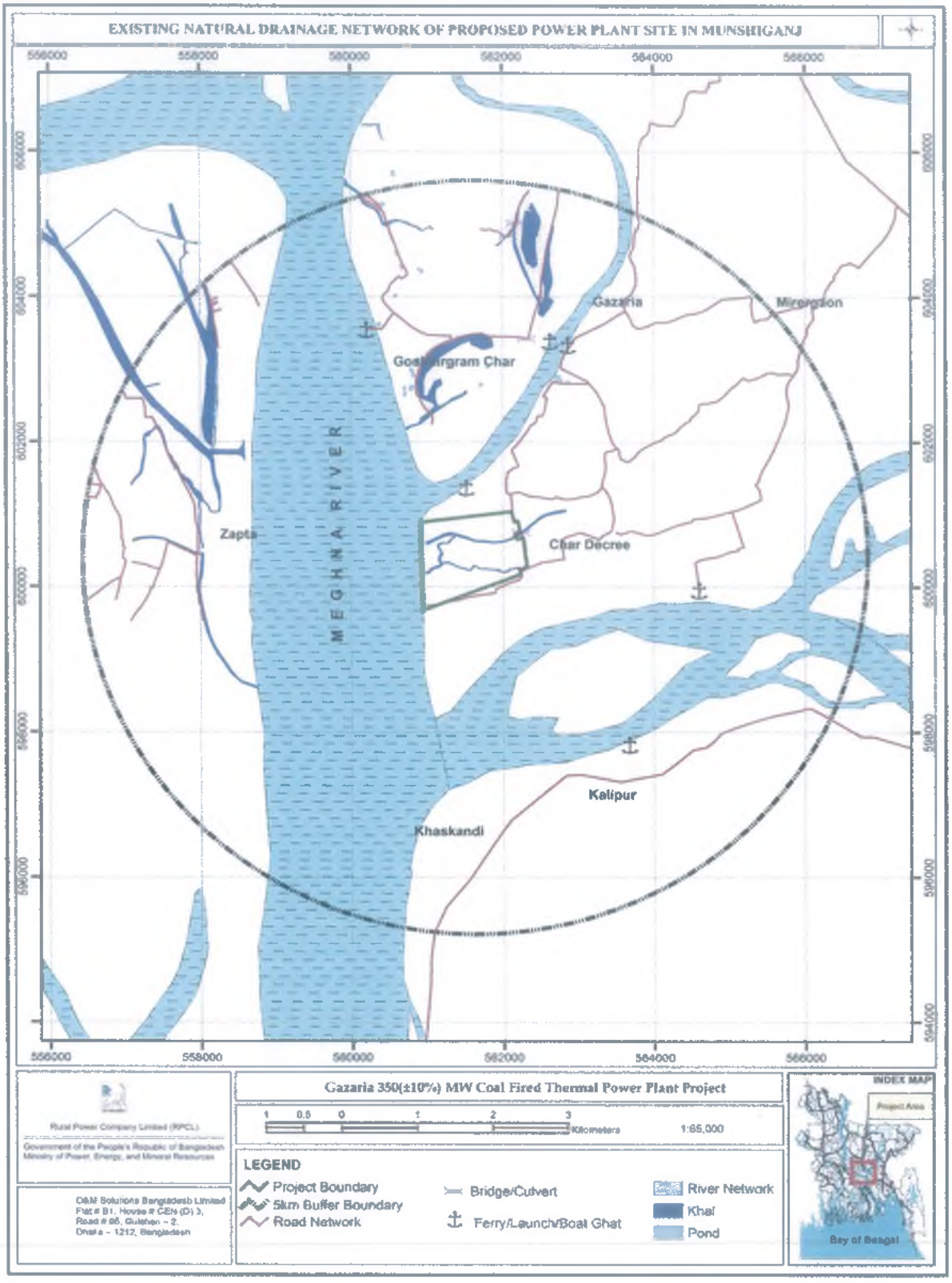
Map 3.12: Generalized Geology around 5KM of the Project Area



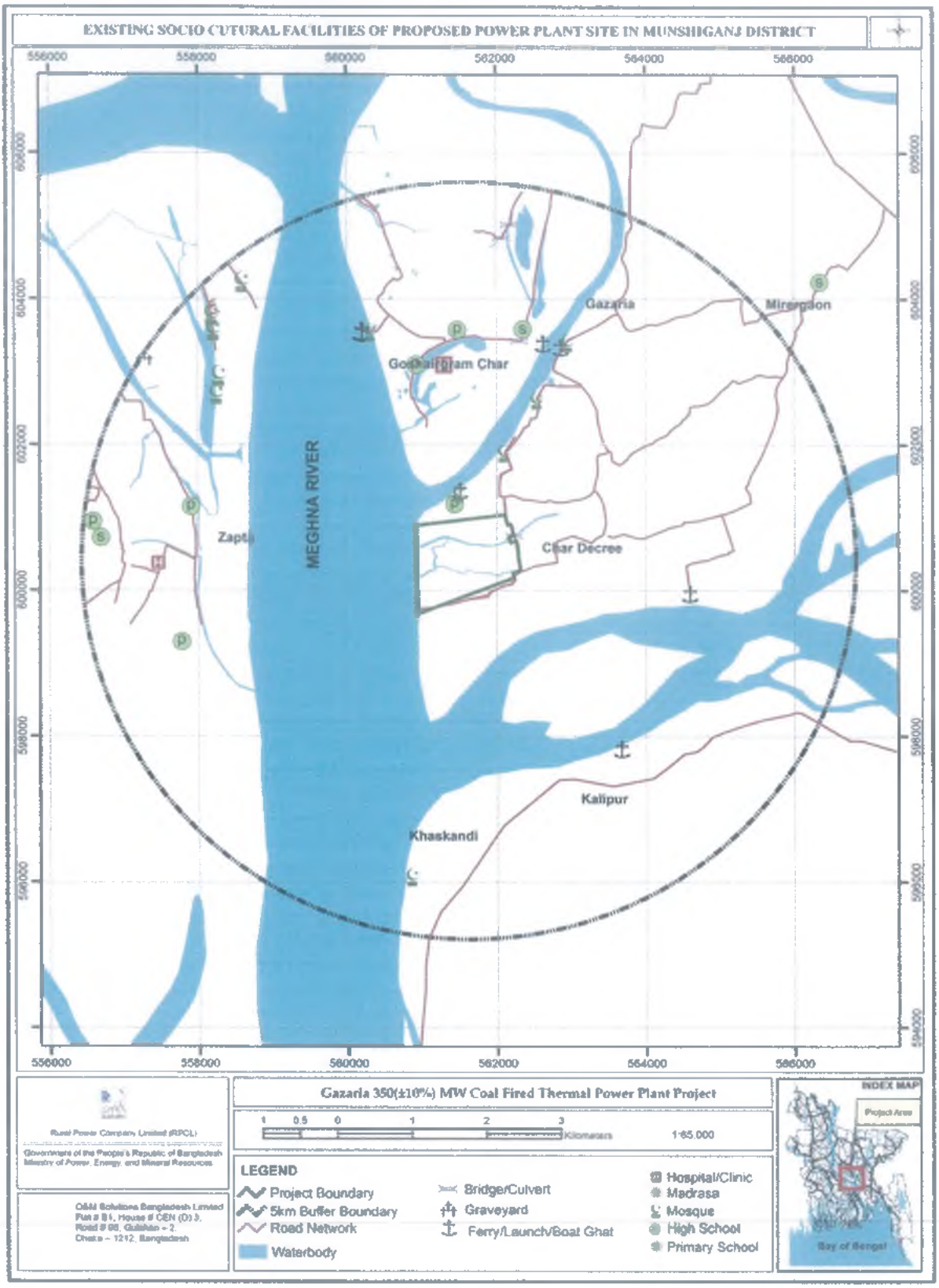
Map 3.13: Existing Generalized Land Use Pattern of the Project Area



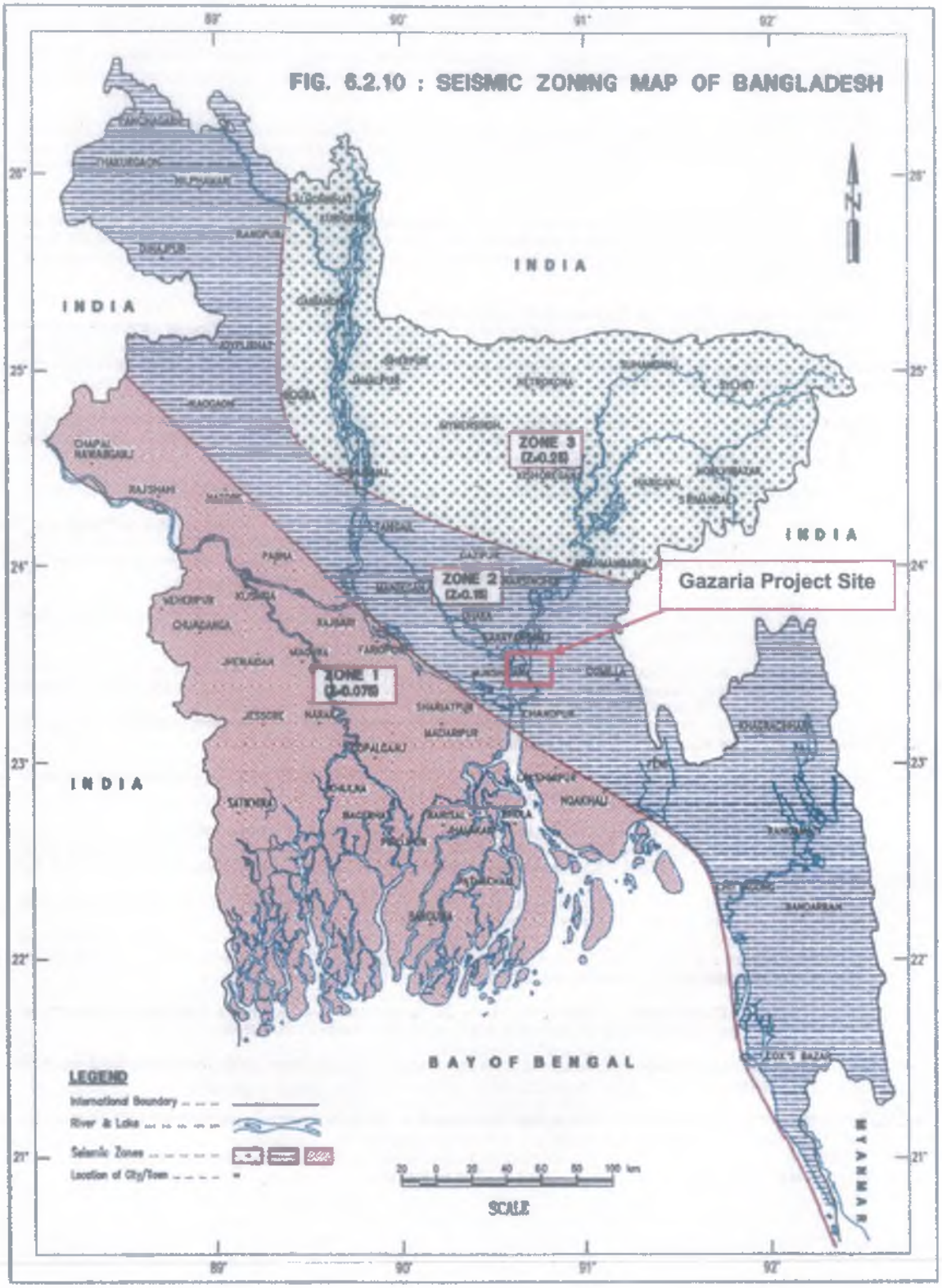
Map 3.14: Existing Natural Drainage Network of the Project Area



Map 3.15: Existing Socio-Cultural Facilities of the Project Area



Map 3.16: Seismic Zonning Map of Bangladesh (BNBC, 1993)



3.5 ACCESS TO THE PROJECT SITE

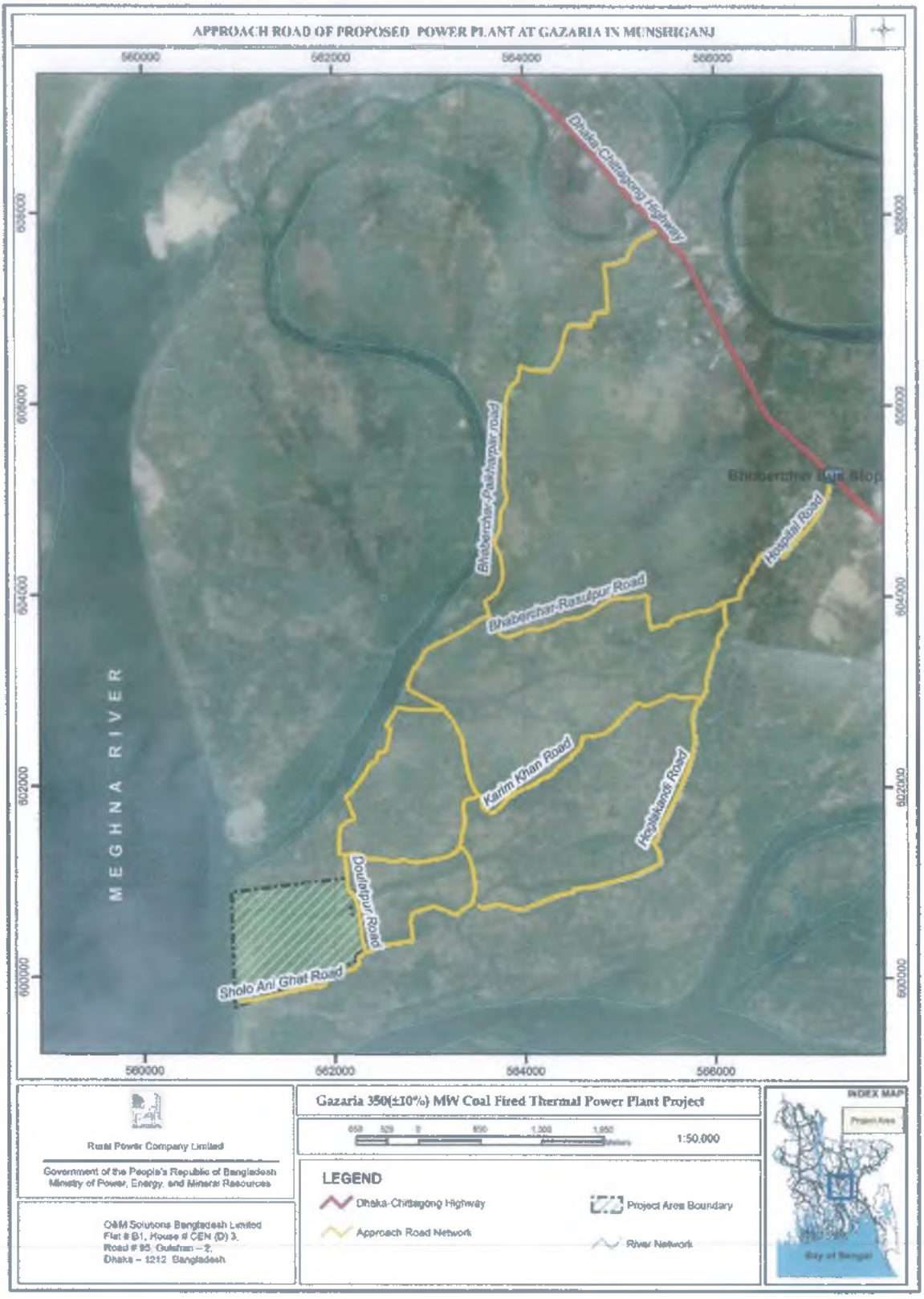
The location of the proposed power plant is such that it is accessible from any part of the country by waterways and highways. Hence, transportation of Coal, alternative fuel, equipment and machineries will be easily done by waterways. It is also important that the proposed power plant is located beside the Meghna River. The nearest river port is "Narayanganj River Port", which is about 15 km from the proposed site at Gazaria by river. The nearest airport is "Hazrat Shahjalal International Airport, Dhaka", which is about 56km away from the proposed site Gazaria. The nearest railway station is "Fatulla Railway Station", which is about 37km from the site. The site is accessible by road just 10km away from "Dhaka-Chittagong Highway".

Map 3.17: Connecting Road from Dhaka-Chittagong Highway to Power Plant

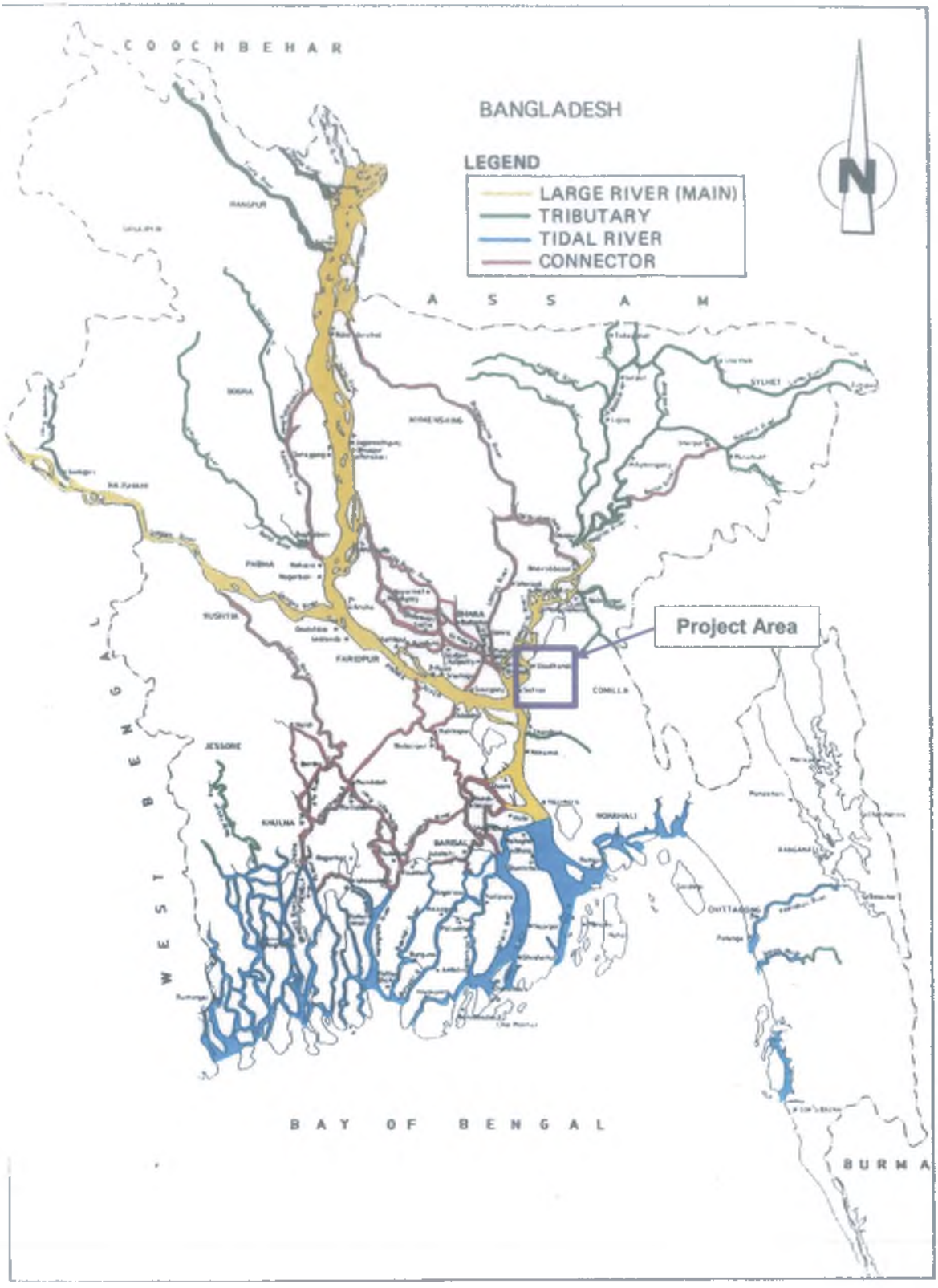
Map 3.18: Route from Riverport to proposed Power Plant

Map 3.19: Route from nearest Railway Station from the proposed power plant area

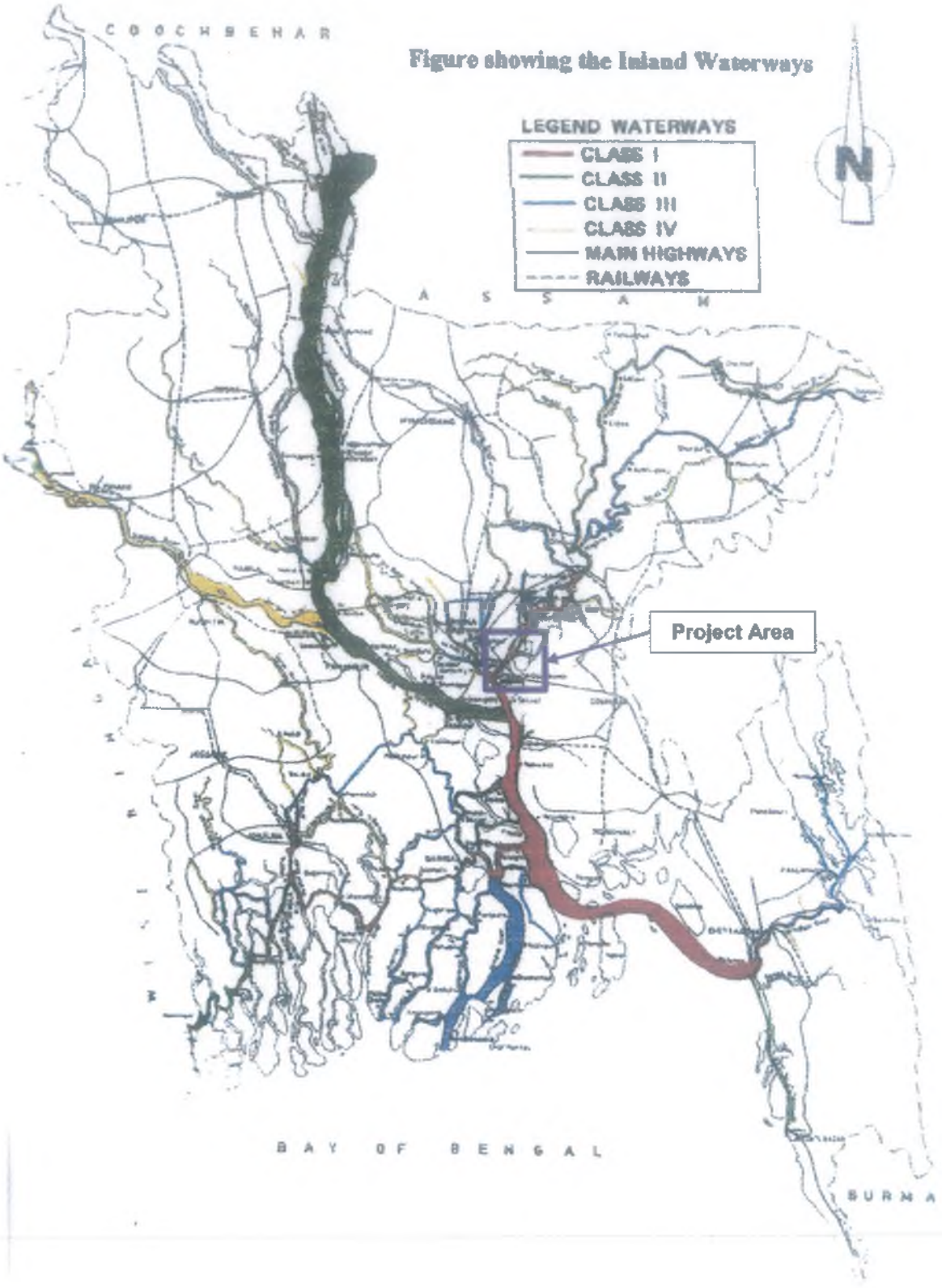
Map 3.20: Approach Road (with options) to the Project Site



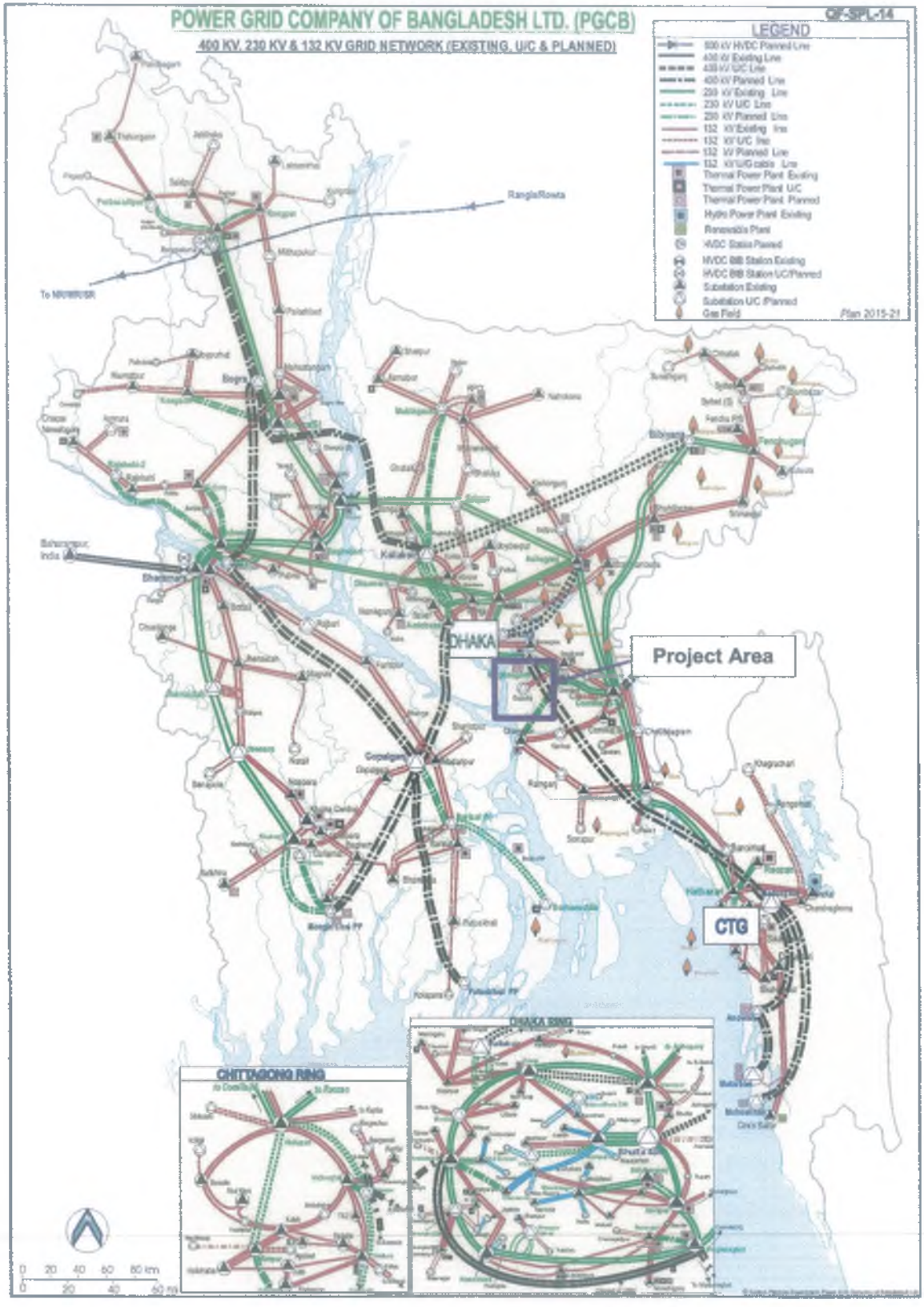
Map 3.21: River Map of Bangladesh



Map 3.22: Inland waterways of Bangladesh



Map 3.23: National Grid Network Map of Bangladesh



CHAPTER 04:
HYDRO-MORPHOLOGICAL STUDY

CHAPTER 04: HYDRO-MORPHOLOGICAL STUDY

4.1 INTRODUCTION

The Gazaria 350 (±10%) MW Coal Fired Thermal Power Plant Project is proposed to be constructed at downstream of the Meghna-Dhaleswari River confluence and the eastern bank of the Upper Meghna River within Mouza namely, Daulatpur (at north) and Sholoani (at south) of Imampur union in Gazaria Upazila under Munshiganj district. The project site is surrounded by Andharmanik, Imampur and Karim Kha Mouza in East, Kalipur Mouza in South, Meghna River in West and Daulatpur Mouza in North.

The proposed power plant will produce net 350 (±10%) MW of electricity. Before proceeding with detail engineering design of the proposed plant, a hydrological and morphological study needs to be carried out to examine the feasibility of the project site about flooding, erosion, water availability. The report of present 'Hydro-Morphological Study of Gazaria 350 (±10%) MW Coal Fired Thermal Power Plant Project' is prepared as part of the detailed study named at 'Detail Feasibility Study, IEE, EIA and SIA Study of Gazaria 350 (±10%) MW Coal Fired Thermal Power Plant Project at Gazaria, Bangladesh of Rural Power Company Limited.' Meanwhile, the present hydro-morphology study is rather preliminary, and therefore, the findings of the study should be considered with caution. A thorough and detail hydrology study was beyond the scope of the current hydro-morphology study. The report outlines the objectives, expected outputs, methodology, and finding of the hydro-morphology study.

4.2 OBJECTIVES AND EXPECTED OUTPUTS

4.2.1 Objectives

The detailed objectives of this study according to the main technical requirement can be summarized as follows:

- Preliminary hydrological and hydrodynamic study of the study area based on available data and information. This preliminary study will include a general analysis of hydrological and hydrodynamic features, flooding and erosion pattern in and around of the project area;
- Assessment of flooding pattern and flood vulnerability based on flood frequency and historical data analysis. The assessment will provide the design parameters such as the design flood level (i.e., water level) of average, 5-year, 10, 25, 50 and 100-year return period flood.
- Assessment surface water availability at the proposed power plant project site.

4.2.2 Expected Outputs

The expected outputs of the current study are:

Hydrological – Hydrodynamic Study

- The water level at the project site against average, 1 in 5, 10, 20 and 100-year return period flood.
- Monthly water availability in the water intake stream (i.e. the Upper Meghna River).
- Typical yearly water level hydrograph of the Upper Meghna River during the wet, average and dry season.
- Monthly maximum and minimum water level of the Upper Meghna River.
- Water level-discharge curve (i.e. rating curve) of the Upper Meghna River at the project site

Morphological

- Assessment of river bank line movement based on historical satellite images in and around the project site.
- A general bank erosion and deposition analysis based on said bank line movement assessment.
- Sediment transport and bed erosion-deposition pattern of the Upper Meghna River in the vicinity of the project site.

4.3 Approach and Methodology

The location of proposed Gazaria 350 (±10%) MW Coal Fired Thermal Power Plant Project is at downstream of the Upper Meghna-Dhaleswari River confluence and the left bank of the Upper Meghna River in Gazaia Upazilla. The flow of the Upper Meghna River is highly seasonal, with an average discharge at Bhairab Bazar point varies from 5,500–12,000 m^3/s during monsoon and 1,000–1,600 m^3/s during the dry season. The recorded maximum discharge of the Meghna River at Bhairab Bazar was 19,800 m^3/s (Khan, 1998). They key hydrological characteristics of the Upper Meghna River are shown in the following Table 4.1.

Table 4.1: Key hydrological characteristics of the Upper Meghna River

Parameters		Upper Meghna at Bhairab Bazar
Catchment area (103 km^2)		77
Average annual rainfall (mm)		4,900
Average annual discharge (m^3/s)		4,600
Discharge(m3/s)	Average flood	—
	Average low flow	—
Water(m + PWD)	Average maximum	6
	Average minimum	1.5

Slope (cm/km)	2
Total sediment transport (M tons/y)	13
Bed material transport (M tons/y)	—
Bed material size (D50) (mm)	0.14
Planform	Anastomosing

Source: Sarker et al. (2003)

Overall, the present hydrological and morphological study dealt with the following processes:

- Data collection
- Hydrology and river hydraulics
- River morphology

A brief discussion on methods of the present study is presented in the following sections of the chapter.

Data Collection

Assessing flow dynamics and movement of sediment in a river requires hydrodynamic, morphological and topographic data. The hydrodynamic data includes water level and discharge. Topographic data includes river cross sections, river lengths, interconnectivity while the morphological data includes sediment size and transport rate.

Hydrology and River Hydraulics Study

The hydrological and river hydraulics analysis includes extreme value analysis of water level to find out the water level of average, 1 in 5, 10, 20 and 100 years return period floods, which are equivalent to 43, 20, 10, 5 and 1% frequency flood, respectively. The hydrological analysis also includes seasonal water availability in the Meghna River at the power plant site.

Morphological Study

The present morphological study assesses the river bank erosion-deposition pattern of the Upper Meghna River in the vicinity of the project site, movement of the river bed and the river navigability.

Carefully studying the river bank alignment using the past satellite images of different years is considered one of the most effective way to understand the bank line shift of the river and river bank stability over a historical period. Surveyed river cross section data has been processed and analyzed to understand the river bathymetry, river bed profile, erosion-deposition pattern, and river navigability. Twenty-three river cross sections have been surveyed under this study at the plant site area to understand the present river bathymetry.

4.4 DATA COLLECTION AND ANALYSIS

4.4.1 Primary and Secondary Data Collection

The river cross sections of the Upper Meghna River in the vicinity of the proposed power plant site and the land elevation of the project area are the primary data that were collected under the present study. Both river cross sections and land elevation data were measured in meter Public Works Datum (mPWD). A DEM of the project area has been prepared by using the land elevation data, and compared with the existing national DEM of Master Plan Organization (MPO).

All hydrometric and hydrological data such as water level, discharge of nearby hydrometric stations were collected from secondary sources, particularly from Bangladesh Water Development Board (BWDB). Apart from surveyed cross-sections, some other cross-sections data of the Upper Meghna, Dhaleswari, and Lakhya River were collected from Bangladesh Water Development Board (BWDB). River bathymetry data was collected from Bangladesh Inland Water Transport Authority (BIWTA) while sediment transport rate of the Upper Meghna River at the project site was collected from the report of past studies. Historical satellite images of the river setup in and around the project area were collected from United States Geological Survey (USGS)'s Earth Explorer website (https://earthexplorer.usgs.gov/) and analyzed to investigate the river bank line shifting over the last 30 years.

A brief discussion on the collected primary and secondary data is presented as below.

4.4.2 River Cross-Sections

Twenty-three cross-sections of the Upper Meghna River in the vicinity of the project area were measured under this study. The newly surveyed cross-sections are then compared with BIWTA bathymetry data. The comparison shows a close bathymetric feature between newly surveyed cross sections and BIWTA bathymetry data, which establishes the reliability of both data sets.

4.4.3 Hydrometric and Hydrological Data

Water level data was collected from seven nearby hydrometric stations while discharge data was collected from three stations. A discussion on the collected data, availability status is discussed as following.

Water level

Water level data of seven gauging stations such as Dhaka (Mill Barack), Rekabi Bazar, Narayanganj, Bhairab Bazar, Meghna Ferry Ghat, Shatnol, and Chandpur was collected from BWDB. Status of the collected hydrometric data regarding their collected period, data type and utility in this study are shown in the following Table 4.2 while locations of these stations are shown in the same table.

Table 4.2: Hydrometric data collection status

Station	River	Data type	Data measurement type	Data Period	Utility in the study
Bhairab Bazar	Upper Meghna	WL and Q	WL: 3-hourly Q: Fortnightly	1981-2014	Hydrodynamic model boundary preparation, calibration
Meghna Ferry Ghat	Upper Meghna	WL	WL: High-Low tide, 3-hourly	1981-2014	Hydrodynamic model calibration, statistical (frequency) analysis
Shatnol	Upper Meghna	WL	WL: High-Low tide, 3-hourly	2002-2014	Hydrodynamic model boundary preparation
Chandpur	Lower Meghna	WL	WL: High-Low tide	2002-2014	Not used
Dhaka (Mill Barrack)	Dhaleswari	WL and Q	WL: High-Low tide, 3-hourly Q: Fortnightly	2002-2014	Hydrodynamic model boundary preparation
Rekabi Bazar	Dhaleswari	WL	WL: High-Low tide, 3-hourly	2002-2014	Hydrodynamic model boundary preparation
Narayanganj	Lakhya	WL and Q	WL: High-Low tide, 3-hourly Q: Fortnightly	2002-2014	Hydrodynamic model boundary preparation

Discharge

Discharge data was collected from three stations such as Bhairab Bazar on Upper Meghna River, Dhaka (Mill Barrack) on Dhaleswari River and Narayanganj on Lakhya River. A status of collected discharge data is also shown in Table 4.1 while the locations are shown in Figure 4.1.

4.4.4 River Bathymetry

The river bathymetry data of Upper Meghna River and downstream part of Dhaleswari and Lakhya River was collected from BIWTA as an image format. The collected images were then geo-referenced with available latitude-longitude coordinates and pointed data was digitized into a GIS shape file. Using an ArcGIS interpolation technique, bathymetry point data was then converted to a river bathy surface. Also, twenty-three cross sections of the Upper Meghna River 5 km up and downstream of the project were measured under the present study, and a river bathymetric data was prepared by using these cross-section data for this part of the river. Later, the newly surveyed bathy was added with BIWTA bathy to prepared a river bathy for a longer Upper Meghna reach.

Figure 4.1: Location of hydrometric stations and river cross-sections

4.4.5 Land Elevation (DEM)

The DEM of this area as part of National DEM was readily available, but that was very coarse (300m resolution) and old. Updating and refinement of national DEM was last done back in mid-1980's.

Figure 4.2: Existing and Updated DEM of the project site and surrounding areas

Therefore, a DEM of the project area with newly surveyed topographic data was prepared with 50m resolution. The following figure shows the national and updated DEM of the power plant area. In the new DEM of the project area, detail land elevation feature is clearly visible that is considered to helpful in detail power plant designing.

4.4.6 Satellite Images

Historical Landsat Thematic Mapper 5 and 8 (TM5 and TM8) of the Upper Meghna River's physical setup in the vicinity of the project area were collected for the period 1988–2016 with 5–10 years interval. These Landsat images were collected from United States Geological Survey (USGS)'s Earth Explorer website (https://earthexplorer.usgs.gov/).

4.5 Data Analysis

The quality of the data has been examined after collecting primary and secondary data from various sources. Standard data correction procedures were applied if any inconsistency had been found in the collected data. Missing data of a particular water level gauging location was filled by applying a correlation factor with nearest water level gauging location. In such case, data of two stations were compared for a longer period and a correlation factor was established.

The present study performed following data analysis for its hydro-morphological study:

- Flood frequency analysis
- Low water level frequency analysis
- Cross section data processing
- Water availability analysis
- Flood inundation analysis
- Bank line digitization (i.e., delineation)

4.5.1 Statistical Analysis

The nearest hydrometric stations on the Upper Meghna River from the project site is the Meghna Ferry Ghat, which is 12 km upstream from the project site. Therefore, the statistical analysis that includes both flood and low water level frequency analysis was done for the Meghna Ferry Ghat water level data. After finding flood and low water levels against different return period floods and low water scenarios at Meghna Ferry Ghat, correction factors were applied to the values of this location to find out the required design flood and low water level values for the project site.

The statistical analysis performed three statistical distributions namely Log-normal, Gumble and Log Pearson III of the data, the value of Chi-square and KS of each distribution were compared to find out the best-fitted distribution among three. The Log-normal distribution was found more accurate for the Meghna Ferry Ghat water level data comparing these key statistical parameters' values (Table 4.3). It is now reasonable to assume that the same distribution is also applicable for the project site since the project site is only 12 km downstream on the same river.

The statistical analysis of Log-normal distribution was, therefore, chosen to find out the flood and low water levels against different return period. A summary of these statistical analyses is shown in Table 4.3 while frequency curves are shown in Figure 4.3 and Figure 4.4

Table 4.3: Statistical parameters' values of Meghna Ferry Ghat water level analysis

Flow Type	Gumble		Log Normal		Pearson III	
	KS	Chi-square	KS	Chi-square	KS	Chi-square
Flood flow	0.224	11.86	0.155	4.62	0.166	6.34
Low flow	0.139	5.31	0.138	1.52	0.129	1.52

Table 4.4: Flood and low water level against different return period at Meghna Ferry Ghat

Return period	Flood level			Low water level		
	Gumbel	Log-Normal	Pearson	Gumbel	Log-Normal	Pearson
Avg.	5.46	5.48	5.44	1.14	1.13	1.14
5	6.26	6.01	6.02	0.98	1.00	1.00
10	6.86	6.32	6.36	0.89	0.93	0.93
25	7.63	6.66	6.73	0.80	0.86	0.86
50	8.20	6.88	6.97	0.74	0.82	0.81
100	8.77	7.07	7.20	0.69	0.79	0.78

Figure 4.3: Log-normal flood frequency analysis of Meghna Ferry Ghat

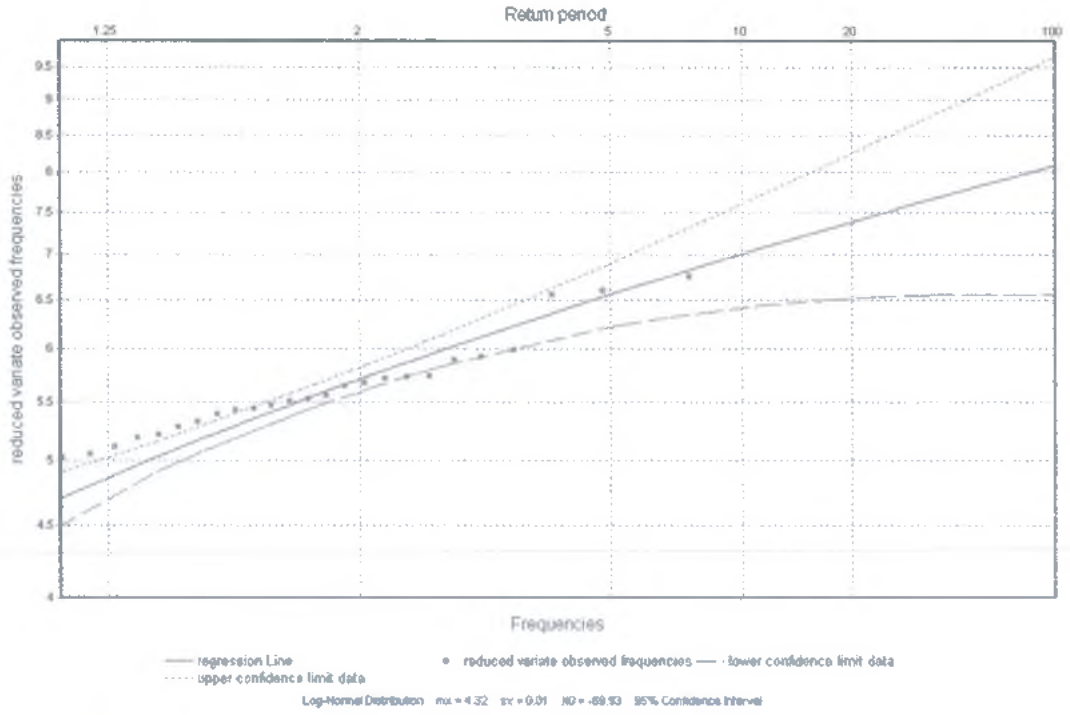
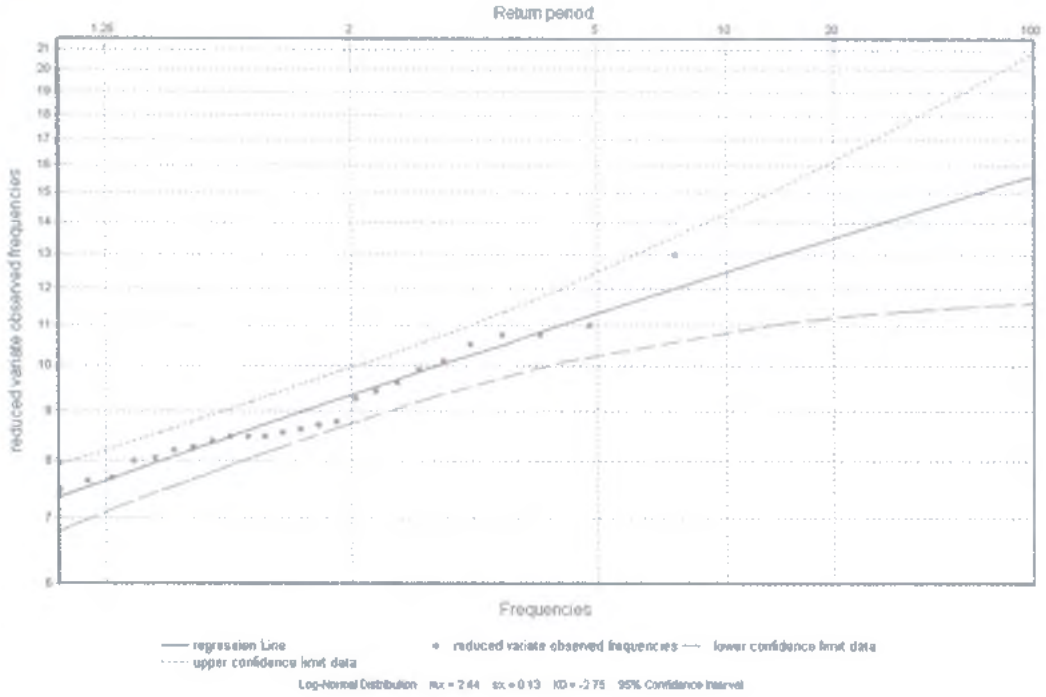


Figure 4.4: Log-normal low water level frequency analysis of Meghna Ferry Ghat water level data



4.6 RESULTS

4.6.1 Design Water Level

Correction factors between water level at the Meghna Ferry Ghat and the project site have been established for both flood flow and low flow by analyzing the Upper Meghna water level slope. Like it is mentioned before, these correction factors were then applied to flood and low flow levels of Meghna Ferry Ghat against different flooding and low flow scenarios to transfer these values to proposed power plant site area. Table 4.4 shows the correlation factor between Meghna Ferry Ghat and project site.

Table 4.5: Correlation factor between Meghna Ferry Ghat and project site

Flow season	Correlation factor (CF) in meter	Correlation equation
Monsoon or flood period	0.24	Project WL = Meghna Ferry Ghat WL - CF
Dry period	0.12	

Flood Water Level: After applying correction factors over the Meghna Ferry Ghat values, the estimated flood water level against different flood return period at the project site are found and shown in Table

Table 4.6: Flood water level of the project area

Return period (year)	Flood water level (mPWD) based on Log-normal distribution
Avg.	5.24
5	5.77
10	6.08
25	6.42
50	6.64
100	6.83

Low Water Level: Applying the correlation factor shown Table 4.4, the low water level at the project site against different return period have been found, and those are shown in Table 4.6.

Table 4.7: Low water level of the project area

Return period (year)	Low water level (mPWD) based on Log-normal distribution
Avg.	1.01
5	0.88
10	0.81
25	0.74
50	0.70
100	0.67

4.6.2 Water Availability

Analysis of water availability of the Upper Meghna River was required to examine the fact that river has enough water to fulfill the requirement of the power plant for its cooling and other operational purposes. It was before estimated that about 42 m^3/s water would be required for the plant operation.

The availability of water was estimated with a consideration that 50% of total water flows in the river should be maintained for its environmental and ecological needs. In other words, 50% of total flows in the river is considered as its environmental flow, hence cannot be considered for any water use purpose. Regarding this, remaining 50% of the total flow is considered the available amount of water which could be utilized for the domestic, industrial and agricultural purpose.

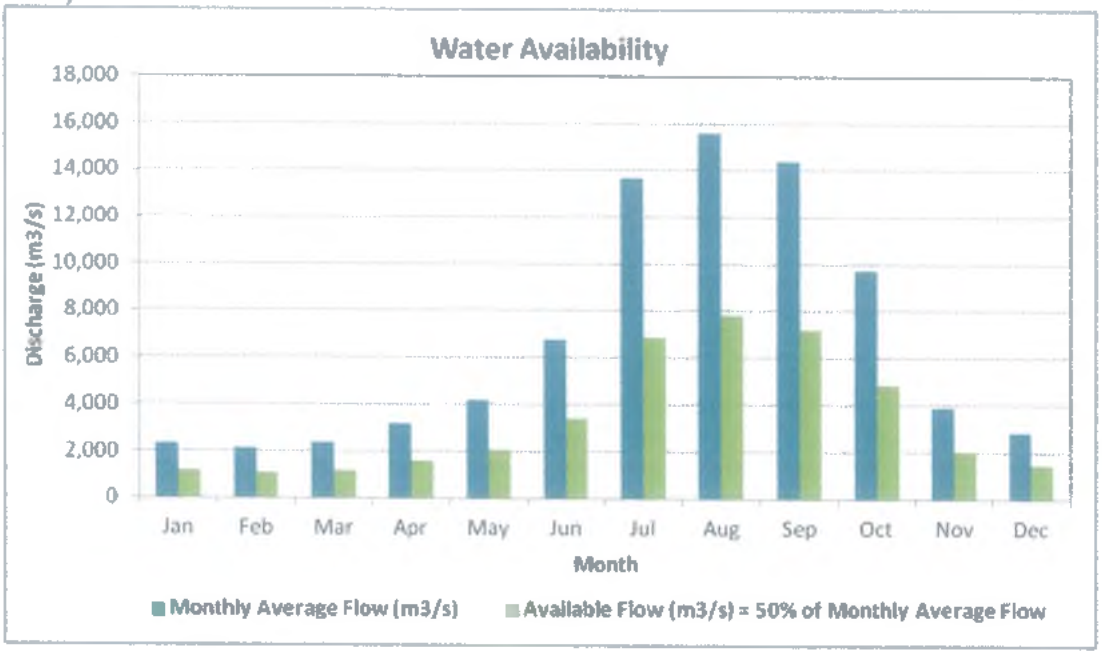
For assessing the water availability in the Upper Meghna River at the project, the present study relies on the findings of a similar hydro-morphological study conducted for the proposed Munshiganj coal-fired power plant (OMS, 2014). The proposed Munshiganj power plant location is just 2 km upstream from the proposed Gazaria power plant site and at the opposite river bank of the Upper Meghna River (i.e., at the right bank of the river). Therefore, it is very much reasonable to use the findings of that earlier study for the assessing the water availability for the present power plant.

Table 4.7 and Figure 4.5 present monthly average flow of the Upper Meghna River at the Munshiganj power plant site which is also same for the proposed Gazaria site. The table and figure clearly show that the river carries sufficient amount of water; therefore, the availability of the water from the Upper Meghna River would not be a critical issue for this proposed coal-fired power plant.

Table 4.8: Water availability of the Upper Meghna River at the project site area (OMS, 2014)

Month	Monthly Average Flow (m^3/s)*	Available Flow (m^3/s) = 50% of Monthly Average Flow
Jan	2,287	1,144
Feb	2,125	1,062
Mar	2,344	1,172
Apr	3,179	1,590
May	4,165	2,082
Jun	6,776	3,388
Jul	13,700	6,850
Aug	15,607	7,804
Sep	14,402	7,201
Oct	9,734	4,867
Nov	3,910	1,955
Dec	2,840	1,420

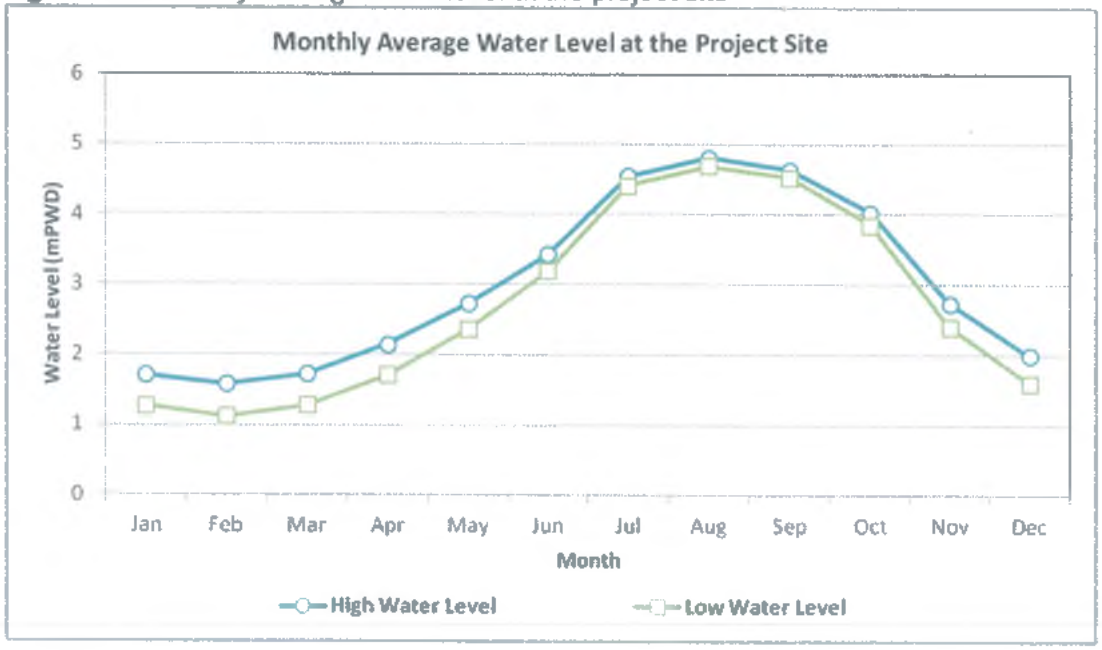
Figure 4.5: Water availability of the Upper Meghna River at the project site area (OMS, 2014)



4.6.3 Seasonal Water Level

The seasonal variability in the monthly average water level of the Upper Meghna River at the project site is shown in the following figure.

Figure 4.6: Monthly average water level at the project site

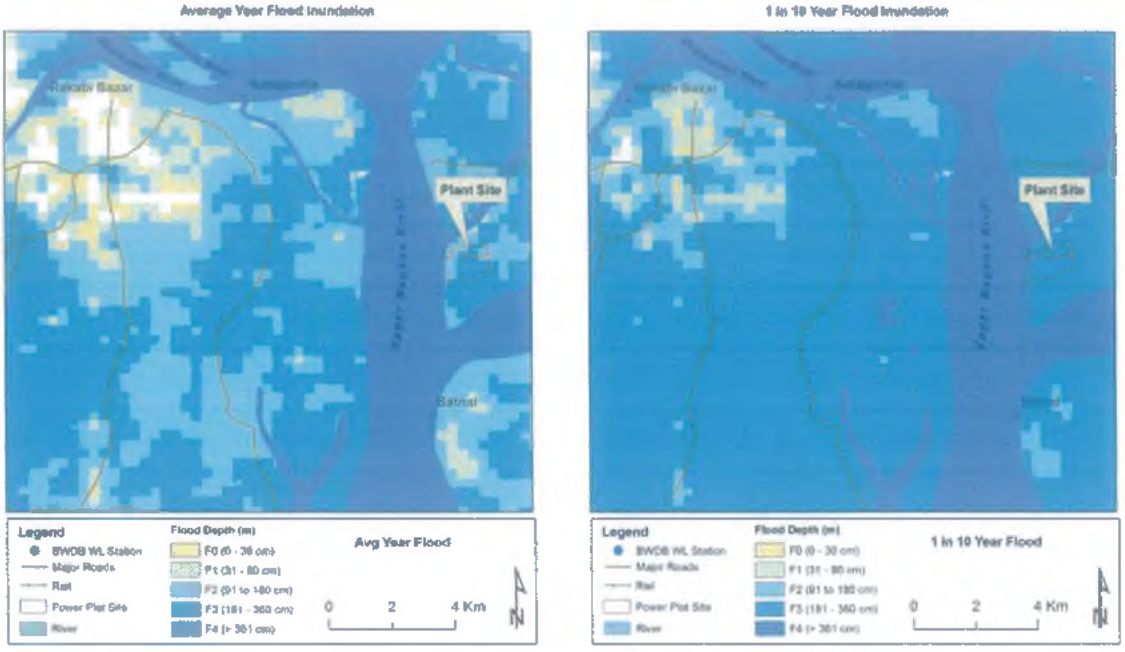


4.6.4 Flooding

The proposed project site is located on the left bank of the Upper Meghna River, just after the confluence with the Dhaleswari River and this area is a flood prone area. A series of flood maps have been prepared using the water level data of hydrometric stations in and around the project area and the national DEM to investigate the flooding problem of the proposed site. Those flood maps include average year flood, 10, 50 and 100 years return period flood. Figure 4.7 shows flood inundation in the project site and surrounding area in different flooding conditions.

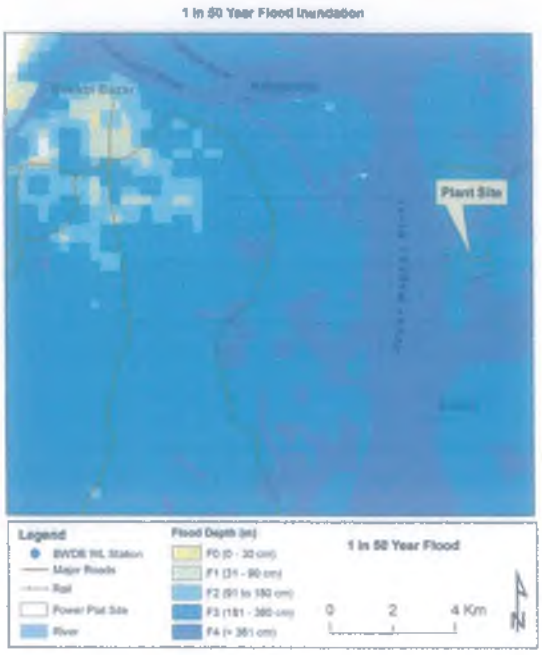
A closer inspection of these flood maps reveals that even during an average year flooding condition, the majority part of the project site as well as surrounding areas is used to go under the flood water. The flooding or inundation condition of the area becomes worse during a severe flooding event as a 1 in 50 or 100-year flood. Therefore, the proposed power plant needs to be protected from sufficient flood protection measures, such as flood wall, embankment, and raising the foundation level of the plant well above the design flood level, etc. The design flood level for such flood wall or embankment and foundation construction should follow the estimated flood water level given in Table 4.5.

Figure 4.7: Flood maps of the project area

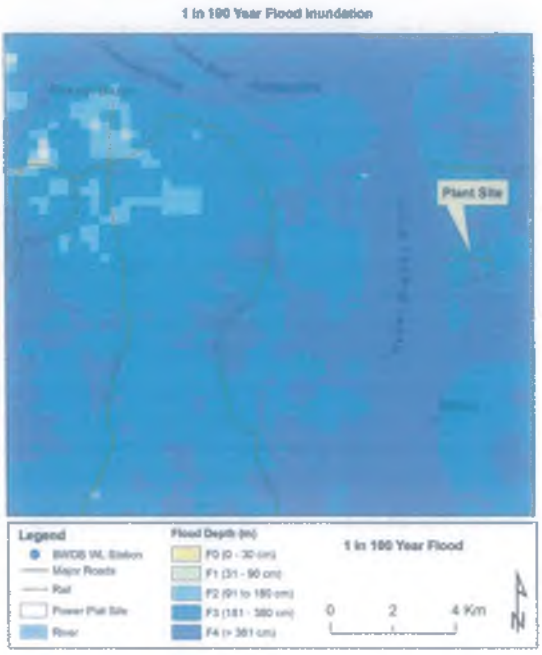


(a) Average flood

(b) 1 in 10 year flood



(c) 1 in 50 year flood



(d) 1 in 100 year flood

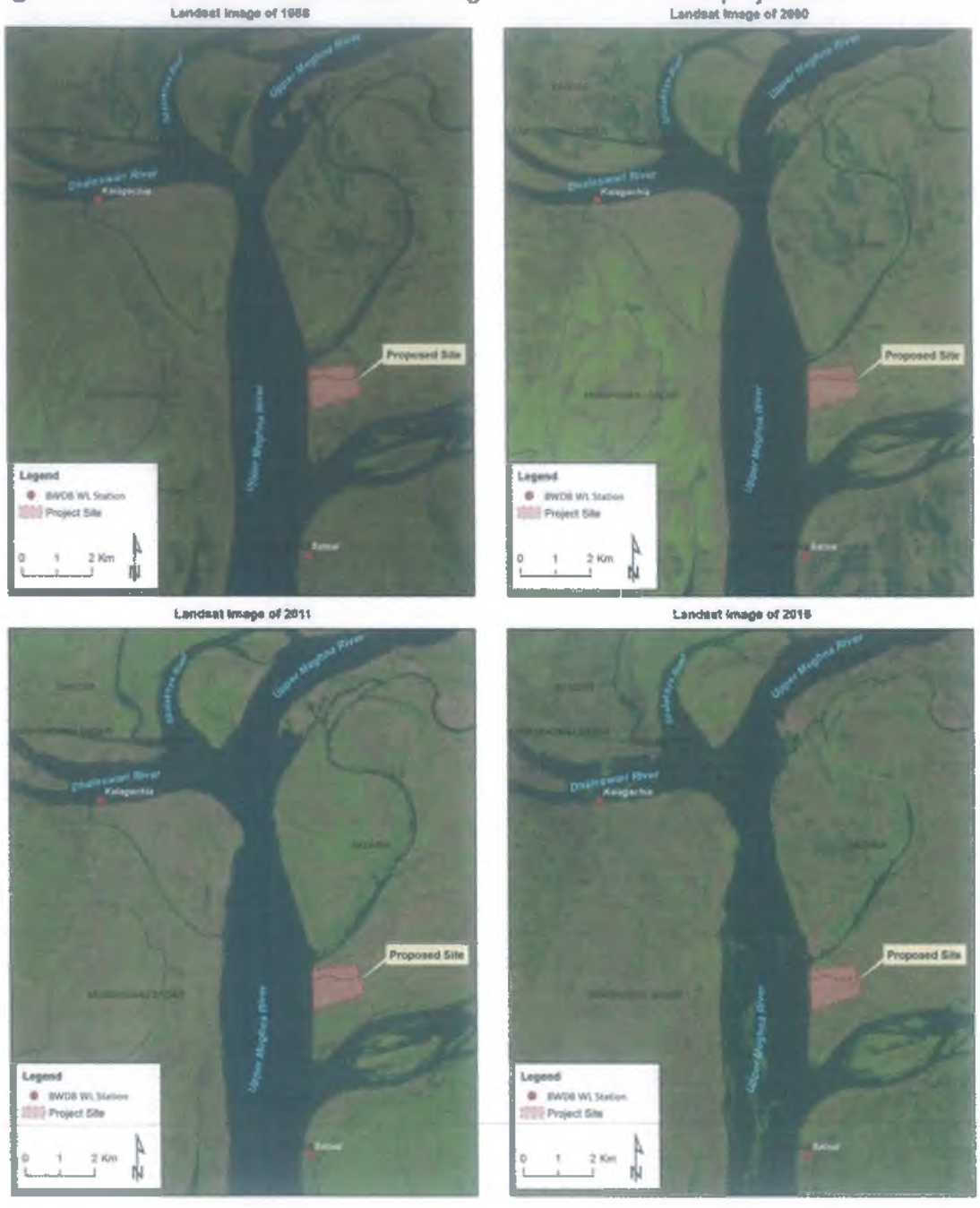
These flood maps could also suggest that the flooding condition in and around the project site may not necessarily become worse after implementing the project. However, the project may trigger some water logging problem in nearby surrounding areas during post-project condition since the project will certainly obstruct the natural drainage pattern of the area. To avoid such problem, necessary measures should be taken appropriately so that the project may not create any obstruction for the flood water recession from immediate surrounding areas.

4.7 MORPHOLOGICAL ANALYSIS

4.7.1 Long-Term Morphological Changes and Bank Erosion Deposition of the Upper Meghna River

The long-term morphological analysis of the Upper Meghna River in the vicinity of the project site and corresponding erosion-deposition analysis were done by inspecting river bank shifting and sand bar or *char* formation and movement over the three decades (1988–2010).

Figure 4.8: Historical Landsat satellite images in and around the project area

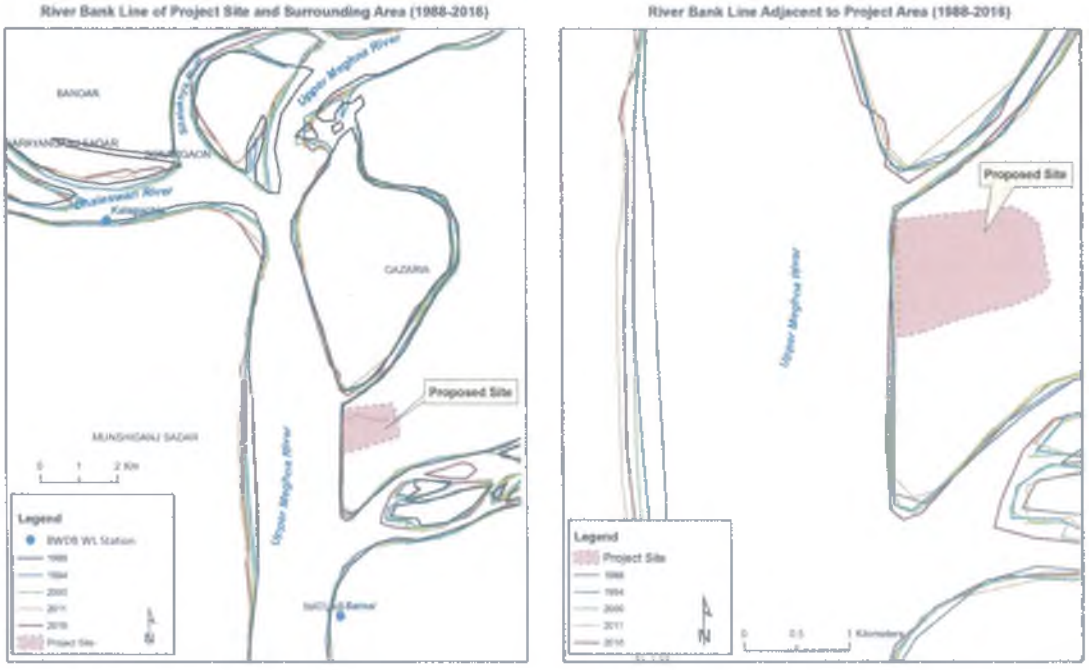


The bank shifting and sand bar/*char* formation and their movement were captured by carefully delineating river bank using historical Landsat satellite images in ArcGIS software. Four Landsat images – taken during the dry season (March–April) of 1988, 2000, 2011, and 2016 – were collected from United States Geological Survey (USGS)'s Earth Explorer website (https://earthexplorer.usgs.gov/). Figure 4.8 shows those historical satellite images along with the project site. Figure 4.9 shows bank erosion-deposition (bank shifting) of the Upper Meghna River in the vicinity of project area from 1988 to 2016.

Analyses of the historical satellite images of the Upper Meghna River and inspection of the physical setup of the river up and downstream of the project site shows that the river bank just at the project site has not been changed much or nearly remain same over the last three decades (1988–2016) (Figure 4.9). This is also true for the whole left bank of the Upper Meghna River 4 km upstream and 4 km downstream of the project site. However, the right bank of the river, which is the opposite side of the project site, has gone through a significant change. Particularly the Dhaleswari-Upper Meghna confluence bend and downstream right bank opposite to the project site have been eroded by quite a big margin over the same period (1988–2016).

Figure shows that the Upper Meghna was bifurcated to the east and western channel by a big island or *char* just upstream of the Upper Meghna-Dhaleswari confluence during 1988. Over the next 28 years (1988–2016), the east or left channel of the Upper Meghna at that part became significantly prominent compared to the right or west channel. Right now, the left or east channel of the Upper Meghna immediately upstream of the Dhaleswari-Meghna confluence is acting as the main flow channel of the river.

Figure 4.9: Bank erosion deposition (bank shifting) of the Upper Meghna River in the vicinity of project area from 1988 to 2016



At the same time, almost a 90^0 angular bend at the right bank of Upper Meghna-Dhaleswari confluence has gone through a major morphological change during this period (1988–2010). For instance, during 1999 the confluence bend at the right bank was considerably sharper

than the present setup. Due to considerable erosion over the last 28 years, the bend becomes much flatten – almost a half-circle shaped bend.

The right bank of the Upper Meghna River starting from 2 km downstream of the confluence and opposite to the present project site has also gone through a significant erosion over the same period (1988–2010). Some part of the present right bank at this place has been eroded about 300–400 m compare to 1988 bank line. In contrast to the right bank, the left bank (i.e. the project site bank) of the Upper Meghna River starting from upstream of the Upper Meghna-Dhaleswari confluence to 4 km downstream of the project site has been remained stable over the last 28 years (Figure 4.9).

The historical image analysis thus strongly suggests that the right bank (i.e., opposite side of the project site) confluence bend and its downstream – which is exactly opposite to the present project site – has a tendency to be eroded. At the same time, the left bank (i.e. project site bank) of the Upper Meghna has been stable over the last three decades.

4.7.2 Present River Bathymetry

Present bathymetry of the Upper Meghna River from Upper Meghna-Dhaleswari confluence to 4 km downstream of the project site (Figure 4.10) has been prepared by using surveyed river bathymetry data under the present project and collected BIWTA data. The figure shows that the deepest channel of around 20 to 30 m depth on zero meter water level (0.0 mPWD) runs through the middle of the Upper Meghna River up and downstream of the Dhaleswari-Meghna confluence. After 5 km downstream of the confluence, the river's thalweg and corresponding deeper channel moves towards right bank of the river; therefore, the river bed on the left bank or project side become relatively shallower, and this continues up to 2 km downstream from the project site.

The depth of the river bed at the project site thus varies 2 to 5 m in general with few deep pockets of 5 to 10 m deep. This is also very clear in. In that figure eight out of 23 surveyed cross-sections of the Upper Meghna across the proposed project site have been drawn. It shows that the left bank of the river where project site is located is considerably shallower than the opposite bank of the river. Particularly the river bed within 150 m from the middle of the project bank (i.e. cross section no. 8) and within 300-400 m from the south end of the project bank to 2 km downstream (cross section 10–18), the depth of the river bed varies from 2 to 5 m depth.

Therefore, if a total depth of around 4.7 m (3.7 m draft + 1.0 m clearance from bottom of the vessel to river bed) is required for a safe navigation of the coal-carrying vessel then the river bed at the project site's immediate vicinity needs to be dredged and maintain the required draught (4.7 m) by the power plant authority under regular O&M management.

Figure 4.10: River bathymetry of the Upper Meghna

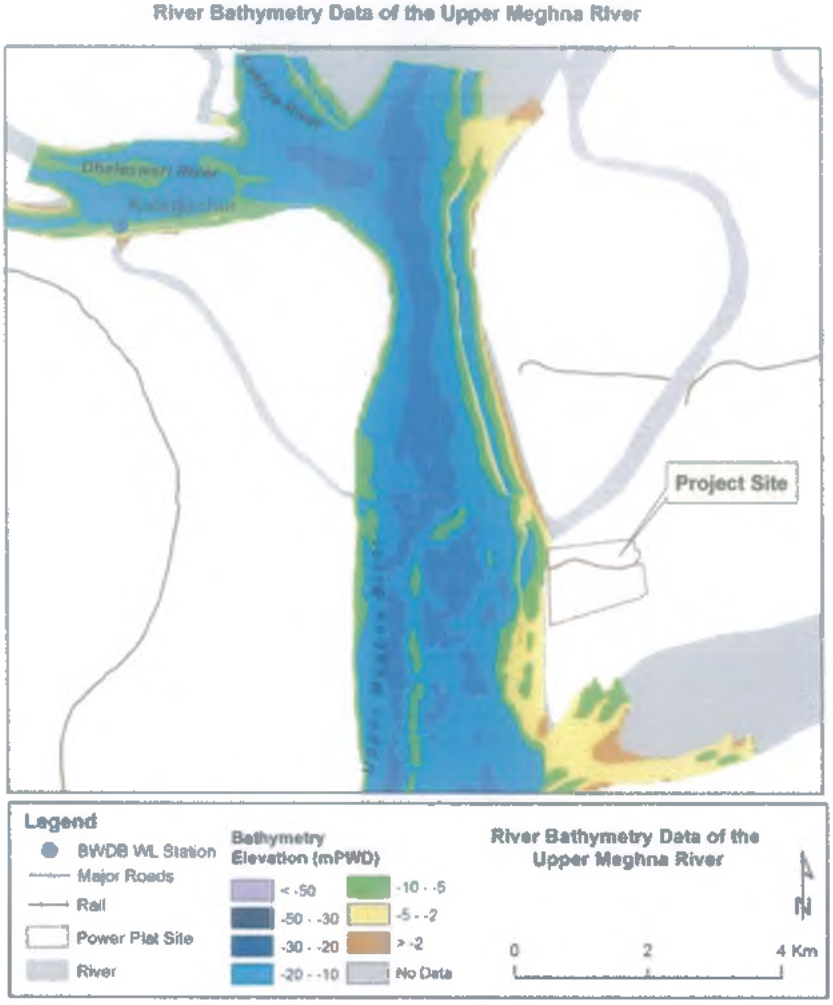
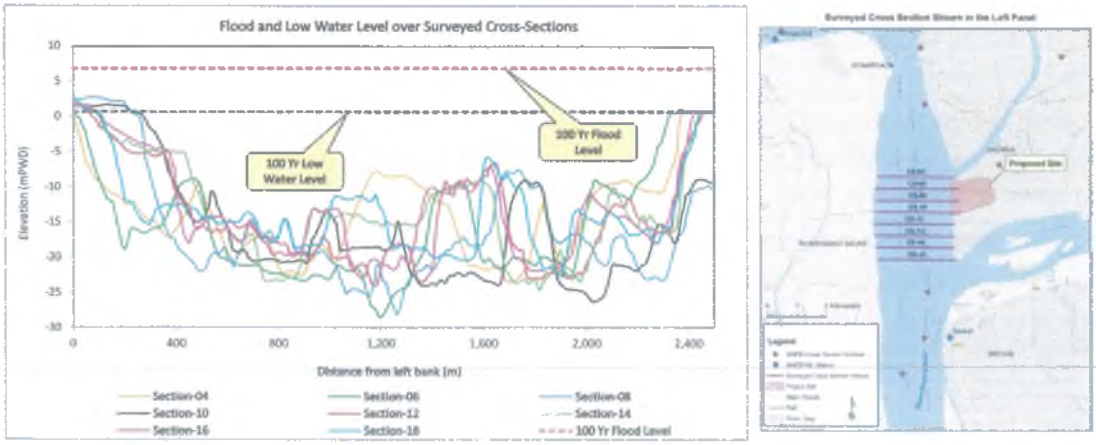


Figure 4.10: River cross section across the project site



4.8 CONCLUSION

4.8.1 Summary of Findings

A summary of findings is presented as following:

Water availability

Water availability analysis shows that the river carries sufficient amount of water, and the availability of the water should not be a problem for this proposed coal-fired power plant.

Flood water level

The Average, 10, 50 and 100 years return period flood level at the project site is 5.24, 6.08, 6.64 and 6.83 mPWD, respectively.

Low water level

The Average, 10, 50 and 100 years return period low water level at the project site is 1.01, 0.81, 0.70 and 0.67 mPWD, respectively.

Seasonal water level variation

During monsoon, the monthly average water level of the Upper Meghna River at the project site is more than 4.5 m while it is less than 2.0 m during the dry period.

From the Bathymetric Survey it is observed that the depth of the river bed at the project site varies 2 to 5 m in general with few deep pockets of 5 to 10 m deep within 150 m distance from the river bank.

Flooding

The proposed power plant site is located in a flood prone area A major part of the project site as well as surrounding areas go under the water during peak flood time. Flood maps prepared using water levels of the Upper Meghna River show that the power plant may not increase the overall flooding problem of the area. However, it may trigger some water logging problem in nearby surroundings during post-project condition due to the obstruction of the natural drainage system. To avoid such problem, necessary measures should be taken appropriately so that the project may not create any obstruction for the flood water recession from surrounding areas.

Long-term morphological changes and bank erosion-deposition (bank shifting)

Analyzing the historical satellite images of the Upper Meghna River and inspecting the physical setup of the river system up and downstream of the project site shows that the river bank just at the project site has not been changed much or nearly remain same over the last three decades (1988–2016). This is also true for the whole left bank of the Upper Meghna River 4 km upstream and 4 km downstream of the project site. However, the right bank of the river, which is the opposite side of the project site, has gone through a significant change. Particularly the Dhaleswari-Upper Meghna confluence bend and downstream right

bank opposite to the project site have been eroded by quite a big margin over the same period (1988–2016).

The historical image analysis thus strongly suggests that the right bank (i.e., opposite side of the project site) confluence bend and its downstream – which is exactly opposite to the present project site – has a tendency to be eroded. At the same time, the left bank (i.e. project site bank) of the Upper Meghna has been stable over the last three decades.

Present River Bathymetry

The depth of the river bed at the project site varies 2 to 5 m in general with few deep pockets of 5 to 10 m deep. The surveyed river cross section analysis shows that the left bank of the river where project site is located is considerably shallower than the opposite bank of the river. Particularly the river bed within 150 m from the middle of the project bank (i.e. cross section no. 8) and within 300-400 m from the south end of the project bank to 2 km downstream (cross section 10–18), the depth of the river bed varies from 2 to 5 m depth.

A total depth of around 4.7 m (3.7 m draft + 1.0 m clearance from bottom of the vessel to river bed) is required for a safe navigation of the coal-carrying vessel.The river bed at the project Jetty's immediate vicinity needs to be maintained for the required draught (4.7 m) by the power plant authority under regular O&M budget for Jetty operation and management.

4.9 REFERENCE

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CHAPTER 05:
SALIENT FEATURES OF THE PROJECT

CHAPTER 05: SALIENT FEATURES OF THE PROJECT

5.1 SITE LOCATION

The proposed project site is located within two Mouza namely, Daulatpur (north) and Sholo Ani (south) of Imampur Union in Gazaria Upazila under Munshiganj District on the eastern bank of river Meghna. The land area is around 314.10 acres which will be acquired by the proponent. RPCL is in the process of acquiring 330.60 acres of land as finalized upon the approval of ECNEC (Executive Committee of the National Economic Council) of GoB for 350 Acres of Land and subsequently advised by Munshiganj DC office. Hence, the Consultants to finalize the delineation of the project boundary and determine the main project area. A cannel locally known as Pangashia Khal passes through the proposed project site from upper region to the Meghna River. The project site is surrounded by Andharmanik, Imampur and Karim Kha Mouzain East, Kalipur Mouza in South, river Meghna in West and Daulatpur Mouza in North.

The site is approximately ten (10) km from Gazaria Upazila headquarter by road. It is approachable by an existing road network which is connected to the Dhaka – Chittagong highway at Bhoberchar Bazar. The project site is also approachable by waterway through the Meghna River from the "Bay of Bengal". Heavy construction materials/ machineries can be transported through water route. RPCL is to acquire 330.60 acres of land for the proposed project.

5.2 METEOROLOGICAL DATA

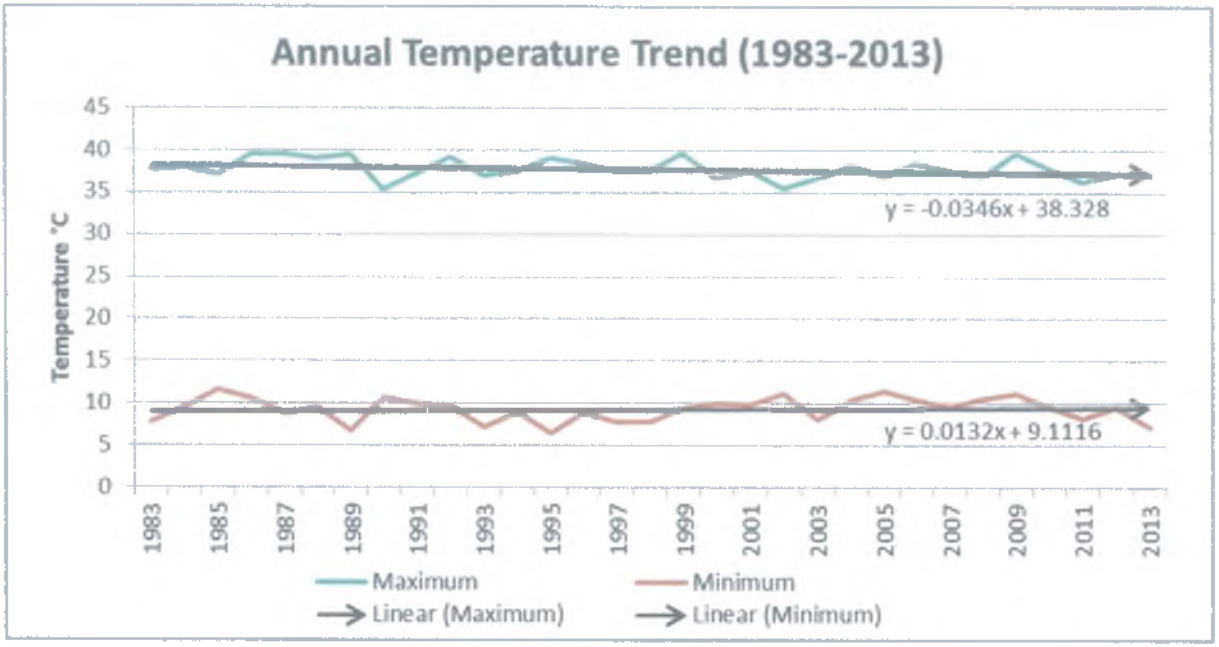
Ambient Air Temperature

Yearly Maximum and Minimum Ambient Air Temperature of the project area for the period of year 1983–2013 are given in Table 5.1 and Graphical Presentation of Ambient Air Temperature (Annually) of year 1983-2013 in Figure 5.1.

Table 5.1: Annually Ambient Air Temperature data of year 1983-2013

Year	Maximum	Minimum
1983	37.7	7.8
1984	38	9.6
1985	37.1	11.6
1986	39.5	10.6
1987	39.5	8.8
1988	39.0	9.6
1989	39.4	6.8
1990	35.4	10.7
1991	37.2	10.0
1992	39.2	9.7
1993	37.0	7.2
1994	37.6	9.0
1995	39.0	6.5
1996	38.4	9.0
1997	37.5	7.8
1998	37.5	7.8
1999	39.6	9.4
2000	36.6	10.0
2001	37.5	9.8
2002	35.5	11.2
2003	36.7	8.1
2004	38.1	10.4
2005	37.0	11.4
2006	38.5	10.4
2007	37.5	9.6
2008	36.9	10.5
2009	39.6	11.1
2010	37.9	9.6
2011	36.2	8.2
2012	37.3	9.6
2013	37.1	7.2

Figure 5.1: Graphical Presentation of Ambient Air Temperature (Annually) of year 1983-2013

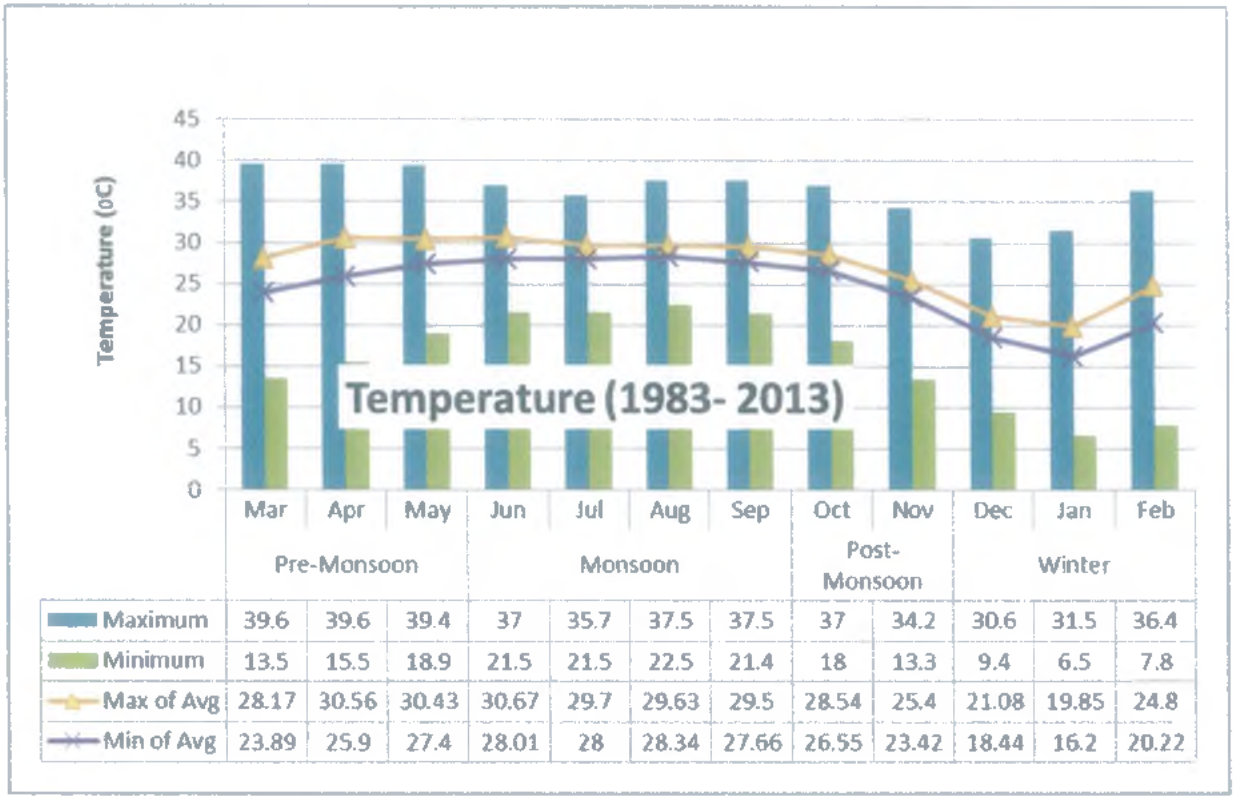


Monthly Maximum and Minimum Ambient Air Temperature of the project area for the period of year 1983–2013 are given in Table 5.2 and Graphical Presentation of Ambient Air Temperature (Monthly) of year 1983-2013 in Figure 5.2.

Table 5.2: Monthly Ambient Air Temperature data of year 1983-2013

Month		Maximum	Minimum	Max of Average	Min of Average
Pre-Monsoon	Mar	39.6	13.5	28.17	23.89
	Apr	39.6	15.5	30.56	25.9
	May	39.4	18.9	30.43	27.4
Monsoon	Jun	37	21.5	30.67	28.01
	Jul	35.7	21.5	29.7	28
	Aug	37.5	22.5	29.63	28.34
	Sep	37.5	21.4	29.5	27.66
Post-Monsoon	Oct	37	18	28.54	26.55
	Nov	34.2	13.3	25.4	23.42
Winter	Dec	30.6	9.4	21.08	18.44
	Jan	31.5	6.5	19.85	16.2
	Feb	36.4	7.8	24.8	20.22

Figure 5.2: Graphical Presentation of Ambient Air Temperature (Monthly) of year 1983-2013



	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Maximum	39.6	39.6	39.4	37	35.7	37.5	37.5	37	34.2	30.6	31.5	36.4
Minimum	13.5	15.5	18.9	21.5	21.5	22.5	21.4	18	13.3	9.4	6.5	7.8
Max of Avg	28.17	30.56	30.43	30.67	29.7	29.63	29.5	28.54	25.4	21.08	19.85	24.8
Min of Avg	23.89	25.9	27.4	28.01	28	28.34	27.66	26.55	23.42	18.44	16.2	20.22

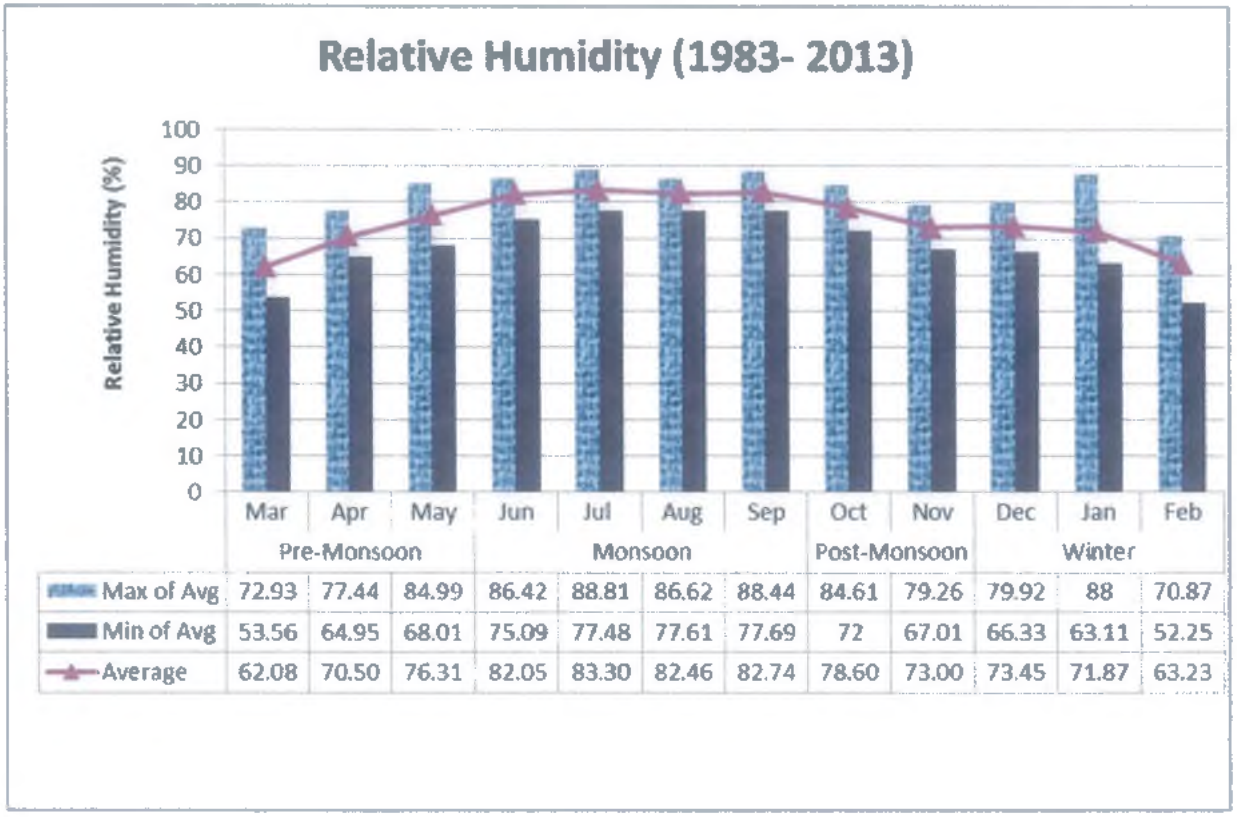
Relative Humidity

Relative Humidity during the wet season is naturally the highest compared to those occurring at other times of the year. Monthly Relative Humidity data of year (1983-2013) is given in Table 5.3. The maximum average Relative Humidity is 88.81% recorded in July and the minimum average Relative Humidity is 52.25% recorded in March. Moreover, Graphical Presentation of Relative Humidity (Monthly) of Year 1983-2013 is shown in Figure 5.3.

Table 5.3: Monthly Relative Humidity data of year 1983-2013

Month		Max of Average	Min of Average	Average
Pre-Monsoon	Mar	72.93	53.56	62.08
	Apr	77.44	64.95	70.50
	May	84.99	68.01	76.31
Monsoon	Jun	86.42	75.09	82.05
	Jul	88.81	77.48	83.30
	Aug	86.62	77.61	82.46
	Sep	88.44	77.69	82.74
Post-Monsoon	Oct	84.61	72.00	78.60
	Nov	79.26	67.01	73.00
Winter	Dec	79.92	66.33	73.45
	Jan	88.00	63.11	71.87
	Feb	70.87	52.25	63.23

Figure 5.3: Graphical Presentation of Relative Humidity (Monthly) of Year 1983-2013



Rain Fall Data

Average Annual rainfall data for the study area are given in Table 5.4. The maximum annual rainfall of 3028 mm occurred in the year 1984 and the maximum monthly rainfall of 732 mm occurred in the month of June 2007. Moreover, Graphical Presentation of Annual Rainfall Trend (1983-2013) and Graphical Presentation of Monthly Rainfall of Year 1983-2013 are shown in Figure 5.4 and Figure 5.5 respectively.

Table 5.4: Annual Rainfall Data of the project site of year (1983-2013)

Year	Annual Rainfall (mm)
1983	2388
1984	3028
1985	2053
1986	2500
1987	2187
1988	2482
1989	1627
1990	2103
1991	2850
1992	1169
1993	2819
1994	1540
1995	1751
1996	2044
1997	1896
1998	2310
1999	2374
2000	2124
2001	1679
2002	1875
2003	1676
2004	2340
2005	2680
2006	1964
2007	2835
2008	2129
2009	1727
2010	1518
2011	1771
2012	1326
2013	1585

Figure 5.4: Graphical Presentation of Annual Rainfall Trend (1983-2013)

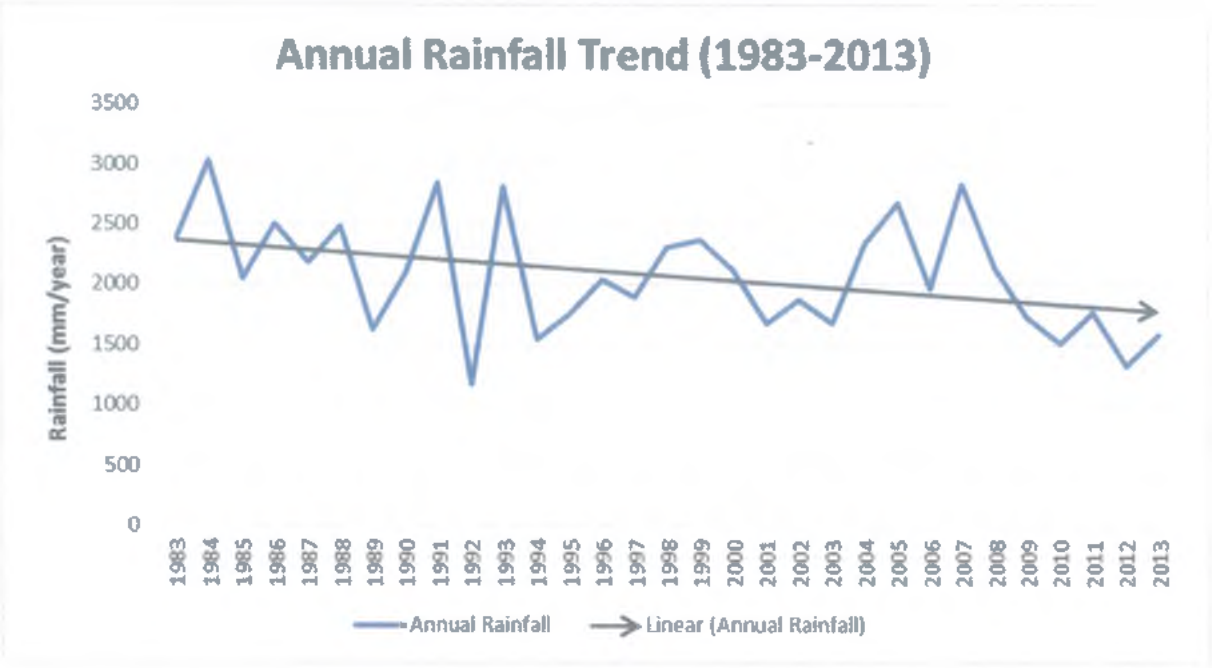
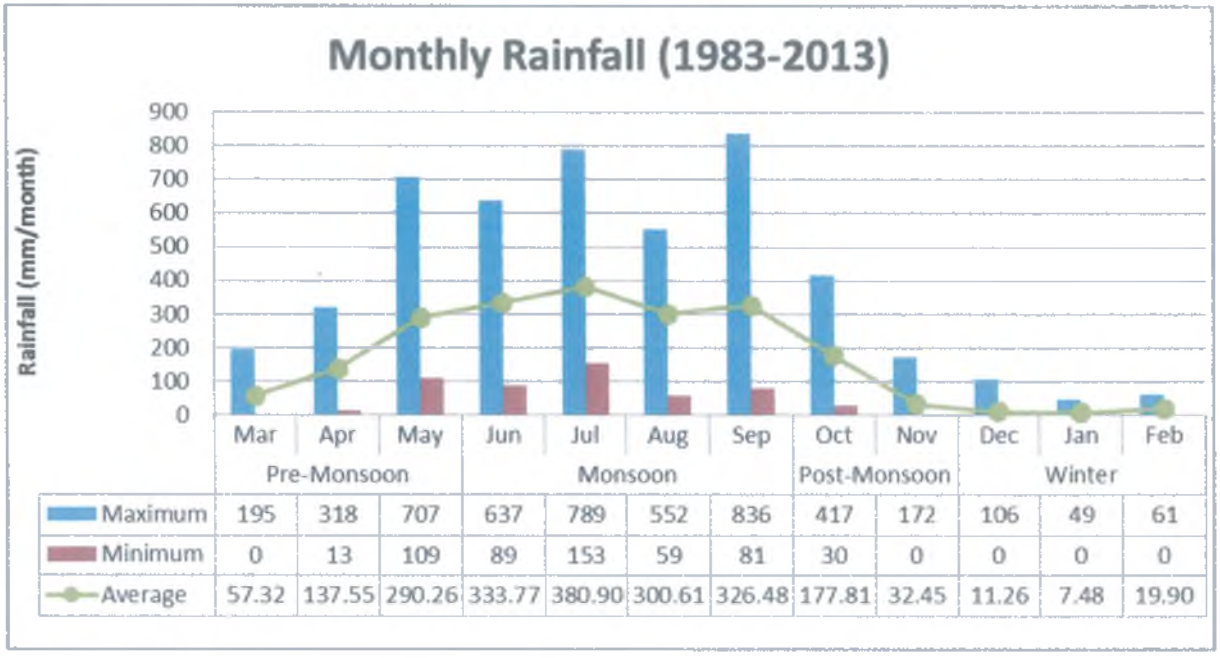


Figure 5.5: Graphical Presentation of Monthly Rainfall of Year 1983-2013



	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
	Pre-Monsoon			Monsoon				Post-Monsoon		Winter		
Maximum	195	318	707	637	789	552	836	417	172	106	49	61
Minimum	0	13	109	89	153	59	81	30	0	0	0	0
Average	57.32	137.55	290.26	333.77	380.90	300.61	326.48	177.81	32.45	11.26	7.48	19.90

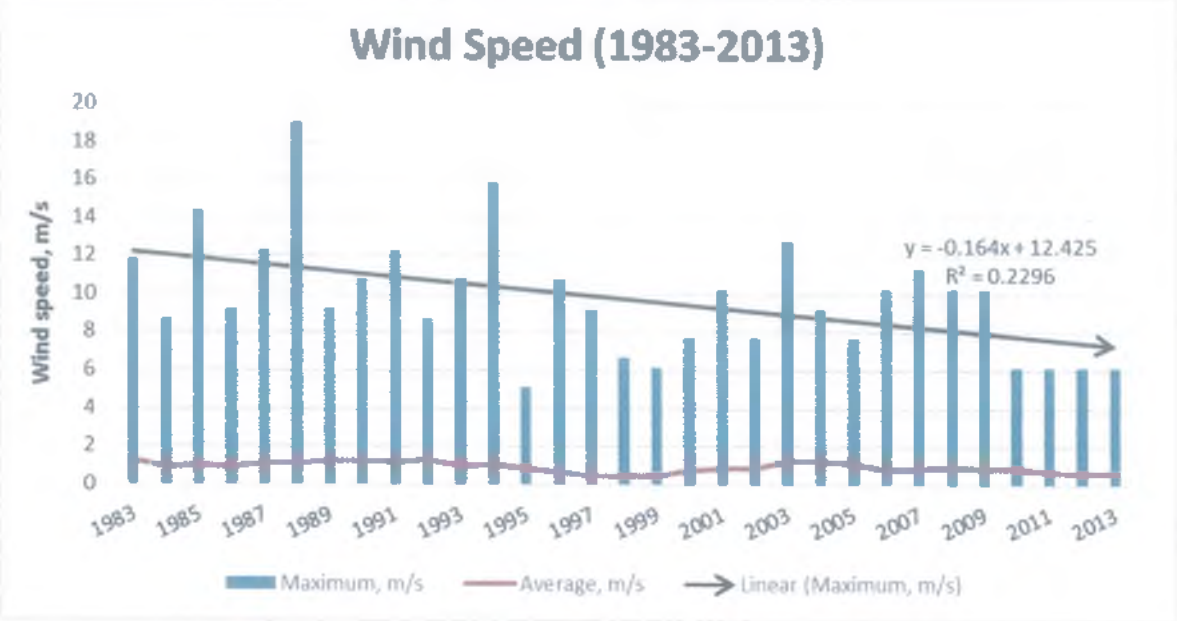
Wind Speed and Direction

Wind Speed and Direction of the site in year 1983-2013 is given in Table 5.5. It is observed that the maximum wind speed of 19.02779300 m/s during the year of 1988. Moreover, Graphical Presentation of Wind Speed and Direction of Year 1983-2013 is shown in Figure 5.6.

Table 5.5: Wind Speed and Direction of the site in year 1983-2013

YEAR	Maximum, m/s	Average, m/s
1983	11.82871317	1.225579684
1984	8.738432917	0.961459103
1985	14.39815967	1.019676742
1986	9.259266667	0.913773879
1987	12.33797283	1.110533296
1988	19.02779300	1.104051809
1989	9.259266667	1.277084355
1990	10.79861975	1.275348243
1991	12.33797283	1.220024124
1992	8.738432917	1.309376048
1993	10.79861975	0.995255426
1994	15.93751275	1.031598048
1995	5.138893000	0.895834050
1996	10.79861975	0.670370907
1997	9.259266667	0.483449461
1998	6.678246083	0.502662439
1999	6.168986417	0.490162429
2000	7.708339500	0.742708928
2001	10.27778600	0.876389590
2002	7.708339500	0.890162749
2003	12.85880658	1.281713988
2004	9.259266667	1.239931548
2005	7.708339500	1.118519413
2006	10.27778600	0.819445100
2007	11.30787942	0.877778480
2008	10.27778600	0.935301674
2009	10.27778600	0.852778460
2010	6.168986417	0.892940529
2011	6.168986417	0.645023664
2012	6.168986417	0.624190314
2013	6.157412333	0.601852333

Figure 5.6: Graphical Presentation of Wind Speed and Direction of Year 1983-2013



Bangladesh is also considered as cyclone prone area. In the last 50 years, several cyclonic storms occurred in Bangladesh. Some of remarkable devastating cyclonic storms occurred in 1970, 1990, 2007 and 2009 respectively, which claimed many lives and huge damage in Bangladesh. List of major cyclonic storms occurred in Bangladesh from 1960- 2011 is given in Table 5.6.

Table 5.6: List of major cyclonic storms occurred in Bangladesh from 1960 – 2011

Date of landfall	Nature of Phenomenon	Landfall Area	Maximum Wind Speed in kph	No. of deaths	Surge height
11.10.1960	Severe Cyclonic Storm	Chittagong	160	3,450	6.0m (19 ft)
31.10.1960	Severe Cyclonic Storm	Chittagong	193	5,149	6.6m (22 ft)
09.05.1961	Severe Cyclonic Storm	Chittagong	160	11,468	5.0m (16 ft)
30.05.1961	Severe Cyclonic Storm	Chittagong (Near Feni)	160	-	2.0-4.55m (6-15 ft)
28.05.1963	Severe Cyclonic Storm	Chittagong- Cox's Bazar	200	11,520	6.0m(20ft)
11.05.1965	Severe Cyclonic Storm	Chittagong-Barisal Coast	160	19,279	3.7m(12 ft)
05.11.1965	Severe Cyclonic Storm	Chittagong	160		20-25 feet
15.12.1965	Severe Cyclonic Storm	Cox's Bazar	210	873	2.4-3.6m (8-12 ft)
23.09.1966	Severe Cyclonic Storm	Noakhali coast	139	850	6-6.67m (20-22ft)
07.12.1966	Severe Cyclonic Storm	Cox's Bazar	81	—	—
08.11.1967	Cyclonic Storm	Khulna (Sundarban)	111 (sandheads)	1000(India)	—
23.10.1967	Severe Cyclonic Storm	near Cox's Bazar	107(cox's) 145(M.mar)	51(Bangladesh) 200 (Myanmar)	—
23.10.1970	Severe Cyclonic Storm of Hurricane intensity	Bangladesh-West Bengal coast	163	300	4.7 meter
12.11.1970	Severe Cyclonic Storm with a core of hurricane wind	Chittagong	224	3,00,000	3-10m (10-33ft)
8.05.1971	Cyclonic Storm	Chittagong	81	—	2.4-4.24m (8-14)ft
29.09.1971	Severe Cyclonic Storm	Sundarban coast	97-113	—	2ft
6.11.1971	Severe Cyclonic Storm	Chittagong-Noakhali coast	--	—	—
18.11.1973	Severe Cyclonic Storm	Chittagong	102	—	—
30.05.1974	Cyclonic Storm	Patuakhali	74-83	—	—
28.11.1974	Severe Cyclonic Storm	Chittagong -Cox's Bazar coast	163	20	(3.0-5.1)m (09-17) feet
10.12.1981	Cyclonic Storm	Khulna	120	72	2.12-4.55m (07-15) feet
15.10.1983	Cyclonic Storm	Chittagong	93	43	—
09.11.1983	Severe Cyclonic Storm	Chittagong -Cox's Bazar coast	136	300	1.5m (5ft)
24.05.1985	Severe Cyclonic Storm	Chittagong	154	4,264	4.55m (15) feet
29.11.1988	Severe Cyclonic Storm with a core of Hurricane wind	Khulna coast	160	5,683	4.4m (14.5ft)
18.12.1990	Cyclonic Storm (crossed as a depression)	Cox's Bazar Coast	115	—	—

Date of landfall	Nature of Phenomenon	Landfall Area	Maximum Wind Speed in kph	No. of deaths	Surge height
29.04.1991	Severe Cyclonic Storm with a core of Hurricane wind	Chittagong	225	1,38,882	6-7.6m (20-25) ft
31.05.1991	Cyclonic Storm	Noakhali coast	83	—	2.5m, (08)ft
02.05.1994	Severe Cyclonic Storm with a core of Hurricane wind	Cox's Bazar-Teknaf Coast	200-250	184	3.64-4.85m (12-16)ft
25.11.1995	Severe Cyclonic Storm	South of Cox's Bazar	55	—	—
26.10.1996	Cyclonic Storm	Sundarban coast	70	9	1.5-2.0m (5-7)ft
19.05.1997	Severe Cyclonic Storm with a core of hurricane wind	Sitakundu	232	155	4.55 meter (15)ft
27.09.1997	Severe Cyclonic Storm with a core of Hurricane wind	Sitakundu	150	67	3.03-4.55 m (10-15)ft
20.05.1998	Severe Cyclonic Storm with core of Hurricane winds	Chittagong Coast near Sitakunda	173	14	3 ft
17.10.1999	Severe Cyclonic Storm of Hurricane intensity	Orissa Coast			
25.10.1999	Severe Cyclonic Storm of Hurricane intensity	Orissa Coast			
28.10.2000	Deep Depression (Probably Cyclonic Storm)	Sundarban coast near Mongla	50-60	3	2-4 ft
16-10.2001	Severe Cyclonic Storm	Andhra coast	65-85		
12.11.2002	Cyclonic Storm	Sundarban coast near Raimangal river	65-85	2	5-7 ft
20.5.2003	Cyclonic Storm	Myanmar coast	65-85	—	3-5 ft
16.12.2003	Severe Cyclonic Storm	Andhra coast	98-115		
19.05.2004	Cyclonic Storm	Cox's Bazar & Akyab Coast	65-90	—	2-4 ft
28.10.2005	Cyclonic Storm	Andhra coast near Ongole.			
10.12.2005	Cyclonic Storm (crossed as a depression)	Tamilnadu coast near Nagapattnam.			
29.04.2006	Severe Cyclonic Storm with a Core of Hurricane "Mala"	Arakan coast of Myanmar between Akyab & Sandoway			
15.05.2007	Cyclonic Storm "AKASH"	Ctg- Cox's Bazar. Coast near Ctg	83		
15.11.2007	Severe Cyclonic Storm "SIDR"_ with a core of Hurricane	Khulna-Barisal coast near Baleshwar river	223	3,363	15-20 feet

Date of landfall	Nature of Phenomenon	Landfall Area	Maximum Wind Speed in kph	No. of deaths	Surge height
	winds				
02.05.2008	Severe Cyclonic Storm "NARGIS"with a core of Hurricane winds	Myanmar coast near Bassein			
26.10.2008	Cyclonic storm "Rashmi"	Khulna-Barisal coast near Patharghata		—	05-07 feet
27.11.2008	Cyclonic Storm "Nisha"	Tamilnadu coast near Nagapathnam.			
17.04.2009	Cyclonic Storm "BIJLI"	Chittagong-Cox'sBazar coast near Ctg.	90	—	—
25.05.2009	Cyclonic Storm "AILA"	West Bengal-Khulna (Bangladesh) coast near Sagar inland of India.	92	190	07-08 feet
20.05.2010	Severe Cyclonic Storm "LAILA"	NE Andhra coast of India			

River Water level (Surface Water Level)

The surface water level is an important issue of water resources. Bangladesh Water Development Board (BWDB) has four stations of tidal water level in the study area. All stations of tidal water level have direct connection with Meghna River. Following Figures showing High and Low tidal water level at Dhaleswari, Meghna, Upper Meghna and Gumti-Burinadi Rivers stations respectively.

Figure 5.7: Surface water level at Kalagachia (Dhaleswari River)

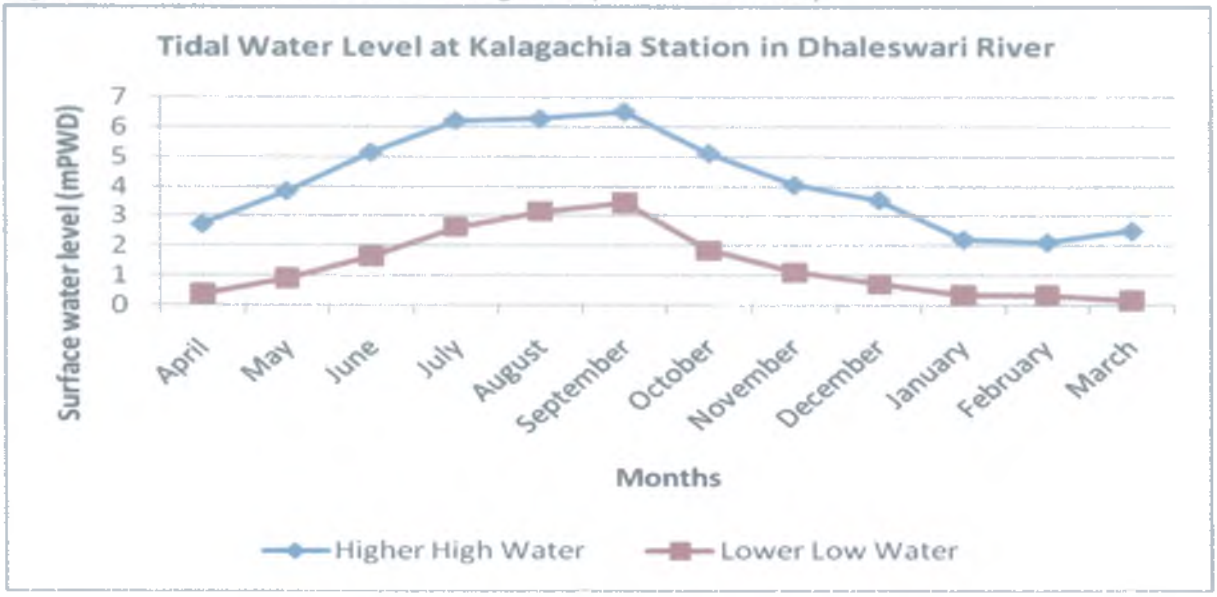


Figure 5.8: Surface water level at Meghna Ferryghat (Meghna River)

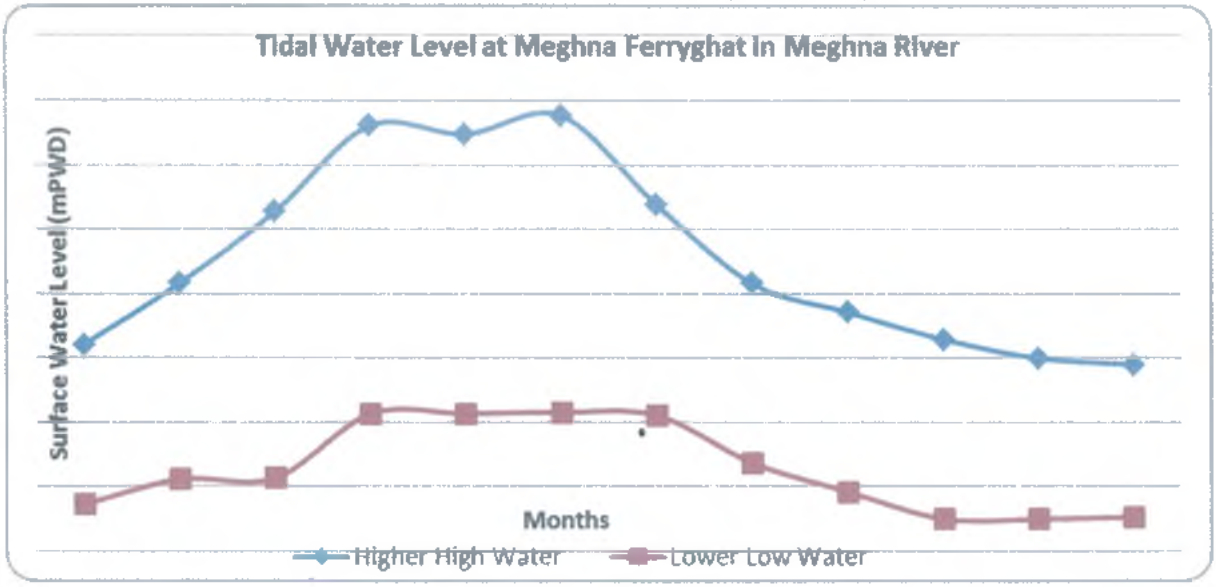


Figure 5.9: Surface water level at Satnal (Upper Meghna River)

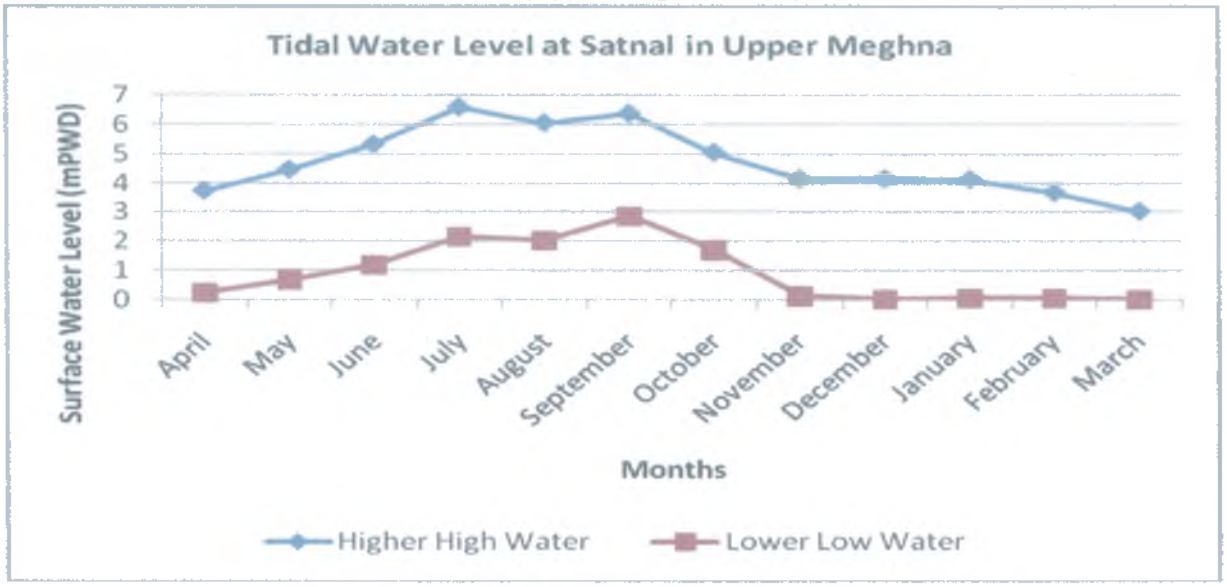
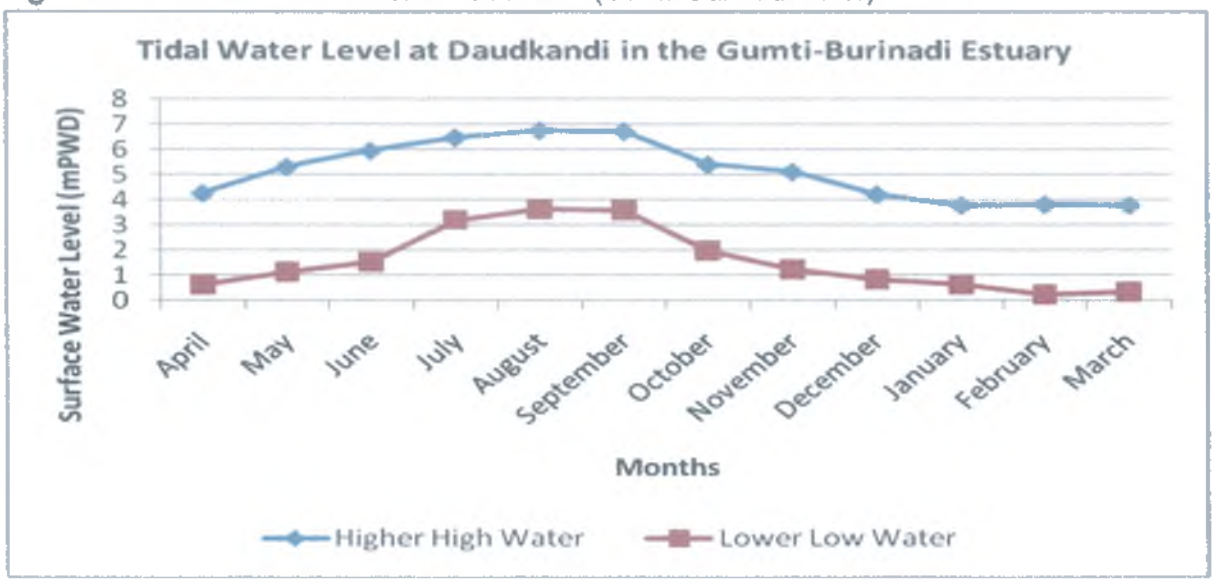


Figure 5.10: Surface water level at Daudkandi (Gumti-Burinadi River)



From the above figures, it is evident that high tide usually observed during July to September. And lower tide observed during December to May in the dry period. Tidal water level has direct connectivity to the meteorological characteristics of the study area. The higher tidal level water has been found 6.76~6.40 mPWD in the month of September and lower tidal water level is 0.49~0.01 mPWD in the month of February and March.

Water Quality Data

Surface and Ground Water source of Gazaria includes khal, river and deep tube wells. Rainfall intensity, surface sediments, water use practices highly influence the quality of surface water. Eight sampling points have been selected to determine surface and ground water quality. The points have been selected considering water to be impacted mostly for power plant project. In-situ tests have been conducted during field visit in February, 2016. The measured values (Temperature, pH, Salinity, DO) are presented in Table 5.7

Table 5.7: In-situ surface water quality during pre-monsoon

Sampling Points	Location		Date	Time (24hr)	Temp (°C)	pH	DO (mg/l)	BOD_5 (mg/l)
	Latitude (North)	Longitude (East)						
SW01	23°32'36.3"	90°35'13.6"	25.02.16	13:10	24.6	7.3	3.2	2.8
SW02	23°31'0.55"	90°35'37.0"	25.02.16	12:47	26.8	7.2	4.0	2.2
SW03	23°31'8.80"	90°35'22.6"	25.02.16	11:14	24.9	7.6	4.0	1.9
SW04	23°32'30.4"	90°36'46.7"	25.02.16	9:10	25.7	7.24	4.4	2.1
SW05	23°31'21.4"	90°38'15.4"	26.02.16	12:30	25.7	7.3	4.4	3.2
SW06	23°29'27.5"	90°35'34.9"	25.02.16	13:18	25.0	7.2	4.4	2.7
GW01	23°30'41.8"	90°36'19.8"	25.02.16	10:40	23.2	7.31	2.9	0.7
GW02	23°31'19.9"	90°36'1.8"	26.02.16	12:35	23.3	6.85	3.8	0.3

(Source: CEGIS study team, February 2016)

The standard values of inland surface water as per Environmental Conservation Rule, 1997 are shown in Table 5.8

Table 5.8: Standard values for Inland Surface Water

Serial No	Classification	pH	DO (mg/l)	BOD (mg/l)
1	Potable water after bacteria freeing only	6.5-8.5	6 or above	2 or less 3
2	Water used for recreational purposes	6.5-8.5	5 of more	3 or less
3	Potable water after conventional processing	6.5-8.5	6 or more	6 of less
4	Water used by fisheries	6.5-8.5	5 or more	6 of less
5	Industrial water including chilling and processes	6.5-8.5	5 or more	10 or less
6	Water used for irrigation	6.5-8.5	5 or more	10 or less

(Source: ECR, 1997)

From Table 5.7 and Table 5.8, it is evident that the values of pH and DO at sampling points are within the standard value in the study area.

The groundwater quality around the proposed power plant site was surveyed. The measurement was conducted in dry season (February, 2016) to reflect the groundwater quality. Table 5.9 represents some of the important in-situ water quality parameter with specific location. To have a clear picture, these sampling points have been selected to assess a number of water quality parameters and samples have been taken in the pre-monsoon. This data will be used as Baseline situation for comparative assessment of water quality change due to power plant intervention.

Table 5.9: In-situ groundwater quality testing result in the study area

Sampling Point	Location		Temp, (deg. C)	pH	Salinity (ppt)	DO (mg/l)
	Latitude (North)	Longitude (East)				
1	23°31'17.79"N	90°38'18.99"E	25.1	7.31	0	2.9
2	23°31'21.34"N	90°36'47.72"E	24.8	6.85	0	3.8
ECR Standard for Drinking Water			20-30	6.5-8.5		6

(Source: CEGIS field team, February 2016)

From the above table it is observed that the values of groundwater quality parameters are within the standard values but significantly lesser amount of DO for drinking purpose.

Soil Quality

Soil quality is the basic indicator for the crop production. The study area is mostly covered by seven types of soil series. They are as follows: Tengarchar, Fuldi, Naraibag, Borda, Meghna Polimati, Sonaltola and Silmondi. Soil samples were collected following the standard practices of composite method. At each plot, soil samples were collected from three dug pit. From each pit, three soil samples were extracted from three different depths. Top soil from 0-15 cm depth, subsoil from 15-30 cm depth and sub stratum from 30-45 cm depth were collected using augur during 25 to 26 February, 2016. The three top soil samples collected from three different pits were then mixed properly to make a composite sample and 500g of soil mass has been taken and stored in an air tight protective poly bag for laboratory analysis. Similar approach has been followed in collecting sub soil and sub stratum soil sample collection. To have more accurate results, it is ensured that the top, subsoil and substratum are taken from the same pit.

Soil reaction (pH), Organic Matter (OM), Major nutrients (N, P, K, S, Ca, Mg and Na) along with micro nutrients (B, Fe, Mn and Zn) and some heavy metals (Pb and Cd) were analyzed from SRDI, Dhaka. Detailed information of soil quality is presented in the Table 6.13. It was observed from the table that, the pH ranges from strongly acidic to slightly alkaline. Besides this the area is inherently rich in Mg, Fe and Mn. Level of nitrogen is very low to low. Zn and Organic Matter are low to medium. Concentration of B is optimum level. The level of Ca, P, K and S are medium to very high in nature. Concentration of Na, Pb and Cd are also observed in soils in the study area.

Table 5.10: Soil quality (analyzed) of the study area

Location (Mouza / Village)	GPS reading	Land use	Depth (cm)	pH	OM	N	K	Ca	Mg	Na	P	S	B	Fe	Mn	Zn	Pb	Cd
					%		Meq/100g				µg/g							
Karim Khan	23°32'12.2"N 90°37'21.6"E	Til+B. Aman-B. Aman-Potato	0-15	4.9	2.59	0.15	0.27	8.44	1.87	0.20	83.28	57.18	0.47	227.02	18.84	1.08	14.53	0.008
			15-30	5.5	2.81	0.16	0.21	8.12	2.06	0.16	80.44	33.19	0.46	68.99	28.43	1.12	16.89	0.001
			30-45	6.0	1.72	0.10	0.17	9.12	2.79	0.15	77.79	25.34	0.42	52.40	42.76	0.85	13.08	0.003
Hoglakandi	23°31'19.8"N 90°38'14.7"E	Maize+B. Aman-B. Aman-Potato	0-15	4.9	2.59	0.15	0.27	9.72	2.49	0.18	64.63	30.74	0.54	59.29	39.11	1.35	15.98	0.000
			15-30	7.0	1.98	0.11	0.15	10.29	2.95	0.13	45.74	15.24	0.46	86.91	34.74	0.85	16.01	0.002
			30-45	7.6	1.29	0.08	0.15	8.69	3.85	0.13	33.56	16.60	0.50	24.34	12.57	0.55	18.89	0.0000
Optimum Level				5.5-7.0	*	0.271-0.36	0.3-0.36	4.6-6.0	1.2-1.5	*	15.8-21.0	22.6-30.0	0.5-0.6	9.1-12	2.3-3.0	1.4-1.8	*	*

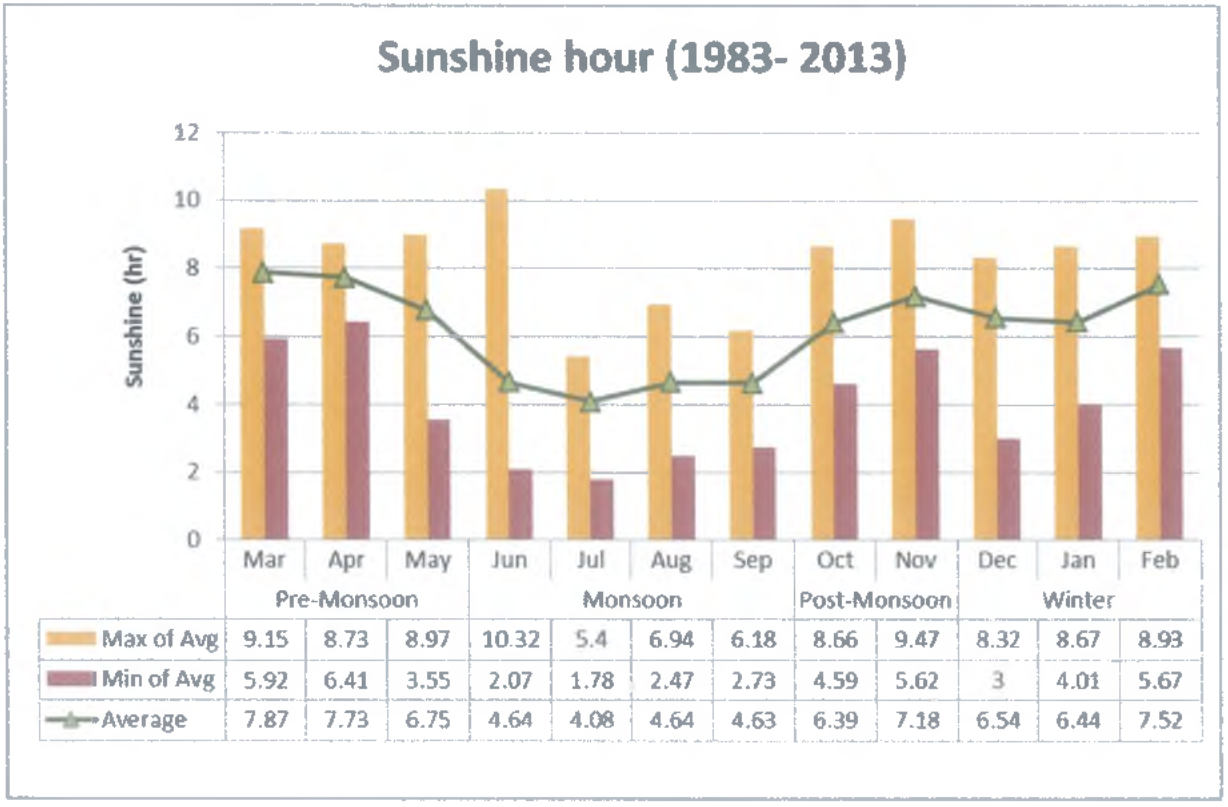
(Source: SRDI Laboratory analysis, May; 2016)

Sunshine Data

Table 5.11: Monthly Sunshine Data of year (1983-2013)

Months		Max of Average	Min of Average	Average
Pre-Monsoon	Mar	9.15	5.92	7.87
	Apr	8.73	6.41	7.73
	May	8.97	3.55	6.75
Monsoon	Jun	10.32	2.07	4.64
	Jul	5.4	1.78	4.08
	Aug	6.94	2.47	4.64
	Sep	6.18	2.73	4.63
Post-Monsoon	Oct	8.66	4.59	6.39
	Nov	9.47	5.62	7.18
Winter	Dec	8.32	3.00	6.54
	Jan	8.67	4.01	6.44
	Feb	8.93	5.67	7.52

Figure 5.11: Graphical presentation of Sunshine Data (Monthly) of year (1983-2013)



5.3 REQUIREMENT OF LAND

The Consultants discussed with RPCL in several meetings and finalized the project boundary at 314.10 acres out of 330.60 acres, as some portion of the land devoured by Meghna river, which has been left vacant to satisfy the River Acts and Environmental Aspects (as the land is situated on the bank of the Meghna River). Indeed, the plot plan for the proposed power plant has been prepared on 314.10 acres of land.

Based on the above basic data and prepared plot plan, the proposed quantity of land may be suitable to build the Gazaria 350 (±10%) MW Coal Fired Thermal Power Plant with future extension of another 350 (±10%) MW Unit with common facilities. RPCL may acquire some more land adjoining to the existing site in future for the 2nd Unit as necessary.

5.4 PLANT CONFIGURATION & TECHNOLOGY

The power plant shall consist of 1 Steam Turbine Generator (STG) set of 350 (±10%) MW capacity and 1 Supercritical Pulverized Boiler (SCPB) and the Balance of Plant (BOP) comprising of coal & ash handling plant, water treatment plant, DM plant, compressed air system, electrical controls, instrumentation and control, power evacuation system, infrastructure facilities, chimney etc.

5.5 FUEL SYSTEM

The steam generator would be designed primarily for imported coal firing having about 15% of ash content with gross calorific value (GCV) of about 5000 kCal / kg. Heavy Fuel Oil (HFO) would be used for start-up and flame stabilisation at low loads and Light Diesel Oil (LDO) will be used for light up and warm up of units. The fuel analysis data of Coal, HFO and HSD are presented in 'Annexure 01: Fuel Analysis Data'.

The annual consumption of coal for the proposed power plant is estimated about 1.11 m MT (maximum) considering average GCV value of coal as 5000 kCal/ kg, plant heat rate 2273 kcal/kWhr and annual PLF of 80%. This amount of coal will be sufficient to cater to the plant requirement of 180 TPH of coal after taking into account the safety buffer stock to be kept at the plant site to cope with any emergency situation. Coal storage yard for 60 days has been proposed in the plant. The coal related arrangements are provided later in this report.

Start-up, warm up and low load (up to 30%) operation shall be carried out with LDO. Boiler will be so designed that oil firing for flame stabilization will not be required beyond 30% MCR. Ignition of heavy oil shall be directly by high energy arc igniters. There shall be LDO firing in at least one burner elevation to facilitate a cold start-up of the unit when no auxiliary steam is available for HFO heating and atomization. The annual requirement is estimated to be about 3000 KL. The oil shall be procured from nearest depot to the site and shall be stored in tanks. For the space planning purpose and in the financial model the provisions have been made assuming a 1 ml per kWh specific oil consumption as per international norms.

The main fuel to be used in the proposed Gazaria 350 (±10) MW Coal Fired Power Plant is bituminous/sub-bituminous coal. Based on the recommended quality of coal (QCV 5,000 Kcal/kg , sulfur less than 1%, ash content around 15% and carbon content 40%), the estimated daily coal requirement for the generation of 350 (±10%) MW power shall be approximately 3000 tons/day and 1.11 million tons per year, considering 80% plant load factor. Besides, light diesel fuel oil (LDO) and heavy fuel oil (HFO) will also be used for boiler start up, flame stabilization and low-load operation. Capacity (proposed) of heavy fuel oil (HSD) tank and liquid diesel oil (LDO) tank are respectively 200 m^3 and 500 m^3.

5.6 REQUIREMENT OF WATER

Due to proximity to the Meghana River, it is proposed to use river water directly for condenser cooling and with appropriate treatment shall be used for the cycle make-up and other consumptive water requirements for the Plant.

The total estimated make up river water requirement for the cooling water system and other consumptive for 350 (±10%) MW plant is,

- For once through cooling system it is 69,600 m³/hr drawn from river out of which only 300 m³/hr is consumed for plants requirement.
- For Closed cooling system it is 1,190 m³/hr drawn from river and entire drawn water is consumed for plant requirement.

The river water will be brought to the site through construction of vertical pump at the jetty and pipe line. Similarly the discharge water shall be returned to the river through Pangashia Khal by pipeline. The analysis of surface and ground water is presented in Annexure 02: Water Quality Data.

5.7 TYPE OF COOLING WATER SYSTEM

Direct or Once-Through Wet Cooling

If a coal plant is next to a large volume of water (big river, lake or sea), cooling can be achieved by simply running water through the plant and discharging it at a slightly higher temperature. There is then hardly any use in the sense of consumption or depletion on site, though some evaporation will occur as it cools downstream. The amount of water required will be greater than with the recirculating set-up, but the water is withdrawn and returned, not consumed by evaporation. The water withdrawal requirement for a one MWe unit is about 0.05625 cubic meters per second.

Many power plants have once-through cooling (OTC), since their location is not at all determined by the source of the fuel, and depends first on where the power is needed and secondly on water availability for cooling. Using sea water / river water means that higher-grade materials must be used to prevent corrosion, but cooling is often more efficient.

Any coal-fired plant that is normally cooled by drawing water from a river or lake will have limits imposed on the temperature of the returned water on the temperature differential between inlet and discharge. (Typically 5 to 6°C higher than inlet water)

Recirculating or Indirect Wet Cooling

Where a power plant does not have abundant water, it can discharge surplus heat to the air using recirculating water systems which mostly use the physics of evaporation.

Cooling towers with recirculating water are a common visual feature of power plants, often seen with condensed water vapor plumes.

Most thermal power plants with recirculating cooling are cooled by water in a condenser circuit with the hot water then going to a cooling tower. This may employ either natural draft (chimney effect) or mechanical draft using large fans (enabling a much lower profile but using power). The cooling in the tower is by transferring the water's heat to the air, both directly and through evaporation of some of the water. The water consumption/requirement for a 1MWe unit is about 0.00125 cubic meters per second, this being about half for evaporation and half for blow-down.

The most common configuration for natural draft towers is called counter-flow. These towers have a large concrete shell with a heat exchange 'fill' in a layer above the cold air inlet at the base of the shell. The air warmed by the hot water rises up through the shell by convection (the chimney effect), creating a natural draft to provide airflow to cool the hot water which is sprayed in at the top. Other configurations include cross-flow, where the air moves laterally through the water, and co-current, where the air moves in the same direction as the water droplets. These towers do not require fans and have low operating but significant maintenance costs. For a large plant they may need to be over 200 meters high.

Mechanical draft cooling towers have large axial flow fans in a concrete/timber and plastic structure. The fans provide the airflow and are able to provide lower water temperatures than natural draft towers, particularly on hot dry days. However, they have the disadvantage of requiring auxiliary power, typically about 1% of the plant's output, and up to 1.2% of it. Mechanical draft towers are used exclusively since they can provide a more controlled performance over a wide range of conditions, ranging from freezing to hot and dry. Also they are less visually obtrusive, being less than 50 m high.

Such cooling towers give rise to water consumption, with up to 3.0 liters being evaporated for each kilowatt-hour produced, depending on conditions. This evaporative water loss by phase change of a few percent of it from liquid to vapor is responsible for removing most of the heat from the coolant water at the cost of only a small fraction of the volume of the circulating liquid (though a rather large fraction of the water actually withdrawn from lake or stream). Water consumption by evaporation is reckoned to be typically about double that with direct cooling (once through cooling).

Cooling towers with recirculating water reduce the overall efficiency of a power plant by 2-5% compared with once-through cooling system and they are about 40% more expensive than a direct, once-through cooling system.

Water evaporating from the cooling tower leads to an increasing concentration of impurities in the remaining coolant. Some bleed – known as "blow down" – is needed to maintain water quality. Replacement water required is thus about 50% more than actual evaporation replacement, so this kind of system consumes (by evaporation) up to 70% of the water withdrawn.

Selection of cooling system:

Option 1:

Direct or Once through Wet Cooling system has got many advantages as follows:

1. Plant is on the bank of river, having sufficient water all over the year.
2. Less consumption of water through cooling system.
3. Less consumption of chemicals through cooling system.
4. Operation and maintenance cost will be less than any other method.

Option 2:

The advantages of Recirculating or Indirect Wet Cooling or Closed Circuit Cooling System are as follows:

1. It is necessary to comply and satisfy environmental regulations and guidelines of DOE, Bangladesh to avoid any environmental hazards that may arise due to the operation of coal fired power plant.

2. For power plants, where once through cooling system is not permitted by DOE on the grounds of environmental issues arising out of the possibilities to endangering acquatic livelihoods in the river, in such cases, induced draft cooling towers is suggested for condenser circulating water. The storage reservoir will be filled up from the river water as and when required, which will be used for makeup water for the induced draft cooling towers.

3. Closed circuit cooling towers completely isolate the process fluid from the atmosphere. This is accomplished by combining the heat rejection equipment with a heat exchanger in a closed circuit tower. A closed loop system protects the quality of the process fluid, reduces system maintenance, and provides operational flexibility at a slightly higher initial cost.

Taking into consideration of the above mentioned facts, Recirculating or Indirect Wet Cooling or Closed Circuit Cooling Systems (Cooling Towers) may be selected for the proposed Gazaria 350 (±10%) MW Coal Fired Thermal Power Plant Project.

5.8 MAJOR EQUIPMENTS

5.8.1 STEAM GENERATOR & ACCESSORIES

The Steam Generator shall be once through, water tube, pulverized coal fired, top supported, balanced draft furnace, single reheat, natural circulation, radiant type, dry bottom type, suitable for outdoor installation. The gas path arrangement shall be two pass types.

The steam generator unit shall be capable of operating on sliding pressure /modified sliding pressure mode. The load range for the sliding pressure unit operation shall be from 40% SGMCR to 100% TGMCR. However it shall also be possible to operate the steam generator with modified sliding pressure mode, with constant pressure mode operation between 90% TGMCR to 100 % SGMCR.

Furnace

The furnace will be radiant, dry bottom type with tangential or opposed wall firing and enclosed by water cooled and all welded membrane walls. The furnace bottom shall be suitable both for installation of water impounded bottom ash system and submerged scrapper chain conveying system. Spray type attemperator is envisaged to control the super heater outlet temperature for varying loads. The super heater and re-heater tubes will be a combination of radiation and convection type. Economizer will be non-steaming type and shall be of modular construction.

Steam Generator Circulation System

The SG start up system envisages boiler start up drain system. Separator(s) will be used during start up for separating the steam water mixture up to a load of around 30% SGMCR, above which it will be running dry. Lower part of furnace / water wall will consist of vertical plain / rifle tubes or wrap around / helical tubes.

Air and Flue Gas System

A balanced draft system will be provided. The draft fans for the SG will be capable of maintaining balanced draft condition in the furnace over the entire load range. The SG will be supplied with a complete set of draft equipment including Forced Draft (FD) fan, Induced Draft (ID) fan, Primary Air (PA) fan, seal / cooling air fan, damper and associated equipment. There will be 2 axial type FD fans and 2 radial / axial type ID fans and 2 pairs of regenerative rotary type air preheaters. A pair of air pre-heater will be used for primary air and the second pair for secondary air.

2 SCAPH on secondary air system will be provided for start-up, low load operation or abnormal conditions when an increased air inlet temperature is considered desirable to minimize the cold end corrosion of regenerative air pre-heaters. The SCAPH will be designed to maintain the average metal temperature of regenerative air pre-heater cold elements 10°C above the acid dew point temperature by increasing the temperature of air during start-up and very low load operation.

The regenerative air pre heater is of Trisect or Ljungstrom vertical type. The air heater will be leak proof and relatively maintenance free. These air pre heaters will be designed passively to avoid the low temperature corrosion of the cold end section of the air heater parts.

5.8.2 STEAM TURBINE & ACCESSORIES

The scope of each Turbine Generator (TG) unit of 350 (±10%)MW shall broadly cover the ST along with its integral systems and auxiliaries like lube oil system, control-fluid system, condensers, condenser air evacuation system, HP & LP bypass system, complete regenerative feed heating system, condensate pumps along with their drives, boiler feed water pumps along with their drives, automatic turbine run-up system, instrumentation and control devices, turbine supervisory instruments, turbine protection and interlock system, automatic turbine testing system and turbine hall EOT cranes.

As the units will operate generally base loaded, it shall be designed to perform in the most efficient manner at 100% MCR condition. However, at times, the units shall operate on cyclic load (load follow mode). Further, during disturbances in the power grid, the unit protection shall be capable of islanding from the grid and operate in islanded mode catering to its own house load. The unit and auxiliaries shall be suitably designed considering the above requirements

5.9 ENERGY ABSORPTION PLAN

The average yearly gross electrical generation from the 1 x 350 (±10%) MW units of the power plant is estimated to be approximately 2698.08 MU (Gross Output: 385 MW) based upon a PLF of 80% which is typical for this type of generating plant. Auxiliary power consumption is considered approximately 7% of gross plant output, which is typical for the power plant of this size. The net power generation at the 230 kV switchyard bus will be approximately 2509.21 MU at 80% PLF.

The power plant will be operated meeting the requirement of grid Code of Power Grid Company of Bangladesh (PGCB). In view of the very good part load efficiency and higher load ramping rates, Supercritical Units making it suitable for part load operation. Power will be dispatched as per the dispatch schedule of the regional load dispatch center in line with the terms and condition of Power Purchase Agreement (PPA).

5.10 POWER EVACUATION

Power evacuation is planned considering the nearest EHV transmission systems. Power generated from the plant units will be evacuated through 230KV outdoor switchyard which will be connected to the 230 KV double circuit transmission line.

The terminal points of the 230 KV switchyard and 230 KV transmission line will be the take-off structures inside the power plant switchyard fence. However, depending upon the requirement of PPA the terminal point of the transmission line will be decided during execution stage of the project.

The generator will be connected to the 230 kV Switchyard through a 19-21/230 kV generator transformer. Start-up power will be drawn from the grid, again through the station transformer. The planning would consider that the construction power required by the project shall be met through an electrical connection from 33 kV grid system nearby to the project. The 230 kV switchyard will be provided with the following bays (tentative):

- 2 generator transformer feeder
- 2 line feeders
- 2 station transformer feeder

All necessary protections for bus, line feeders, and transformer and reactor feeders will be provided in the 230 kV switchyard subject to the final design.

5.11 FIREFIGHTING SYSTEM

General

Fire protection systems consists both outdoor and indoor firefighting system and fire detection/ alarm system to be installed in all buildings and equipment in the plant area. Various types of firefighting systems, such as water fire extinguishing, Clean Agent Fire extinguish, dry chemical powder and foam fire extinguishing, shall be selected to provide an appropriate fire protection. Firefighting Water for the add-on steam cycle firefighting system shall be branched from the existing firewater loop. Water is to be supplied to every protected area with enough quantity and pressure for effective fire extinguishing. The water for the firefighting system cannot be used for any other purposes.

Fire Fighting Water Supply extension

The firefighting water will be drawn from Ground Water Storage Basin and fire water pumps will be installed in cooling water pump house. The major equipment's will be,

- A.C Motor Driven pump (2x100%)
- Diesel Engine driven pump of same capacity of motor driven pump.
- Jocky pump to maintain constant pressure of fire hydrant header.
- Air compressor, pressure vessel.

A hydrant and hose station system will be located at various positions in the proposed plant, outdoor and indoor. The outdoor hydrants shall be connected to underground fire water supply piping. The distance between two adjacent outdoor hydrants around Steam turbine and generator building and transformer area shall not exceed 60 m and other areas not exceed 120 m.

The fire hydrant will be of coupling type of relevant standards. Outdoor locations shall be protected by pillar hydrants, each with two DN65 mm bib-nosed landing valve outlets and a main operating hand wheel. Underground pipe will be of 250mm nominal bore.

The plant's indoor locations will be protected by DN65mm gunmetal bib-nosed landing valves. All landing valves will be made to standard. These will be of either open or recessed type as appropriate to the location.

Zone valves will be installed in the system to facilitate maintenance of individual section without interrupting the whole system.

Portable Fire Extinguishers

Portable fire extinguishers of suitable types will be provided throughout the Plant as required.

Fire Fighting Measure

The portable & moveable fire extinguisher system will be designed to extinguish the initial fire at the hazardous areas.

Deluge System

Deluge System with sprinklers will be provided in the high voltage transformer area of plant's 230 kV sub-station.

5.12 ENVIRONMENT ASPECTS

All necessary pollution control measures would be planned for the power plant, and these are expected to meet the requirement of environmental authorities. The power plant would be burning Coal. The plant will have latest pollution control equipment and ETP. 220 meter high Stack shall be installed to limit the SPM, SOx, NOx emissions well within the prescribed permissible limits, which shall meet the World Bank Group and DoE norm.

The plant will have no adverse impact on the environment and surrounding areas of the project. Adequate provision has been made for neutralizing the liquid effluents from the plant and ensuring low discharge. Blow down from the cooling water system would be treated in the effluent treatment plant. The above features have been incorporated to minimize the plant effluent water discharge from plant.

CHAPTER 18:
ENVIRONMENTAL ASPECTS

CHAPTER 18: ENVIRONMENT AND POLLUTION ASPECTS

18.1 ENVIRONMENT AND POLLUTION ASPECTS

In Bangladesh, the Department of Environment (DOE) is the government agency, who is responsible for environmental planning, management, and monitoring according to the Environmental Conservation Rules (ECR), 1997 issued under the Ministry of Environment and Forest (MOEF). According to Schedule 1 of the ECR, the Project falls under the Red Category classification.

The environmental impacts of the proposed Gazaria 350 (±10%) MW Coal Fired Thermal Power Plant Project covering the following pollution aspects are considered and discussed in this chapter.

- Air Pollution
- Water Pollution
- Sewage Disposal
- Noise Pollution
- Pollution Monitoring and Surveillance Systems
- Waste Water (Liquid Effluent) Treatment and Recycling

18.2 AIR POLLUTION

The Air Pollutants from the proposed unit are:

- Dust Particulates from Fly Ash in Flue Gas
- Sulphur Dioxide in Flue Gas
- Nitrogen Oxides in Flue Gas
- Coal Dust Particles During Storage/ Handling
- Ash Dust

For the thermal power plants, notification by Ministry of Environment and Forests (Environmental Conservation Act, 1995 and Environmental Conservation Rules (ECR), 1997 of Bangladesh) stipulate the limits for particulate matter emission, as furnished in the table below and the minimum stack height to be maintained to keep the sulphur dioxide level in the ambient air within the air quality standards is also furnished below.

Table18.1: Thermal Power Plant Standard for Particulate Matter Emission

Power plant with capacity of 200 Megawatt or above	**150 mg / Nm^3**
Power plant with capacity less than 200 Megawatt	350 mg / Nm^3

Source: Schedule 11, Standards for Gaseous Emission from Industries or Projects, ECR – 199

Table 18.2: Stack Height Requirement for Sulphur Dioxide Control of Coal Based Power Plant

Less than 200 MW	$H = 14 (Q)^{0.3}$ Where, Q = Sulphur dioxide emission rate in kg/hr H = Stack height in metres
200 MW & more to less than 500 MW	**220 m**
500 MW and more	275 m

Source: Schedule 11, Standards for Gaseous Emission from Industries or Projects, ECR - 1997

As per the regulations, it is proposed to install a stack of 220 m height to meet the above statutory requirement.

The height of the stack which disperses the pollutants has been fixed based on the above guidelines of the Emission Regulations set by DOE. The Electrostatic Precipitators (ESP) which remove most of the fly ash from the flue gas, thereby limiting the quantity of fly ash emitted to atmosphere. The ESP will be designed for outlet dust concentration of maximum 100 mg/Nm^3.

18.3 NO_X & SO_2 EMISSIONS

By selecting a suitable Super Critical technology in which furnace and burner for the steam Generator, NO_x formation has been avoided and no additional equipment for NO_x control is required. The boiler is designed for maximum of 510 mg/m^3 with provision of low NO_x burners.

SO_2 concentration level for this power station will be expected below permissible limit based on the sulphur content of the coal. However, flue gas desulphurising (FGD) system has been planned for installation.

Dust nuisance due to Coal handling would be minimised by providing suitable dust suppression/extraction systems at crusher house, junction towers etc. For the coal stockyard, dust suppression system would be provided. Boiler bunkers would be provided with ventilation system with bag filters to trap the dust in the bunkers.

Table 18.3: Thermal Power Plant Ambient Air Quality Standards

Pollutant	Time Weighted average	Concentration in ambient air			
		Industrial Area	Residential Rural & mixed Use area	Sensitive Area	Method of measurement
Sulphur dioxide (SO_2)	Annual average* 24 hours**	80 mg/m^3 120 mg/m^3	60 mg/m^3 80 mg/m^3	15 mg/m^3 30 mg/m^3	• Improved West & Gaeke method • Ultraviolet fluorescence
Oxides of Nitrogen (as NO_2)	Annual average* 24 hours**	80 mg/m^3 120 mg/m^3	60 mg/m^3 80 mg/m^3	15 mg/m^3 30 mg/m^3	• Jacob & Hochheiser (Na-Arsenite) method • Gas phase chemiluscence
Suspended particulate matter (SPM)	Annual average* 24 hours**	360 mg/m^3 500 mg/m^3	140 mg/m^3 200 mg/m^3	70 mg/m^3 100 mg/m^3	• High volume sampling (average flow rate not less than 1.1 m3/minute)
Respirable particulate Matter(size <10 mm) (RPM)	Annual average* 24 hours**	120 mg/m^3 150 mg/m^3	60 mg/m^3 100 mg/m^3	50 mg/m^3 75 mg/m^3	• Respirable particulate matter sampler
Lead (Pb)	Annual average* 24 hours**	1.0 mg/m^3 1.5 mg/m^3	0.75 mg/m^3 1.00 mg/m^3	0.50 mg/m^3 0.75 mg/m^3	• AAS method after sampling using EPM 2000 or equivalent filter paper
Carbon monoxide (CO)	8 hours* 1 hour	5.0 mg/m^3 10.0 mg/m^3	2.0 mg/m^3 4.0 mg/m^3	1.0 mg/m^3 2.0 mg/m^3	• Non-dispersive infrared spectroscopy

Source: National Ambient Air Quality Standards (NAAQS), USA

* Annual arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval.

**24 hourly values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days.

1. The levels of air quality necessary with an adequate margin of safety, to protect the public health, vegetation and property.
2. Whenever and wherever two consecutive values exceeds the limit specified above for the respective category, it would be considered adequate reason to institute regular / continuous monitoring and further investigations.
3. The above standards shall be reviewed after five years from the date of notification.

Source : S.O. 384(E) – The Central Pollution Control Board in exercise of its powers conferred under section 16(2) (h) of Air (Prevention and Control of Pollutants) Act, 1981 [14 of 1981]

18.4 WATER POLLUTION

The water pollutants from the proposed unit are:

- Effluent from water treatment plant.
- Boiler drain/blowdown.
- Dust Suppression system – Coal yard Run off.
- Cooling tower blowdown.
- Oil handling area runoff water.
- Waste water from Air heater washing & Acid cleaning of boiler.
- Clarifier Sludge
- Sewage Water from Power Plant, Canteen etc.
- Ash pond run-off.

These water effluents will be duly treated to meet the stipulations of Pollution Control Board and will be recycled or used for Horticulture. The treated waste water will be fed to the sedimentation basin and then clear water to effluent pond for reuse like make up for ash recycling water, gardening, horticulture etc.

Effluent from Water Treatment Plant:

Hydrochloric acid and caustic soda would be used as reagents in the proposed water treatment plant. The acid and alkali effluents generated during the regeneration process of the ion exchangers would be drained into a chemical waste pond. The effluent would be neutralised by the addition of either acid or alkali to achieve the required pH. The effluent would then be pumped from the effluent pond for reuse.

Water treatment plant effluent comprises also of Condesate Polishing Unit (CPU) regeneration waste. The effluent is either acidic or alkaline in nature. This effluent shall be pumped to the Central Monitoring Basin (CMB) after neutralizing.

Boiler and Cooling Tower Blowdown:

As such there is no blowdown from once through boiler but start up drains from the boiler will have a provision of proper disposal. The salient characteristics of the blowdown water from the point of view of pollution are the pH and temperature of water since suspended solids are negligible. The pH would be in the range of 9.5 to 10.3 and the temperature of the blowdown water would be about 100°C since it is first flashed in an atmospheric flash tank. It is proposed to lead the steam generator blowdown into chemical waste pond from there it would be pumped to sedimentation basin after PH adjustment. The discharge from sedimentation basin shall be clear water for further reuse.

Cooling Tower COC – ("cycles of concentration", the ratio of conductivity of blowdown and make-up water) shall be maintained at 5, and the blow down salinity will be kept low. Provision for fresh water mixing with the blow down shall be provided for further dilution.

Dust Suppression System:

Waste water from the Coal yard suppression system and leaching water is collected in the settling tank. The clear water will be disposed through chemical waste pond and sedimentation basin. The Sludge will be dried in a Drying Pond and then Reused.

Sewage Disposal:

Sewage water from power plant and canteen will be collected in the anaerobic treatment pond and from there it will be sent to the effluent pond. The treated water will be used for horticulture purpose.

Clarifier Sludge:

The Clarifier Sludge is allowed to settle in a sedimentation tank and the clear water is disposed off through effluent treatment plant.

Oil Handling Area Run Off:

The oily waste water will be treated in an Oily Water Separator. The clear water is disposed through sedimentation basin and the Oily Sludge is taken to drying bed.

Waste Water from Air Heater Washing & Acid Cleaning:

The acidic cleaning water used for Air Heater Washing & Boiler cleaning will be taken to a treatment plant for neutralisation and then after sedimentation, it is taken for reuse.

Table 18.4: Thermal Power Plant: Standards For Liquid Effluent

Source	Parameter	Concentration not to be exceed, (mg/l) (except for pH)
Boiler blowdown	Suspended Solids	100
	Oil & Grease	20
	Copper (total)	1
	Iron (total)	1
Cooling Tower Blowdown	Free available Chlorine	0.5
	Zinc	1
	Chromium (Total)	0.2
	Phosphate	5
	Other corrosion inhibiting material	Limit to be established on case by case basis.
Ash Pond Effluent	pH	6.5 - 8.5
	Suspended Solid	100
	Oil & Grease	20

Table 18.5: General Standards for Discharge of Environmental Pollutants: Effluents

No	Parameters	Standards for discharge into/on				
		Inland Surface Water	Public Sewers	Land for Irrigation	Marine Near River Areas	
1	Colour and odour	*	*	*	*	
2	Suspended solids, mg/l	100	600	200	(a)	For process wastewater-100
					(b)	For cooling water effluent 10% above total suspended matter of influent
3	Particle size of suspended solids	Shall pass 850 micron IS sieve	–	–	(a)	Floatable solids, max. 3 mm
					(b)	Settable solids, max. 850 microns
4	pH value	5.5-9.0	5.5-9.0	5.5-9.0	5.5-9.0	
5	Temperature	Shall not exceed 5 °C above the receiving water temperature	–	–	Shall not exceed 7 ^{0}C ** above the receiving water temperature	
6	Oil and grease, mg/l	10	20	10	20	
7	Total residual chlorine, mg/l	1	–	–	1	
8	Ammonical nitrogen, mg/l	50	50	–	50	
9	Total Kjeldahl nitrogen (as N), mg/l	100	–	–	100	
10	Free ammonia (as NH_3),mg/l	5	–	–	5	
11	Biochemical oxygen demand (5 days at 20 0C), mg/l	30	350	100	100	
12	Chemical oxygen demand, mg/l	250	–	–	250	
13	Arsenic (as As), mg/l	0.2	0.2	0.2	0.2	
14	Mercury (as Hg), mg/l	0.01	0.01	–	0.01	
15	Lead (as Pb), mg/l	0.1	1	–	2	
16	Cadmium (as Cd), mg/l	2	1	–	2	
17	Hexavalent chromium (as Cr+6), mg/l	0.1	2	–	1	
18	Total chromium (as Cr),mg/l	2	2	–	2	
19	Copper (as Cu), mg/l	3	3	–	3	
20	Zinc (as Zn), mg/l	5	15	–	15	

21	Selenium (as Se), mg/l	0.05	0.05	–	0.05
22	Nickel (as Ni), mg/l	3	3	–	5
23	Cyanide (as Cn),mg/l	0.2	0.2	0.2	0.2
24	Fluoride (as F), mg/l	2	15	–	15
25	Dissolved phosphates (as P), mg/l	5	–	–	–
26	Sulphide (as S), mg/l	2	–	–	5
27	Phenolic compounds (as C6H5OH), mg/l	1	5	–	5
28	Radioactive materials				
	(a) Alpha emitters, uc/ml	10-Jul	10-Jul	10-Jul	10-Jul
	(b) Beta emitters, uc/ml	10-Jun	10-Jun	10-Jun	10-Jun
29	Bio-assay test	90% survival of fish after 96 hours in 100% effluent	90% survival of fish after 96 hours in 100% effluent	90% survival of fish after 96 hours in 100% effluent	90% survival of fish after 96 hours in 100% effluent
30	Manganese (as Mn), mg/l	2	2	–	2
31	Iron (as Fe), mg/l	3	3	–	3
32	Vanadium (as V), mg/l	0.2	0.2	–	0.2
33	Nitrate nitrogen, mg/l	10	–	–	20

Note: * All efforts should be made to remove colour and unpleasant odour as far as Practicable.

18.5 NOISE POLLUTION

All equipment in the power plant would be designed / operated to have a noise level not exceeding 85dBA as per the requirements of Occupational Safety and Health Administration Standard (OSHA) of USA. As per this standard, protection from noise is required when sound levels exceed those as shown in Table below when measured on the 'A' scale at slow response on a standard sound level meter.

Table 18.6: Thermal Power Plant Standards for Ambient Noise

Area Code	Category of Area/Zone	Limits in dB(A) L	
		Day Time	Night Time
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silence Zone	50	40
Note: 1.	Day time shall mean from 6.00 a.m. to 10.00 p.m.		
2.	Night time shall mean from 10.00 p.m. to 6.00 a.m.		
3.	Silence zone is defined as an area comprising not less than 100 meters around hospitals, educational institutions and courts. The silence zones are zones which are declared as such by the competent authority.		
4.	Mixed categories of areas may be declared as one of the four above mentioned categories by the competent authority.		

In addition, since most of the noise generating equipment's would be in enclosed structures, the noise transmitted outside would be still lower.

18.6 POLLUTION MONITORING AND SURVEILLANCE SYSTEMS

For thermal power stations, the Emission Regulations stipulate the limits for particulate matter emission and minimum stack heights to be maintained for keeping the sulphur dioxide levels in the ambient within the air quality standards.

The characteristics of the effluent from the plant would be maintained so as to meet the requirements of the Pollution Control Board and the minimum National Standards for Thermal Power Plants stipulated by the Central Board for Prevention and Control of Water Pollution.

Air Quality Monitoring Program:

The purpose of air quality monitoring is acquisition of data for comparison against prescribed standards, thereby ensuring that the quality of air is maintained within the permissible levels. It is proposed to monitor the following from the stack emission:

- Suspended particulate matter
- Sulphur dioxide
- Oxides of Nitrogen (NOx)

For this purpose it is proposed to acquire following monitoring equipments:

- High volume sampler for monitoring particulate matter
- Sulphur dioxide monitor

- NOx monitor

It is also proposed to monitor particulate emission qualitatively and quantitatively using a smoke detector on the stack and with the aid of a continuous stack particulate monitoring system. The stack monitoring data would be utilized to keep a continuous check on the performance of ESPs.

18.7 WATER QUALITY MONITORING PROGRAMME

The monitoring schedule and parameters to be analyzed in the effluent generated from various sources is presented in table below.

Table 18.7: Monitoring Schedule for Effluents in Thermal Power Plants

Source of Effluent	Frequency of analysis	Parameters for Examination
Ash pond	Weekly	pH, suspended solids, oil and grease, Chromium, Zinc, Iron, Manganese, nickel
Boiler blowdown	Weekly	pH, suspended solids, oil and grease, Copper, Iron

Qualified persons would be in-charge of the system for monitoring of the parameters. Adequate instruments would be provided to monitor the parameters.

18.8 IMPACT OF POLLUTION/ ENVIRONMENTAL DISTURBANCE

Since all necessary pollution control measures to maintain the emission levels of dust particles and sulphur dioxide within the permissible limits would be taken and necessary treatment of effluents would be carried out, there would be no adverse impact on either air or water quality in and around the power station site on account of operation of the proposed plant.

18.9 ASH UTILISATION AND DISPOSAL

Ash Generation:

The daily ash generation of the plant is about 570 tonnes at 100% MCR. The maximum ash generation with ash content of 15% is 0.167 mTPA at a plant load factor of 80%. Out of this, about 20% would be bottom ash and about 80% would be fly ash.

Ash Utilization Project:

According to the recent international guide lines utilization of fly ash from power plants are to be utilized as per the following guidelines.

Table 18.8: Ash Utilization Norms

Serial	Fly ash utilization level	Target date
1.	At least 50% of fly ash generation	One year from the date of Commissioning.
2.	At least 75% of fly ash generation	Two years from the date of Commissioning.
3.	100% of fly ash generation	Three years from the date Of commissioning.

The unutilized fly ash in relation to the target during a year, if any, shall be utilized within next two years in addition to the targets stipulated for these years. The unutilized fly ash accumulated during first three years (the difference between the generation and utilization target) shall be utilized progressively over next five years in addition to 100% utilization of current generation of fly ash.

The fly ash generated in thermal power stations has commercial value because of its usage in cement and construction industries in various forms.

Fly Ash consists of inorganic materials mainly silica and alumina with some amount of organic material in the form of un-burnt carbon. Its fineness is comparable to cement, however, some particles have size less than 1 micron in equivalent diameter. It possesses pozzolanic characteristics. Fly ash collected through dry collection system is preferred for pozzolanic applications (i.e. in Building Industry).

It may be noted that proportions of different ingredients to make bricks / cellular concrete / briquettes with fly ash chiefly depends on the constituents of the particular fly ash. Therefore, the particular type of fly ash is to be analyzed for the properties of its constituents and checked for suitability or otherwise and suitable proportions of ingredients are to be determined by laboratory tests / pilot plant tests.

In line with project's commitment towards utilization of fly ash, it is planned to firm up an ash utilization plan with all potential possibilities fly ash use which shall progressively achieve utilization level up to 100%. In this direction the following alternatives have been envisaged.

Fly ash generated from the proposed power plant would be commercially utilized in one or more of the following industries, to the extent possible.

- Manufacture of fly ash bricks
- Manufacture of aerated wall blocks and panels
- Fly ash Aggregate

- Land reclamation
- Ready Mixed Fly Ash Concrete
- Utilization in Roads/Paving
- Use in cement manufacturing using fly ash in combination

Fly ash produced in modern thermal power stations can be used in making bricks. The Cement has conducted research and experiments for making hollow bricks using fly ash. Research has also conducted experiments in making bricks by using fly ash as an admixture with black cotton soil. In this project, bricks of minimum 105 kg/sq.cm strength were produced. The bricks are being manufactured by local brick manufacturers with 70% fly ash and 30% clay which give higher strength than conventional bricks.

Production of Fly Ash Bricks:

For production of good quality fly ash bricks, the quality of fly ash should be as under:

- It should be either dry or moist {containing moisture not more than 5 %}
- Visual appearance should be light steel grey or smoky grey in color. The brownish or light yellowish grey color fly ash is of inferior quality.
- The fly ash should be very fine and can pass through 200 mesh sieve.
- The un-burnt carbon in fly ash with negligible fraction is tolerable for use.

Moreover those can also be used in the manufacture of mosaic tiles, plain tiles, pre-stressed roofing steps, thermal insulation bricks and road sub-grades. The fly ash can also be used as fertilizer to increase the production of crops particularly rice, wheat and cereals. Depending on the type of crops, an optimum amount of fly ash can be used for better production. Field trials have been made in this regard.

Fly Ash- Sand-Lime - (Gypsum / Cement) Bricks / Blocks:

Fly Ash can be used in the range of 40-70%. The other ingredients are lime, gypsum (/cement), sand, stone dust/chips etc. Minimum compressive strength (28 days) of 70 kg/cm^2 can easily be achieved and this can go up to 250 Kg/cm^2 (in autoclaved type).

Advantage of these bricks over burnt clay bricks:

- Lower requirement of mortar in construction
- Plastering over brick can be avoided
- Controlled dimensions, edges, smooth and fine finish & can be in different colors using pigments
- Cost effective, energy-efficient & environment friendly (as avoids the use of fertile clay)

Clay-Fly Ash Bricks:

Fly Ash content can be 20 to 60% depending on the quality of clay. Process of manufacturing is same as for the burnt clay bricks. Advantages are as under:

- Fuel requirement is considerably reduced as fly ash contains some percentage of un-burnt carbon
- Better thermal insulation
- Cost effective and environment friendly

Manufacture of Aerated Wall Blocks and Panels:

Fly ash is used in the building industry largely as a concrete additive. Fly ash can also be sintered into pellets for use as light weight aggregate.

Laboratory and pilot plant trials carried out and have established that sintered light weight aggregate can be successfully produced from fly ash and used for producing plain concrete as well as reinforced concrete beams and slabs. Laboratory investigations and factory trials have shown the technical feasibility of manufacture of cellular concrete from lime and fly ash. It is more economical to produce this cellular concrete than the cement-sand cellular concrete, which is being produced in the many country at present.

Fly ash can also be used as masonry mortar. The work done at laboratory suggests that mixtures shall be thicker than 1:6 (by volume) to enable them to be used as mortar. As a masonry mortar, fly ash is used in place of Surkhi and prepared in a way similar to Lime-Surkhi mortar. Lime fly ash mortars are cheaper and better in performance and strength than Lime-Sand mortars.

Fly Ash Aggregate:

The fly ash can be converted to light weight aggregate which can substitute the presently used conventional aggregate, in concrete blocks, flooring and non-load bearing structures such as compound walls, canals, pavements, etc. The main components of the process are fly ash, calcium oxide, fresh water quenched bottom ash (optional), sand, water and chemically bonding additives.

The calcium from lime reacts with silica and alumina in fly ash to produce calcium/aluminium materials in a reaction similar to that of Portland cement. These minerals bond the fly ash particles tightly so that hard, strong and practically un-leachable pellets are formed. These pellets are heated at low temperature to cure them.

Land Reclamation:

Land reclamation by filling low lying areas after which the application of a top layer of soil and trees shall be planted, which shall be given as free of cost

Ready Mixed Fly Ash Concrete:

Though Ready Mix concrete is quite popular in developed countries. Only recently its application has started growing at a fast rate. On an average 20% Fly ash (of cementations material) in the many countries is being used which can easily go very high. In ready mix concrete various ingredients and quality parameters are strictly maintained/controlled which is not possible in the concrete produced at site and hence it can accommodate still higher quantity of fly ash

Utilisation in Roads / Paving:

It has been reported from the laboratory tests conducted by the Cement Association that fly ash with other ingredients can be used for paving roads and airport runways. Fly ash mixed with sand and hydrated lime is used as a base course of asphalt pavement. The breaking strength of such a pavement is calculated to be as high as 68 kg/sq.cm (1000 psi). As a result of a series of experiments, the mixtures of ingredients added in the following recommended proportions gave a good paving material with adequate strength and reasonable setting time.

Ingredients	**Composition by Weight (%)**
Fly ash	12 – 14
Lime	2.8 – 3.6
Portland Cement	0.7 – 0.9
Sand	80 – 84.5

The above mixture developed strength from 54 to 95 kg/sq.cm (800-1400 psi) in about 90 days at a temperature of 18 deg. C to 21 deg. C. Further, the experiments have shown that 30% of crushed stones (instead of sand) established strength of 102 – 136 kg/sq.cm (1500-2000 psi).

The total cost of manufacturing the paving mixture comes to about one and half that of ordinary road stone which has much less strength and to less than one third the cost of lime concrete which has good strength. Even the extra strength obtained by using 30% crushed stones as a substitute for sand the cost is not expected to exceed that of conventional materials.

Cement Manufacturing Using Fly Ash:

Pozzolans are defined as silicious and aluminous materials which in themselves possess little or no cementitious value but, will in finally divided form and in the presence of moisture chemically react with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties.
Up to 35% of suitable fly ash can directly be substituted for cement as blending material. Addition of fly ash significantly improves the quality & durability characteristics of resulting concrete. Hence even without enhancing the production capacity of cement; availability of the cement (fly ash based PPC) can be significantly increased.

Fly ash is used in the production of Pozzolona cement by inter-grinding Portland cement clinkers and fly ash or by blending intimately and uniformly Portland cement and fly ash. Standard specifications limit the Pozzolona (fly ash or similar material) component up to 25% by weight whereas in other countries it varies from 15 to 50%.

Type of cement process

- Wet Process
- Dry Process - 74% of cement produced
- Preheater / Precalciner Process

Hydraulic cement made by finely pulverizing the clinker produced by calcining to incipient fusion a mixture of argillaceous and calcareous materials. Portland cement is the fine gray powder that is the active ingredient in concrete

Portland Pozzolana Cement (Fly Ash Based):

The advantages of fly ash in the manufacture of Portland Pozzolona Cement (PPC) as compared to other Pozzolonic materials are two-fold. Better hydraulic properties of fly ash. Cement retains its natural and accepted grey color instead of becoming mud-red in case bricks / tiles are used as Pozzolonic materials.

Ash Utilisation Logistics:

Fly ash generated from the project can be transported to the cement based industries nearby.
Following are few alternatives for transportation of fly ash disposal from the project.

Fly ash shall be transported from project jetty to cement factory located proximity in Narayanganj area by barges. Most of the cement factories are also having their captive jetty for cement transport and receiving imported clinkers, gypsum and fly ash.

18.10 GREEN BELT

A green belt of minimum 10m width will be provided all around the plant. In addition, avenue trees will be planted all along the roads. The following species are suggested for plantation in order to reduce noise, dust emissions and ambient temperature in the vicinity of the site:

Table 18.9: List of species suggested for plantation

Name of the few species suggested for plantation
1. Alstonia scholaris
2. Azadirachta indica
3. Polyalthialongifloia
4. Tamarindus indica
5. Cassia fistula
6. Butea monosperma
7. Megnifere indica
8. Eucalyptus hybrid
9. Techtonagrandis
10. Melia asadirachta
11. Pongamia glabra

18.11 ENVIRONMENT IMPACT ASSESSMENT STUDIES

Environment Impact Assessment (EIA) studies will be carried out and base line data collection will be completed. Rapid EIA Report will be prepared to identify the impact of the proposed power plant on the flora, fauna, human inhabitations, etc. in the surrounding area and prescribe mitigation measures. Rapid Environmental Impact Assessment (EIA) report will elaborate the assessment of the impact on the environmental scenario around the proposed power plant, with regard to the main environmental attributes viz., air, water, soil, noise, ground level concentration (GLC) and socio-economic conditions.

The success of any EIA study will primarily depend on the accuracy of assessing the baseline environmental situation prior to superimposing the predicted result on the ambient situation to arrive at the post project scenario. The baseline environmental situation will be assessed with respect to land use, soil, demography and socio-economics, meteorology, hydrology, water quality, terrestrial ecology and aquatic ecology. Suitable remedial / mitigation measures will be incorporated in the plant, to comply with pollution control authorities norms.

The project will also carry out the Rapid Marine Environmental Impact Assessment Report to addresses the concerns related to silting at jetty and outfall point of cooling water discharge in river, Suitability of the schemes for jetty and outfall and other issues related to marine environment.

18.12 RISK ASSESSMENT & DISASTER MANAGEMENT PLAN

Risk Assessment:

Environmental risks are inherent in design and operation of any power plant. Risk involves the occurrence or potential occurrence of an accident consisting of an event or sequence of events. The main objectives of risk assessment are as follows:

- Identification of hazard prone area and estimation of damage distance for the maximum credible accident scenario visualized for storage.
- Computation of frequency of occurrence of hazards and evaluation of risks
- Recommendation of risk mitigation measures and arriving at a Disaster Management and Emergency Preparedness Plan.

Identification of hazards in a power plant is of primary significance in the analysis, quantification and cost effective control of accidents involving chemicals and process. Hence, all the components of a process/system/plant need to be thoroughly examined to assess their potential for initiating or propagating an unplanned event/sequence of events, which can be termed as an accident.

As coal is subject to spontaneous combustion it may catch fire given the slightest opportunity. This fire hazard is greatly influenced by the amount of airflow through the mass of coal. Thus, storage of coal will be designed in such a way that the air content in the coal pile is minimized. Dimension of the coal stack, particularly the height, is a very important parameter for making storage of coal safe.

Fuel oils (LDO/HFO) will be used in small quantity for initial start-up.

Chlorine and other chemicals are used in the water treatment & DM Plant. The hazards associated with the use of these materials need careful consideration and it is necessary to take due precaution for safe handling at various stages of usage.

Disaster Management Plan:

A major emergency in a plant is one that has the potential to cause serious injury or loss of life. It may cause damage to property and serious disruption, both inside and outside of the plant. The disasters identified as most likely to occur in the power plant are:

- Fire at oil storage area
- Fire at coal storage area
- Toxic release of chemical

Hazard analysis has revealed that the damage distance is mainly confined to plant boundary only. The main objective of the disaster management plan is to prevent or at least reduce the risk of accidents through design, operation, maintenance and inspection. An important element of accident mitigation is emergency planning, which would consist of:

- Recognising the possibilities and probabilities of each kind of accident
- Assessing the on-site and off-site implications of such incidents and deciding the emergency procedures that would need to be carried out.
- A number of elements make-up a good and workable disaster management plan.

CHAPTER 21:
SAFETY & HEALTH PLAN

CHAPTER 21: SAFETY AND HEALTH

21.1 INTRODUCTION

Large industries like power plants in particular where multifarious activities are involved during construction, erection, testing, commissioning, operation & maintenance, the personnels, materials and machines are the basic inputs. Industrialization of a country generally brings several issues, those needs to be adhered to properly like for occupational safety and health of the persons working in the environment.

21.2 SAFETY PLAN

Safety of both men and materials during construction and operation phases is of much concern. The preparedness of an industry for the occurrence of possible disasters is known as emergency plan. The disaster in the plant is possible due to leakage of hazardous chemicals, collapse of structures and fire / explosion etc. Keeping in view the safety requirement during construction, operation and maintenance phases of power plant project, safety policy with the following regulations have been formulated:

i. To allocate sufficient resources to maintain safe and healthy conditions at work;
ii. To take steps to ensure that all known safety factors are taken into account in the design, construction, operation and maintenance of plants, machinery and equipment;
iii. To ensure that adequate safety instruction are given to all employees
iv. To provide wherever necessary protective equipment, safety appliances and clothing, and to ensure their proper use
v. To inform employees about materials equipment or processes used in their work which are known to be potentially hazardous to health and safety.
vi. To keep all operations and methods of work under regular review for making necessary changes from the point of view of safety in the light of experience and up to date knowledge.
vii. To provide appropriate facilities for first aid and prompt treatment of injuries and illness at work.
viii. To provide appropriate instruction, training, retraining and supervision to employees in health and safety, first aid and to ensure that adequate publicity is given to these matters.
ix. To ensure proper implementation of fire prevention methods and an appropriate fire fighting service together with training facilities for personnel involved in this service;
x. To organize collection, analysis and presentation of data on accident, sickness and incident involving personnel injury or injury to health with a view to taking corrective, remedial and preventive action.
xi. To promote through the established machinery, joint consultation in health and safety matters to ensure effective participation by all employees.

xii. To publish/notify regulations, instruction and notices in the common language of employees.

xiii. To prepare separate safety rules for each type of occupation/processes involved in a project

xiv. To ensure regular safety inspection by a competent person at suitable intervals of all buildings, equipment, work places and operations.

xv. To ensure regular safety meeting organized by the project authority involving peoples working there with a view to exchange opinion on safety and health issues concerning the project.

21.3 SAFETY ORGANIZATION

21.3.1 Construction & Erection Phase

A qualified and experienced safety officer will be appointed. The responsibilities of the safety officers include identification of the hazardous conditions and unsafe acts of workers and advice on corrective actions, conduct safety audit, organize training programs and provide professional expert advice on various issues related to occupational safety and health. He is also responsible to ensure compliance of works following Safety Rules/Statutory Provisions.

In addition to employment of safety officer by power plant every contractor, who employs more than 70 workers, should also employ one safety officer to ensure safety of the workers, in accordance with the conditions of contract.

21.3.2 Operation & Maintenance Phase

When the construction is completed the posting of safety officers should be in accordance with the requirement of Factories Act and their duties and responsibilities should be as defined thereof.

21.4 SAFETY CIRCLE

In order to fully develop the capabilities of the employees in identification of hazardous processes and improving safety and health, safety circles would be constituted in each area of work. The circle would consist of 5-6 employees from that area. The circle normally should meet for about an hour every week.

21.5 SAFETY TRAINING

A full-fledged training centre will be set up. Safety training will be provided by the Safety Officer with the assistance of faculty members called from Corporate Centre, Professional Safety Institutions and Universities. In addition to regular employees, limited contractor labours are also provided safety training. To create safety awareness safety films will be shown to workers and leaflets etc. will be distributed. Some precautions and remedial measures proposed to be adopted to prevent fires are:

i. Compartmentalisation of cable galleries, use of proper techniques of cable passages and crevices in all directions would help in localizing and identifying the area of occurrence of fire as well as ensuring effective automatic and manual firefighting operations;
ii. Spread of fire in horizontal direction would be checked by providing fire stops for cable shafts;
iii. Reliable and dependable type of fire detection system with proper zoning and interlocks for alarms are effective protection methods for conveyor galleries;
iv. Housekeeping of high standard helps in eliminating the causes of fire and regular fire watching system strengthens fire prevention and firefighting; and
v. Proper fire watching by all concerned would be ensured.
vi. Reliable, dependable and appropriate type of fire extinguishing equipment need to be ensured in appropriate place. The fire extinguishing equipment shall be tested periodically for its proper functionality.

21.6 OCCUPATIONAL HEALTH

Occupational health needs attention both during construction & erection and operation & maintenance phases. However, the problem varies both in magnitude and variety in the above phases.

21.6.1 Construction & Erection

The occupational health problems envisaged at this stage can mainly be due to constructional accident and noise. To overcome these hazards, in addition to arrangements to reduce it within the acceptable limits, Personnel Protective Equipment (PPE) should also be supplied to workers.

21.6.2 Operation and Maintenance

The problem of occupational health, in the operation and maintenance phase is due to Respirable dust and noise. With suitable engineering controls the exposures can be reduced

to less than the acceptable limits and proper personnel protective devices should be given to employees. The working personnel should be given the following appropriate PPE.

21.6.3 Industrial Safety Appraisals

- Crash Helmets
- Zero power plain goggles with cut type filters on both ends.
- Zero power goggles with cut type filters on both sides and blue colour glasses
- Chemical goggles
- Welders equipment for eye & face protection
- Cylindrical type earplug
- Ear muffs
- Dust masks
- Canister Gas mask
- Self-contained breathing apparatus (SCBA)
- Leather apron
- Aluminized fibre glass fix proximity suit with hood and gloves
- Boiler suit
- Safety belt/lime man's safety belt
- Leather hand gloves
- Asbestos hand gloves
- Acid/Alkali proof rubberized hand gloves
- Canvas cum leather hand gloves with leather palm
- Lead hand glove
- Electrically tested electrical resistance hand gloves
- Industrial safety shoes with steel toe
- Rubber boots (alkali resistant)
- Electrical safety shoes without steel toe and gum boots

Full-fledged hospital facilities should be made available round the clock for attending emergency arising out of accidents, if any. All working personnel should be medically examined at least once in every year and at the end of his term of employment. This is in addition to the pre-employment medical examination.

CHAPTER 23:
LEGAL ASPECTS OF THE PROJECT

CHAPTER 23: LEGAL ASPECTS

23.1 INTRODUCTION

Every development project is governed and regulated by some legal and institutional requirements. Therefore, assessment of relevant legal provisions, policies, strategies and institutional issues are very important for any project proponent or developer before they actually execute a program or plan.

In Bangladesh, there are statutory laws related to environmental clearance, mode of transportation, import and export of goods, river navigation, dredging and ports. There are also many rules and regulations that provide specific provision for the principle laws, and additional secondary legislation.

23.2 LAWS REGULATING ENVIRONMENT IN BANGLADESH

The process of environmental impact assessment has become an integral part of the planning process for large-scale development projects, since a planning authority is required to have regard to all material considerations, of which the environmental impact is inevitably one. Environmental impact assessment does not in itself require preventive action, or indeed any mitigating steps, to be taken. It is a mechanism intended to ensure decision making authorities are aware of the relevant issues relating to the environment.

Like all other nations of the world, Bangladesh also acted to the global call for the protection and conservation of natural environment and ecology. Despite to the limited resources, the people of Bangladesh are putting their efforts towards modern technological benefits in many respect responded to the available resources and their own environment friendly indigenous technologies and wisdom.

A research in the regulatory regime shows that there are about 185 laws which have bearing on environment, directly, indirectly and casually. These laws provide for measures relevant for environment conservation, offer protection against various environmental offences and by prescribing or prohibiting certain activities, lay down rights and duties. A great bulk of these environmental legislation were existent in the country right from 19th century although they remained either unenforced to a large extent due to several factors or vaguely known to the responsible public agencies. The traditional practices prevailing in the legal regime were not much conducive to reading the law with new ideas like environmental protection or conservation of resources etc. Moreover, lack of consciousness amongst the implementers and general public as to the very existence and scope of these laws rendered them ineffective functionally. Some laws have also become redundant since the situation for which they were enacted do not exist anymore.

On the other hand legal research has been carried out to identify national laws, policies relevant to this project i.e. regulation of power, coal sourcing, transportation and handling.

These laws and policies have been reviewed to identify statutory requirement to be complied with.

The arrangement of the laws and policies in this study is issue and sector based. They are environment, power and mineral resources related laws adopted as Acts, Ordinances, and Policies etc.

23.3 POLLUTION AND CONSERVATION

A total 23 laws have been identified which contain provisions regarding conservation of environment and control of environmental pollution from various sources. Of course, the Bangladesh Environment Conservation Act, 1995 which has been enacted in Bengali as mentioned in its preamble to control and mitigate pollution and environmental conservation demands specific mentioning. However, there are laws enacted earlier to deal with pollution and conservation. For example, the Penal Code of 1860 has provisions to check pollution to the atmosphere; the Protection and Conservation of Fish Act, 1950 provides for measures to ensure undisturbed spawning grounds; the Wild Life (Protection & Preservation) Act, 2012 prohibits certain dealings with specified species of wildlife, etc. Besides, various other legislation contains provisions to address pollution of air, soil, water and other competent of the environment. These legislative requirements covering areas, inter alia, specific with industrial, vehicular and marine pollution prohibit certain activities which might destroy and damage the surrounding ecosystem of all living creatures.

The Constitution of the People's Republic of Bangladesh

The Constitution is the supreme law of the country as set out in Article-7. The Constitution of Bangladesh has placed the highest priority as the state's fundamental principle to protect and improve the public health, environment and bio-diversity. Article 18 and 18A read as follows:

Article-18: (1) The State shall regard the raising of the level of nutrition and the improvement of public health as among its primary duties, and in particular shall adopt effective measures to prevent the consumption, except for medical purposes or for such other purposes as may be prescribed by law, of alcoholic and other intoxicating drinks and drugs which are injurious to health.

Article-18A: The State shall endeavour to protect and improve the environment and to preserve and safeguard the natural resources, bio-diversity, wetlands, forests and wild life for the present and future citizens.

Environmental Conservation Act, 1995 (Amended in 2000 & 2002)

The Bangladesh Environment Conservation Act of 1995 (ECA '95) is currently the main legislation in relation to environment protection in Bangladesh. This Act is promulgated for environment conservation, environmental standards development and environment pollution control and abatement. It has repealed the Environment Pollution Control Ordinance of 1977. The main objectives of ECA '95 are:

Conservation and improvement of the environment and Control and mitigation of pollution of the environment. The main strategies of the Act can be summarized as:

- Declaration of ecologically critical areas and restriction on the operations and processes, which can or cannot be carried/initiated in the ecologically critical areas;
- Regulations in respect of vehicles emitting smoke harmful for the environment;
- Environmental clearance;
- Regulation of the industries and other development activities' discharge permits;
- Promulgation of standards for quality of air, water, noise and soil for different areas for different purposes;
- Promulgation of a standard limit for discharging and emitting waste; and
- Formulation and declaration of environmental guidelines.

Before any new project can go ahead, as stipulated under the rules, the project promoter must obtain Environmental Clearance from the Department of Environment (DoE). An appeal procedure does exist for those promoters who fail to obtain clearance. Failure to comply with any part of this Act may result in punishment to a maximum of 3 years imprisonment or a maximum fine of Tk. 300,000 or both. The Department of Environment (DoE) executes the Act under the leadership of the Director General (DG).

Bangladesh Environmental Conservation Act (Amendment 2000)

This amendment of the Act focuses on: (1) ascertaining responsibility for Compensation in cases of damage to ecosystems, (2) increased provision of punitive measures both for fines and imprisonment and (3) fixing authority on cognizance of offences Bangladesh Environmental Conservation Act (Amendment 2002)

This amendment of the Act elaborates on: (1) restriction on polluting automobiles, (2) restriction on the sale and production of environmentally harmful items like those that polythene bags, (3) assistance from law enforcement agencies for environmental actions, (4) break up of punitive measures and (5) authority to try environmental cases.

The Environment Conservation Rules, 1997

These are the first set of rules, promulgated under the Environment Conservation Act of 1995 (so far there have been three amendments to this set of rules - February and August 2002 and April 2003).
The Environment Conservation Rules of 1997 has provided categorization of industries and projects and identified types of environmental assessments needed against respective categories of industries or projects.

Among other things, these rules set (i) the National Environmental Quality Standards for ambient air, various types of water, industrial effluent, emission, noise, vehicular exhaust etc., (ii) the requirement for and procedures to obtain environmental clearance, and (iii) the requirement for IEE and EIA's according to categories of industrial and other development interventions.

The Environment Court Act, 2010

The Environmental Court Act, 2010 provide for the establishment of environment courts and matters incidental thereto. This act also provides the jurisdictions of environment court, penalty for violating court's order, trial procedure in special magistrate's court, power of entry and search, procedure for investigation, procedure and power of environment court, authority of environment court to inspect, appeal procedure and formation of environment appeal court. It has repealed the Environment Court Act, 2000.

The Smoke Nuisances Act, 1905

The Smoke Nuisances Act, 1905 was enacted to amend the laws relating to the abatement of nuisances arising from the smoke of furnaces or fire-places in certain areas in Bangladesh. This Act has empowered the Government to prohibit the followings:

- The erection or use of any specified class of brick tile or lime-kilns, or, clamps for making bricks;
- The erection or use of furnaces to be used for the calcinations or smelting of ores or minerals, or for the casting, pudding or rolling of iron or other metals, or for the conservation of pig-iron into wrought-iron;
- The manufacture of coke, in ovens, or with special appliances; or
- The making of coke without ovens or special appliances.

The Act also empowers the Government to make rules to carry out the objects of this Act and without prejudice to generality such rules may:

- Prescribe a scale for the purpose of determining the density of smoke;
- Prescribe the density of smoke that may be emitted from a furnace;
- Prescribe the time during which smoke of such density may be emitted from a furnace;

- Regulate with due regard to the safety of shipping, the emission of smoke from the furnaces of vessels;
- Prescribe the altitude below which smoke may not be emitted from a furnace.

The Forests Act, 1927

An Act to consolidate law related to forests, the transit of forest-produce and the levee duty on timber and other forest-produce. This Act provides power to the government to constitute any forestland, wasteland or any land suitable for afforestation which is the property of the Government, or over which the Government has proprietary rights, or to the whole or any part of the forest-produce.

The Sundarbans Reservation was established in 1875/76 and was retained after the partition between the then East Pakistan and India. The Forest Act (Act No. XVI, 1927) consolidated the previous rules relating to forests, transit timber, and levee duty on forest products and comprises the following effects:

i) Grant power to the government to reserve forests.
ii) Grant power to impose duty on timber and other forest products.
iii) Prohibit acquisition rights over land described in the notification except in accordance with rules defined by the government.
iv) Prohibit the clearing of forests.
v) Prohibit the removal of timber.
vi) Prohibit the felling of trees.
vii) Prohibit hunting, shooting, fishing, poisoning of water, snares or traps.
viii) Allow acts done by permission in writing of the Forest Officer or under any rule made by the government.

23.4 HEALTH AND SAFETY

The rights to have protection against the offences to human health have been guaranteed under various laws of the country. A total 45 such laws have been identified which directly contain such provisions while scattered provisions are there in other laws having bearing on health.

The Fatal Accidents Act, 1855

This Act is to provide compensation to families for loss occasioned by the death of a person caused by actionable wrong. It is mentioned in s.1, whenever the death of a person shall be caused by wrongful act, neglect or default, and the act, neglect or default is such as would (if death had not ensued) have entitled the party injured to maintain an action and recover damages in respect thereof, the party who would have been liable if death had not ensued shall be liable to an action or suit for damages, notwithstanding the death of the person injured, and although the death shall have been caused under such circumstances as amount in law to felony or other crime.

The Mining Settlement Act, 1912

This Act is to provide for better control and sanitation of Mining Settlements in Bangladesh. According to Section 5 of this Act, the Government shall appoint as many Sanitary Officers as it may consider necessary for mining settlements, and shall declare the Mines Board of Health to which each such officer shall be subordinate. It shall be the duty of a Sanitary Officer appointed to a mining settlement or any part thereof:

- To report to the Mines Board of Health what measures should, in his opinion, be taken-
    a. To provide for the supply of filtered, boiled or other water;
    b. To provide for sanitation and conservancy; and
    c. To provide for the housing of residents
- To exercise, subject to the control of the Mines Board of Health to which he is subordinate, such other functions, consistent to prevent the outbreak or spread of dangerous epidemic disease, as the Government may by general or special order, direct, or as may be delegated to him by such Board.

The Explosives Act, 1884

This Act was enacted to regulate the manufacture, possession, use, sale, transport and importation of Explosives. According to this Act "explosive" means gunpowder, nitro-glycerin, dynamite, gun-cotton, blasting powders, fulminate of mercury or of other metals, coloured fires and every other substance, whether similar to those above-mentioned or not, used or manufactured with a view to produce a practical effect by explosion, or a pyrotechnic effect; and also includes fog-signals, fireworks, fuses, rockets, percussion-caps, detonators, cartridges, ammunition of all descriptions, and every adaptation or preparation of an explosive as above defined.

The Government is empowered by notification under this Act to prohibit, either absolutely or subject to conditions, the manufacture, possession, use, transportation or importation of any explosive which is of so dangerous a character that, in the opinion of the Government it is expedient for the public safety to issue the notification.

The officers of customs at every port or border check-post shall have the same power in respect of any explosive with regard to the importation of which a notification has been issued under this Act and the vessel or carriage containing the explosive as they have for the time being in respect of any article the importation of which is prohibited or regulated by the law relating to customs and the vessel or carriage containing the same; and the enactments for the time being in force relating to customs or any such article or vessel or carriage shall apply accordingly.

Any person manufacturing, possessing, using, selling, transporting or importing an explosive

in contravention of a notification issued under this section shall be punishable with imprisonment for a term which may extend to ten years and shall not be less than two years and also with a fine which may extend to fifty thousand Taka, in default of which with a further imprisonment for a term which may extend to one year, and in the case of importation by water or land, the owner and master of the vessel or carriage in which the explosive is imported shall, in the absence of reasonable excuse, each be punishable with imprisonment for a term which may extend to ten years and shall not be less than two years and also with a fine which may extend to fifty thousand Taka, in default of which with a further imprisonment for a term which may extend to one year.

The Explosive Substances Act, 1908

Under this Act the expression "explosive substance" shall be deemed to include any materials for making any explosive substance; also any apparatus, machine implement or material used, or intended to be used, or adapted for causing, or aiding in causing, any explosion in or with any explosive substance; also any part of any such apparatus, machine or implement.

Any person who unlawfully or maliciously causes by any explosive substance an explosion of a nature likely to endanger life or to cause serious injury to person or property shall, whether any injury to person or property has been actually caused or not, be punishable with death, or with imprisonment for life, to which fine may be added, or with imprisonment for a term which may extend to ten years and shall not be less than five years, to which fine may be added.

The Poisons Act, 1919

An Act to consolidate and amend the law regulating the importation, possession and sale of poisons. Section 2 of this Act states as follows:

(1) The Government may by rule regulate within the whole or any part of Bangladesh the possession for sale and the sale, whether wholesale or retail, of any specified poison.
(2) In particular, and without prejudice to the generality of the foregoing power, such rules may provide for-

(a) the grant of licences to possess any specified poison for sale, wholesale or retail, and the fixing of the fee (if any) to be charged for such licences;
(b) the classes of persons to whom alone such licences may be granted;
(c) the classes of persons to whom alone any such poison may be sold;
(d) the maximum quantity of any such poison which may be sold to any one person;
(e) the maintenance by vendors of any such poison of registers of sales, the particulars to be entered in such registers, and the inspection of the same;
(f) the safe custody of such poisons and the labeling of the vessels, packages or

coverings in which any such poison is sold or possessed for sale; and

(g) the inspection and examination of any such poison when possessed for sale by any such vendor.

The Dangerous Cargoes Act, 1953

The Dangerous Cargoes Act, 1953 was enacted to provide provisions related to the safety of ports in respect of the transit, working and storage of dangerous cargoes. Relevant provisions include s.3 (which deals with explosives and fires on vessels), s.6 (safety of vessels imports) and s.9 (enforcement). The concerned authority is the Deputy Conservator of the Port, Board of Trade or the Ministry of Communication and the Chief of Naval Staff.

The Fire Prevention and Protection Act, 2003

The Act states that the owner needs to obtain a license before using premises as a warehouse, multistoried building, factory, workshop etc. In addition, under this Ordinance the Government by order no. HSLG/SVII/1R-1/60/295 dated June 3, 1960 declared that any stock of coal exceeding four tons shall be considered a fire risk.

The Labour Act, 2006

This is a very important piece of legislation for the employees as well as for the entrepreneurs. The objectives of this Act is to regulate the employment of labour, owner-labour relationship, compensation for labour in case of accidents, health care of labour, remuneration of labour, trade union etc.

23.5 REGULATION OF POWER GENERATION

Bangladesh Energy Regulatory Commission Act, 2003

Bangladesh Energy Regulatory Commission Act was enacted in 2003. The aim of the act is to make provisions for the establishment of an independent and impartial regulatory commission for the energy sector in Bangladesh. The objective is to create an atmosphere conducive to private investment in the generation of electricity and transmission, transportation and marketing of gas resources and petroleum products, to ensure transparency in the management, operation and tariff determination in these sectors; to protect consumers' interest and to promote the creation of a competitive market.

The commission has started its operation shortly after enactment of the Act and now it is functioning full-fledged implement its objective.

The Bangladesh Petroleum Act, 1974

The Bangladesh Petroleum Act is enabling legislation that allows the Government of Bangladesh to enter into all aspects of petroleum exploration, development, exploitation, production, processing, refining and marketing. In addition, the Government is authorized to enter into Petroleum Agreement(s) with any person(s) for the purpose of petroleum operations. The duties of such person(s) are:

-To ensure that petroleum operation is carried out in a proper and worker like manner and in accordance with good oil field practice.
-To carry out petroleum operation in any area in a manner that does not interfere with navigation, fishing and conservation of resources.
-To consider the factors connected with the ecology and environment. Clause 6(2) of the Act sets out certain details related to environment and safety:

"In particular, and without prejudice to the generality of the foregoing provision, a person engaged in any petroleum operations shall, in carrying out such operations in any area:

Control the flow and prevent the waste or escape' in the area, of petroleum or water;
Prevent the escape in that area of any mixture of water or drilling fluid with petroleum or any other matter;
Prevent damage to petroleum-bearing strata in any area, whether adjacent to that area or not; and keep separate any petroleum pool discovered in the area."

Apart from the above, the law provides the following obligations:

(a) prescribing places where petroleum may be imported and prohibiting its import elsewhere; regulating the import of petroleum;
(b) prescribing the periods within which licenses for the import of [class I] petroleum shall be applied for, and providing for the disposal, by confiscation or otherwise, of any [class I] petroleum in respect of which a license has not been applied for within the prescribed period or has been refused and which has not been exported;
(c) regulating the transport of petroleum;
(d) specifying the nature and condition of all receptacles and pipe-lines in which petroleum may be transported;
(e) regulating the places at which and prescribing the conditions subject to which petroleum may be stored;
(f) specifying the nature, situation and condition of all receptacles in which petroleum may be stored;
(g) prescribing the form and conditions of licenses for the import of dangerous petroleum, and for the transport or storage of any petroleum, the manner in which applications for such licenses shall be made, the authorities which may grant such licenses and the fees which may be charged for such licenses; (i) determining in any

class of cases whether a license for the transport of petroleum shall be obtained by the consignor, consignee or carrier;

(h) providing for the granting of combined licenses for the import, transport, storage and distribution of petroleum, or for any two of such purposes;

(i) prescribing the proportion in which any specified poisonous substance may be added to petroleum, and prohibiting the import, transport or storage of petroleum in which the proportion of any specified poisonous substance exceeds the prescribed proportion;

(j) regulating the distribution of petroleum;

(k) prescribing the conditions for the appointment of, and the granting of the licenses to, agents, dealers and stock list;

(l) prescribing the form and conditions of agreement between and agent, dealer or stockist and an oil marketing company;

(m) providing for cancellation or restoration of licenses of an agent or a dealer and of agreement between an oil marketing company and an agent, dealer or stockiest; and

(n) generally providing for any matter which in its opinion, in expedient for proper control over the import, transport, storage and distribution of petroleum."

Other regulatory legal instruments are: The Electricity Act, 1910; The Power Development Board Order, 1972; The Rural Electrification Board Act, 2013; The Speedy Distribution of Power and Energy Act, 2010 and The Development of Industries (Government Control) Act, 1949.

23.6 COAL SOURCING

The Power System Master Plan, 2010

The main objective of this study is to formulate a Master Plan for the attainment of stable power supply in the People's Republic of Bangladesh up to year 2030 in consideration of the diversification of fuel resources, including an optimum power development plan, power system plan, and identification of the potential power plant sites based on the fuel diversification study. Therefore, this study includes a comprehensive power development master plan where the study of the fundamental conditions of the development (demand forecast, procurement of primary energy resources, optimum power development plan, future optimum power supply structure including the positioning of gas- fired power plants, and so on) are added.

The power sector was heavily dependent on natural gas. Currently, about 62% of the electricity generated from the natural gas of the country and rest by HFO, HSD, hydroelectricity and coal. The power sector master plan 2010 has stressed on the diversification of the fuel sources such as imported coal, LNG as well as renewable energy sources (Solar, Wind Turbine).

In this Master Plan, the target composition of power supply as of 2030 is set at 50% for domestic and imported coal, 25% for domestic natural gas and imported gas (in the form of LNG) and 25% for other sources such as; Liquid Fuel, Nuclear power and Renewable energy.

National Energy Policy

National Energy Policy of Bangladesh approved in 1995 and gazette in 1996. This is a comprehensive energy policy which contents renewable energy, non-renewable energy and power sector.

The Policy, estimated total energy requirement of the country with time and per capita income. From the energy balance of the Policy report, a guide was given for the possible contribution of different energy sources. Both public and private initiative was emphasized for the energy sector development in Bangladesh. Incentives were declared for the private investment in the energy sector. In this policy, coal is considered under non-renewable energy. Private initiatives have been encouraged for exploration and development of coal. Until now, the energy sector activities are being carried out under this policy guideline.

Initiative was taken to prepare individual policy for coal since 2005, but not yet finalizes and approved by the appropriate authority. Still, a committee has been working for drafting a coal policy for Bangladesh for last three months. It is expected, the committee will submit their recommendations to the government within next two to three months.

Draft Coal Policy

The Draft Coal Policy (version 1) was published on 1st December 2005 by the Energy and Mineral Resources Division of Ministry of the Power, Energy and Mineral Resources. After that, it was revised for several times. The latest one is the Bangladesh Draft Coal Policy, 2010. The latest Draft Coal Policy (2010) outlines gas shortage, power generation, coal development, investment for coal sector, import coal, environment etc in Bangladesh. Therefore, this policy will become useful data in relation to the domestic coal supply. This policy states that coal will be used for power generation instead of gas as an alternative fuel to maintain national energy stability.

23.7 COAL TRANSPORTATION

The Import and Export (Control) Act, 1950

The Government may prohibit, restrict or otherwise control the import or export of goods of any specified description, or regulate generally all practices (including trade practices) and procedures connected with the import or export of such goods. No goods of the specified description shall be imported or exported except in accordance with the condition of a license to be issued by the Chief Controller.

The Territorial Water and Maritime Zones Act, 1974

It is mentioned in s.3(1) the Government may, by notification in the official Gazette, declare the limits of the sea beyond the land territory and internal waters of Bangladesh which shall be the territorial waters of Bangladesh specifying in the notification the baseline-
a) From which such limits shall be measured; and
b) The waters on the landward side of which shall form part of the internal waters of Bangladesh

In s.3 (4), No foreign ship shall, unless it enjoys the right of innocent passage, pass through the territorial waters. In s.3 (5), foreign ship having the right of innocent passage through the territorial waters shall, while exercising such right, observe the laws and rules in force in Bangladesh. In s.3(6), the Government may, by notification in the official Gazette, suspend, in the specified areas of the territorial waters, the innocent passage of any ship if it is of opinion that such suspension is necessary for the security of the Republic. It also mentioned in s.3 (7), No foreign warship shall pass through the territorial waters except with the previous permission of the Government.\

The Territorial Water and Maritime Zones Rules, 1977

Under S.3(1) Passage of foreign ships through the territorial waters shall be considered prejudicial to the security or interest of Bangladesh if it engages in embarking or disembarking any person or loading or unloading of any commodity or currency in violation of any laws or rules in force in Bangladesh relating to customs, fiscal matters, immigration, health or sanitation; any act of willful or serious marine pollution; fishing; carry out any search or survey activities.

The Ferries Act, 1885

It is mentioned in Section 27, every person who, after being warned by any toll-collector, lessee or assistant not to do so, goes, or takes any animals, vehicles or other things, into any ferry boat, or upon any bridge at such a ferry, which is in such a state or so loaded as to endanger human life or property, or who refuses or neglects to leave, or remove any animals, vehicles or goods from any such ferry-boat or bridge or being requested by such toll collector, lessee or assistant to do so, or who moors any boat, raft or other substance to, or in any way obstructs, any part of a public ferry, shall be punished with fine which may extend to fifty taka.

The Ports Act, 1908

The Ports Act 1908 was adopted to consolidate the enactments relating to Ports and port charges. The administering authority is the Ministry of Shipping. Subject to this Act, a Conservator is appointed to each port. Now, the Mongla Port's Harbour Master is acting as Conservator of Mongla Port and administers the provisions of the Act for the Port.

Specific environmental management provisions of the Act are given under s.21 (1) which prohibits the discharge of ballast, rubbish and oil into any port or adjacent areas. Under s.31 of the Act, the movement of vessels of 200 tons or more cannot enter, leave or be moved within any port without having a pilot on board. In addition, no vessel of more than 100 tons is to enter, leave or be moved within any port without having a pilot, unless authority to do so has been given in writing. The lawful use of infrastructure such as piers and moorings, and ensuring navigable waters are not obstructed is detailed under s.10, whereas s.21 prohibits interference with buoys, beacons and moorings. Unless the Conservator has granted permission, any action that causes or may cause injury to the bank or shore is prohibited under s.30 (1).

The Bangladesh Merchant Shipping Ordinance 1983

Under the Bangladesh Merchant Shipping Ordinance 1983, it is prohibited for any foreign ship to load or unload cargo within the territorial waters of Bangladesh without written permission from the Shipping Authority. This Ordinance sets standards for the construction of vessels. If the vessel has not been surveyed within Bangladesh, the Ordinance will require the ship to hold evidence of equivalent inspection such as a valid Safety Convention Certificate. A valid International Load Line Certificate (or proof of exemption) is also required under s.297 and s.339 for port clearance and to avoid undue delay in loading and unloading.

The Prevention of the Interference with Aids to Navigable Water Ways Ordinance, 1962

Under the Prevention of the Interference with Aids to Navigable Water Ways Ordinance, 1962; whoever commits mischief by damaging, removing, tampering with or handling any of the aids to navigation, or by doing any act which renders any of the aids to navigation less useful as such, and whoever abets such mischief, shall be punished with imprisonment which may extend to three years, or with fine, or with both.

The Mongla Port Authority Ordinance, 1976

The Mongla Port Authority (MPA) Ordinance 1976, under the Ministry of Shipping, Government People's Republic of Bangladesh established the MPA. The Ordinance provides the MPA with the authority, function and jurisdiction over docks (wharves, warehouses, railways, piers, bridges, and other works) and vessels (including any ship, barge, boat, or raft designed or used for the transport by water of passengers or goods) within the port limits. The MPA also has authority to reclaim or excavate any part of the bank or bed of the river, to construct, maintain and operate dredgers and appliances for clearing, deepening and improving the bed of the river, and to construct, maintain and operate all means and appliances for berthing, loading and discharging vessels. The MPA's authority also extends to improvements made to the land and riverbank of its existing Port at Khulna (Roosevelt Jetty).

Under s.18 of the Act, the MPA may permit any person to make, erect or fix below high water-

mark within the Port any dock, pier, erection or mooring. This provision may apply at Akram Point if moorings are established for securing barges or the floating transfer vessel (FTV).

The MPA also has the authority to issue fines for the pollution of water or environment by throwing or allowing into the water, bank or land, any goods, ballast, ashes or any other material that leads to pollution.

The Chittagong Port Authority (CPA) Ordinance, 1976

It is mentioned in s.10(1) Subject to the provisions of this Ordinance, the Authority may take such measures and exercise such powers as may be necessary for carrying out the purposes of this Ordinance.

Without prejudice to the generality of the powers conferred by sub-section (1), the Authority shall, in particular, have power-

a) To construct, maintain and operate docks, moorings, piers and bridges within the Port, with all necessary and convenient drains, arches, culverts, roads, railways, fences and approaches;
b) To undertake any work of or in connection with the loading, unloading and storing of goods in the port;
c) To construct, maintain and operate ferry vessels to carry passengers, vehicles and goods within the port;
d) To construct, maintain and operate railways, warehouses, sheds, engines, cranes, scales and other appliances for conveying, receiving, handling and storing goods to be landed or shipped or otherwise dealt with by the Authority;
e) To reclaim, excavate, enclose or raise any part of the bank or bed of the river;
f) To construct, maintain and operate dredgers and appliances for clearing, deepening and improving the bed of the river;
g) To construct, maintain and operate all means and appliances for berthing, loading and discharging vessels;
h) to construct, maintain and operate vessels, saving life and property or recovering any property lost, sunk or stranded;
i) To supply fuel or water to vessels;
j) To provide fire and security services within the port;
k) To acquire, hire, procure, construct, erect, manufacture, provide, operate, maintain or repair anything whatsoever required by the Authority for the purposes of this Ordinance.

In s.42(1) in the -case of any damage or mischief is done to any dock, pier or work of the Authority by any vessel, through the negligence of the master thereof or of any of the mariners or persons employed therein, not being in the service of the Authority, any Magistrate of the first class having jurisdiction in the port area may, on the application of the Authority and on declaration by it that payment for such damage or mischief has been

refused or has not been made on demand, issue a summons to the master or owner of such vessel, requiring him to attend on a day and at an hour named in the summons to answer touching such damage or mischief.

The Railway Act, 1890

The primary legislation for the management of the Bangladesh rail network is the railway Act, 1890. This Act applies to the land, lines, administration buildings and other infrastructure, goods and rolling stock. Subject to the provisions of this Act, authority is given to the railway administration to undertake works that may have environmental impact including the ability to alter the course of any watercourse or road for the purposes of constructing and maintaining tunnels, bridges and railway lines.

Under the Act, the railway administration is required to cause as little damage as possible when undertaking its work. Provisions for the payment of compensation support this. Compensation is payable for any damage caused through the works of the railway administration.

The Act assigns an Inspector of the railway to make periodical inspections of any railway or rolling stock and to conduct an inquiry into the cause of any accident on the railway. In addition to undertaking inspections of equipment and incidents, operations are also subject to investigation. For example, maximum loads for every rail wagon and locomotive may be subject to the assessment of railway administration under the provisions of this Act. The Railway Act 1890 is further supported by the Railway (Transport of Goods) Ordinance of 1963, 1969 and 1976 and the Bangladesh Railways (Transport of Goods) Order 1972. Currently, the Ordinance and Order have not allowed particular provisions for the transport of coal.

In addition to reviewing the national acts, rules and policies; relevant international conventions, treaties, protocols and agreements will also be reviewed related to the coal sourcing, handling and transportation activities and will be discussed later on.

The Motor Vehicles Ordinance, 1983

A legislation to consolidate and amend the law relating to motor vehicles. It's a regulatory piece of legal instrument to bring all the vehicles and vehicles related matters in a disciplined framework. It gives power to the Government to make rules upon the following matters:

(a) the width, height, length and overhang of vehicles and of the loads carried;
(b) seating arrangements in public service vehicles and the protection of passengers against the weather;
(c) the size, nature and condition of tyres;
(d) brakes and steering gear;
(e) the use of safety glass;
(f) signaling appliances, lamps and reflectors;

(g) speed governors;
(h) the emission of smoke, visible vapour, sparks, ashes, grit or oil;
(i) the reduction of noise emitted by or caused by vehicles;
(j) prohibiting or restricting the use of audible signals at certain times or in certain places;
(k) prohibiting or restricting the use as transport vehicles of any motor vehicle or any motor vehicle with left hand steering control;
(l) prohibiting the carrying of appliances likely to cause annoyance or danger;
(m) the periodical testing and inspection of vehicles by prescribed authorities;
(n) the particulars other than registration marks to be exhibited by vehicles and the manner in which they shall be exhibited;
(o) the use of trailers with motor vehicle;
(p) prohibiting or enforcing the painting in particular colours of motor vehicles of particular descriptions or for particular purposes or in particular areas;
(q) registration, control and supervision of establishments undertaking repair works of motor vehicles and the conditions governing such establishment; and
(r) any other matter which is to be or may be prescribed by the rules.

The Highways Act, 1925

An Act to provide for the better maintenance and control of Government roads in Bangladesh. Section 2 of this Act provides that:
"Government road" means a road vested in the Government, or under the control and administration of the Works Department of the Government, and includes:

(a) the slope, berm, borrow-pits and side-drains of any such road;
(b) all lands and embankments vested in, or under the control and administration of, the said Works Department, and attached to a Government road;
(c) all bridges, culverts or causeways built on or across any Government road; and
(d) all fences and posts on any Government road or on any land attached to a Government road, and all roadside trees on such land.

The Obstruction in Fairways Act, 1881

This Act empowers the Government to remove or destroy obstructions to navigation in fairways leading to ports in Bangladesh and to prevent the creation of such obstructions.

The Inland Water Transport Authority Ordinance, 1958

This Act makes provisions for setting up of an Authority for the development, maintenance and control of inland water transport and of certain inland navigable waterways in Bangladesh. The Authority set up under this legislation performs the following functions

according to Section 15:

(i) carry out river conservancy works including river training works for navigational purposes and for provision of aids to navigation, including marks, buoys, lights and semaphore signals;

(ii) disseminate navigational and meteorological information including publishing river charts;

(iii) maintain pilotage and hydrographic survey services;

(iv) draw up programs of dredging requirements and priorities for efficient maintenance of existing navigable waterways, and for resuscitation of dead or dying rivers, channels, or canals, including development of new channels and canals for navigation;

(v) develop, maintain and operate inland river ports, landing Ghats and terminal facilities in such ports or Ghats;

(vi) carry out removal of wrecks and obstructions in inland navigable waterways;

(vii) conduct traffic surveys to establish passenger and cargo requirements on the main rivers, feeders and creek routes;

(viii) develop the most economical facilities for passenger traffic to ensure comfort, safety and speed on mechanized craft;

(ix) fix maximum and minimum fares and freight rates for Inland Water Transport on behalf of the Government as provided in section 59 of the;

(x) approve time-tables for passenger services;

(xi) develop rural water transport by progressing of schemes for modernizing and mechanizing country craft;

(xii) ensure co-ordination of Inland Water Transport with other forms of transport, with major sea ports, and with trade and agricultural interests for the optimum utilization of the available transport capacity;

(xiii) conduct research in matters relating to Inland Water Transport including development of-

(a) Craft design,

(b) Technique of towage,

(c) Landing and terminal facilities,

(d) Port installations;

(xiv) arrange programs of technical training for Inland Water Transport personnel within and outside Bangladesh;

(xv) maintain liaison with the shipyard and ship repair industry to meet the requirements of the Inland Water Transport fleet repairs and new constructions;

(xvi) facilitate import of repair materials for the Inland Water Transport Industry;

(xvii) prepare plans or development schemes for carrying out any of the above mentioned functions;

(xviii) any other function or functions which the Government may, from time to time, prescribe.

The Bangladesh Inland Water Transport Corporation Order, 1972

This legislation speaks about the establishment of a Corporation for the purpose of operation, promotion and development of coastal and inland shipping and water transport services and for the vesting in that Corporation of the assets and liabilities of the Bangladesh Shipping Corporation and of certain companies, firms and individuals carrying on coastal and inland Shipping and water transport business in Bangladesh and for matters connected therewith or incidental thereto.

The Inland Shipping Ordinance, 1976

An Ordinance is to provide for the survey, registration and control of navigation of vessels plying on inland waters.

The Bangladesh Shipping Corporation Order, 1972

This legal instrument provides for the establishment of a Corporation for the purpose of ensuring better operation and development of shipping and ocean transport services and for purposes connected therewith.

23.8 FISHERY

The regulatory regime governing fisheries in Bangladesh distinctly possess the characteristics of both substantial and procedural laws and hence may be conveniently mentioned under two separate broad heading. The substantial laws have been complied under the laws namely, the Protection and Conservation of Fish Act, 1950, The Government Fisheries Ordinance, 1959, The Private Fisheries Protection Act, 1889 and The Marine Fisheries Ordinance, 1983, while the Rules of Business, 1976, The Land Management Manual, 1990, The Bangladesh Fisheries Development Corporation Act, 1973 and The Fisheries Research Institute Ordinance, 1984 enumerate regulation establishing statutory institutions and mechanism followed in the management of fisheries.

23.9 WATER RESOURCES

The potential for the transmission of disease through the public water supplies, and hence the need to safeguard their quality, is recognized in the recent years in Bangladesh. The priority for the protection of public health is to ensure effective drainage away from drinking water sources, but the discharges of drains from urban areas and from industry into streams and rivers inevitably resulted in their becoming severely polluted, and increasingly unsuitable for use by those further downstream.

If rivers and streams are to be of high quality, readily capable of use for drinking water and supporting thriving populations of aquatic flora and fauna, there must be management of their

whole catchment area, with sufficient control over the location of industry and over other developments and all actually or potentially polluting activities in the area, in particular over all discharges to water, and also the power to maintain a satisfactory balance between consumption of water and available supplies.

There has also been increasing concern, both at official level and among the public at large over the effects of pollution of water, not only on public health but on the fish and other creatures that depend on the aquatic environment, in both inland waters, and also coastal and other marine waters. In this regard the legal framework to safeguard the aquatic environment is very poor. However, upon legal research the following legal instruments have been found:

- The Embankment and Drainage Act, 1953;
- The Bangladesh Water Act, 2013;
- The National Rivers Protection Commission Act, 2013;
- The Ground Water Management Ordinance, 1985;
- The Territorial Water and Maritime Zones Act, 1974;
- The Coast Guard Act, 1994; and
- The Water Resources Planning Act, 1992.

23.10 LAND USE, ADMINISTRATION AND MANAGEMENT

Bangladesh is a small country having a big population, in fact most densely populated country in the world. For this reason here in Bangladesh, the land use and its administration & management is crucial. Upon legal research, the following relevant laws have been found:

- The Bangladesh Land Holding Limitation Order, 1972;
- The Transfer of Property Act, 1882;
- The State Acquisition & Tenancy Act, 1950;
- The Non-Agricultural Tenancy Act, 1949;
- The Acquisition of Wasteland Act, 1950;
- The Culturable Waste Land (Utilization) Ordinance, 1959;
- The Land Reforms Ordinance, 1984;
- The Development Act, 1935;
- The Acquisition and Requisition of Immovable Property Ordinance, 1982; and
- The Land Management Manual, 1990.

23.11 RURAL AND URBAN PLANNING AND PROTECTION

The Building Construction Act, 1952

An Act is to provide for the prevention of haphazard construction of buildings and excavation of tanks which are likely to interfere with the planning of certain areas in Bangladesh. The Bangladesh National Building Code and the Building Construction Rules have been formulated under this Act to regulate construction of buildings in Bangladesh.

The Public Parks Act, 1904

This Act applies to any public park or garden in Bangladesh by order of the Government published in Official Gazette. According to this law, the Government may, by notification in the Official Gazette declare that any specified land, bridge or pontoon shall, for the purposes of this Act, be deemed to be included in any park. The Government may make rules for the management, and preservation of any park, and for regulating the use thereof by the public. In particular, and without prejudice to the generality of the foregoing power such rules may,-

(a) regulate the admission of persons, horses and ponies, and carriages, palanquins and other conveyances, into the park, and prescribed fees to be paid therefor;
(b) prohibit or regulate the bringing of dogs, motor-cars, bicycles or tricycles into the park;
(c) prohibit the doing of all or any of the following things, by persons other than employees of the park, that is to say, plucking or gathering anything growing in the park, breaking trees, branches or plants cutting names or marks on trees, disfiguring buildings, furniture or monuments, removing or disfiguring labels or marks attached to trees or plants;
(d) prohibit the purchase of any produce of the park otherwise than from the superintendent or some other authorized person;
(e) prohibit shooting, bird-nesting, the catching of butterflies, or any act of cruelty;
(f) prohibit or regulate fishing or boating and prescribe fees to be paid by persons obtaining permission to fish or to use boats;
(g) prohibit bathing, or the pollution of water by any other means;
(h) prohibit the grazing of horses or ponies;
(i) prohibit the teasing or annoying of animals or birds kept in the park;
(j) prohibit the commission of any nuisance, or the molestation or annoyance of any person resorting to the park.

The Places Public Amusement Act, 1933

This Act provides better control of certain places of public amusement and for the prevention of gambling in such places. The Government may, by notification in the official Gazette, declare that any places, or classes of places, of public amusement, specified in the notification, shall be notified places of public amusement for the purposes of this Act.

23.12 WILDLIFE

The Wildlife (Preservation and Protection) Act, 2012

According to Section 6 (1), no person shall –

(a) (i) hunt any wild animal by means of a set-gun, drop spear, deadfall, gun trap, an explosive projectile bomb, grenade, electrical contrivances, a baited hook or any other trap whatsoever;

(ii) hunt any game animal by means of an automatic weapon of a calibre, used by the Bangladesh Army, Bangladesh Rifle or Police Force, a shot gun, rifle of 22 calibre or less, or a projectile containing any drug or chemical substance having the property of anesthetising, paralysing, stupifying or rendering a wild animal] crippled whether partly or totally;

(b) (i) use any motor vehicle, motor driven vessel, watercraft of any type or aircraft or any other manually or mechanically propelled vehicle of any type to pursue any game animal, or to drive or stampede game animals for any purpose whatsoever;

(ii) use or have in his possession any poison or like injurious substance for the purpose of hunting a game animal;

(iii) shoot any game animal from any aircraft, motor vehicle, rail trolley cart, boats or any kind of watercraft or any other conveyance;

(iv) hunt with the help of live decoys, call birds or any other artificial contrivances;

(c) construct or use or have in his possession any pitfall, game pit, trench or similar excavation or any fence or enclosure, or set fire to any vegetation or any other contrivance for the purpose of hunting any game animal.

23.13 ENERGY AND MINERAL RESOURCES

The Mines Act, 1923

This Act was enacted to amend and consolidate the law relating to the regulation and inspection of mines.

The Petroleum Act, 1934

This Act is to consolidate and amend the law relating to the import, transport, storage, production, refining, blending or reclaiming by recycling, distribution and marketing of petroleum and other inflammable substances.

The Bangladesh Petroleum Act, 1974

The Bangladesh Petroleum Act is enabling legislation that allows the Government of Bangladesh to enter into all aspects of petroleum exploration, development, exploitation, production, processing, refining and marketing. In addition, the Government is authorized to enter into Petroleum Agreement(s) with any person(s) for the purpose of petroleum operations. The duties of such person(s) are:

- To ensure that petroleum operation is carried out in a proper and worker like manner and in accordance with good oil field practice.
- To carry out petroleum operation in any area in a manner that does not interfere with navigation, fishing and conservation of resources.
- To consider the factors connected with the ecology and environment. Clause 6(2) of the Act sets out certain details related to environment and safety:

"In particular, and without prejudice to the generality of the foregoing provision, a person engaged in any petroleum operations shall, in carrying out such operations in any area:
Control the flow and prevent the waste or escape' in the area, of petroleum or water;
Prevent the escape in that area of any mixture of water or drilling fluid with petroleum or any other matter;

Prevent damage to petroleum-bearing strata in any area, whether adjacent to that area or not; and keep separate any petroleum pool discovered in the area."

Apart from the above, the law provides the following obligations:

a) Prescribing places where petroleum may be imported and prohibiting its import elsewhere; regulating the import of petroleum;
b) prescribing the periods within which licenses for the import of [class I] petroleum shall be applied for, and providing for the disposal, by confiscation or otherwise, of any [class I] petroleum in respect of which a license has not been applied for within the prescribed period or has been refused and which has not been exported;
c) regulating the transport of petroleum;
d) specifying the nature and condition of all receptacles and pipe-lines in which petroleum may be transported;
e) regulating the places at which and prescribing the conditions subject to which petroleum may be stored;
f) specifying the nature, situation and condition of all receptacles in which petroleum may be stored;
g) prescribing the form and conditions of licenses for the import of dangerous petroleum, and for the transport or storage of any petroleum, the manner in which applications for such licenses shall be made, the authorities which may grant such licenses and the fees which may be charged for such licenses; (i) determining in any class of cases whether a license for the transport of

petroleum shall be obtained by the consignor. consignee or carrier;

h) providing for the granting of combined licenses for the import, transport, storage and distribution of petroleum, or for any two of such purposes;
i) prescribing the proportion in which any specified poisonous substance may be added to petroleum, and prohibiting the import, transport or storage of petroleum in which the proportion of any specified poisonous substance exceeds the prescribed proportion;regulating the distribution of petroleum;
j) prescribing the conditions for the appointment of, and the granting of the licenses to, agents, dealers and stockist;
k) prescribing the form and conditions of agreement between and agent, dealer or stockist and an oil marketing company;
l) providing for cancellation or restoration of licenses of an agent or a dealer and of agreement between an oil marketing company and an agent, dealer or stockiest; and
m) generally providing for any matter which in its opinion, in expedient for proper control over the import, transport, storage and distribution of petroleum."

Besides the above legislation, the Boilers Act, 1923, The Bangladesh Oil, Gas and Mineral Corporation Ordinance, 1985 and the Atomic Energy (Control) Act, 2012 have to be considered.

23.14 LOCAL GOVERNMENT LAWS

The legal instruments like the Local Government (Union Parishad) Act, 2009; the Local Government (Pourashava) Act, 2009; the Upazilla Parishad Act, 1998 and the Zilla Parishad Act, 2000 are very important for this development project. Because for the proper implementation of a development project, the cooperation of local government bodies is needed now and then.

23.15 MISCELLANEOUS

The Penal Code, 1860 anf the Code of Criminal Procedure, 1898 have to be considered also. There are many penal provisions in the Penal Code as well as in the Code of Criminal Procedure for creating excessive noise, nuisance, pollution etc.

International Maritime Conventions, Protocols and Agreements

Bangladesh is signatory of the International Maritime Organization (IMO). Therefore, all activities relating to shipment of coal through the Port shall have to be done strictly in compliance with the standards set by the IMO, particularly the conventions, protocols and agreements.

The GoB-has agreed the following Conventions/Protocols of IMO

1. IMO Convention 48
2. IMO amendments 91
3. IMO amendments 93
4. SOLAS Convention 74
5. SOLAS Protocol 88
6. LOAD LINES Convention 66
7. LOAD LINES Protocol 88
8. TONNAGE Convention 69
9. COLREG Convention 72
10. STCW Convention 78
11. SAR Convention 79
12. STP Agreement 71
13. STP Protocol 73
14. IMSO Convention 76
15. INMARSAT OA 76
16. FACILITATION Convention 65
17. MARPOL 73/78 (Annex I/II)
18. MARPOL 73/78 (Annex III)
19. MARPOL 73/78 (Annex IV)
20. MARPOL 73/78 (Annex V)
21. MARPOL Protocol 97 (Annex VI)
22. INTERVENTION Convention 69
23. SUA Convention 88
24. SUA Protocol 88
25. OPRC Convention 90

Some of the Conventions/Protocols acceded by GOB are highlighted below-

Table 23.1: International maritime conventions, protocols and agreements of different issues

Issues	International Maritime Conventions, Protocols and Agreements	Remarks
International Maritime	IMO Convention, 1948	The Convention establishing the IMO was adopted in 1948 but the Organization started life as the Inter-Governmental Maritime Consultative Organization (IMCO) until it was changed to the IMO in 1982. The Aims of the IMO include a range of objectives: -To provide machinery for co- operation among Governments in the field of governmental regulation and practices relating to technical matters of all kinds affecting shipping engaged in international trade, and to encourage the general adoption of the highest practicable standards in matters concerning maritime safety and efficiency of navigation; - To provide for the consideration by the Organization of any matters concerning shipping that may be referred to it by any organ or specialized agency of the United Nations; - To provide for the exchange of information among Governments on matters under consideration by the Organization. There have been a series of amendments to the Convention, which are 1975 amendments, 1977 amendments, 1991 amendments. This Convention came into force in Bangladesh on May 27, 1976. The amendment 1993 acceded on November 7, 2002.
Maritime safety	SOLAS Convention, 1974	The SOLAS Convention in its successive forms is generally regarded as the most important of all international treaties concerning the safety of merchant ships. The 1974 version includes the tacit acceptance procedure - which provides that an amendment shall enter into force on a specified date unless, before that date, objections to the amendment are received from an agreed number of Parties. The Convention came into force on May 25, 1980 and acceded by GOB on February 6, 1982. The 1988 Protocol of SOLAS 1974 was acceded by Bangladesh on November 4, 2002.
Measurement of ships	Load Lines Convention, 1966	It has long been recognized that limitations on the draught to which a ship may be loaded make a significant contribution to her safety. These limits are given in the form of freeboards, which constitute, besides external weather tight and watertight integrity, the main objective of the Convention. The Convention acceded by GOB on August 10, 1978. The Protocol of the Load Line Convention acceded by GOB on November 4, 2002.
Preventing collisions at sea	Convention on International Regulations for Preventing Collisions at Sea (COLREG), 1972	The 1972 Convention was designed to update and replace the Collision Regulations of 1960, which were adopted at the same time as the 1960 SOLAS Convention. One of the most important innovations in the 1972 COLREGs was the recognition given to traffic separation schemes - Rule 10 gives guidance in determining safe speed, the risk of collision and the conduct of vessels operating in or near traffic separation schemes. The Convention was acceded by Bangladesh on May 10, 1978.

International Maritime Satellite System	Convention on International Maritime Satellite Organization (INMARSAT), 1976	IMO recognized the potential for satellite communications to assist in distress situations at sea soon after the launch of the world's first telecommunications satellite, Telstar, in 1962. In February 1966, IMO's Maritime Safety Committee (MSC) decided to study the operational requirements for a satellite communications system devoted to maritime purposes. In 1973, IMO decided to convene a conference to establish a new maritime communications system based on satellite technology. The Convention came into force by GOB on July 16, 1979.
Prevention of Pollution from Ships	International Convention for the Prevention of Pollution from Ships (MARPOL)	The MARPOL Convention is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. It is a combination of two treaties adopted in 1973 and 1978 respectively and includes the Protocol of 1997 (Annex VI). It has been updated by amendments through the years. MARPOL 73/78 (Annex-I, II, III, IV, V and VI) was acceded by GoB on November 4, 2002.
	Convention on Facilitation of International Maritime Traffic (FACILITATION), London, 1965	The Convention's main objectives are to prevent unnecessary delays in maritime traffic, to aid co-operation between Governments, and to secure the highest practicable degree of uniformity in formalities and other procedures. In particular, the Convention reduces the number of declarations, which can be required by public authorities. The Convention came into force in Bangladesh on October 28, 2000.
Safety of maritime navigation	Convention for The Suppression of Unlawful Acts of Violence Against the Safety of Maritime Navigation (SUA convention), 1988	The main purpose of the convention is to ensure that appropriate action is taken against persons committing unlawful acts against ships. These include: the seizure of ships by force; acts of violence against persons on board ships; and the placing of devices on board a ship which are likely to destroy or damage it.The convention obliges Contracting Governments either to extradite or prosecute alleged offenders. The Convention came into force in Bangladesh on September 7, 2005.

In addition to the aforementioned conventions, Government of Bangladesh will sign the following conventions very soon-

1. STCW- 2010
2. Bunker Convention
3. Anti-fouling Convention
4. Hong Kong Convention for Ship Recycling
5. Ballast Water Management Convention

International Environmental Conventions, Protocols and Agreements

Bangladesh is signatory to a number of Multilateral Environmental Agreements (MEAs) and to some bilateral instruments. Some of them are very important in context of environmental protection. The legal obligations and provisions of MEAs related to the proposed project activities such as; Convention on Biological Diversity; Convention on Wetlands of International Importance Especially as Waterfowl Habitat; United Nations Convention on the Law of the Sea; Convention concerning the Protection of the World Cultural and Natural

Heritage will be reviewed.

Bangladesh has already had accessed to, ratified or signed a number of important MEAs related to environment protection and conservation of natural resources which shall have to be complied with during implementation of the project. The pertinent ones of these are highlighted below:

Rio Declaration

The 1992 United Nations Conference on Environment and Development (UNCED) adopted the global action program for sustainable development called 'Rio Declaration' and 'Agenda 21'.

Principle 4 of the Rio Declaration, 1992, to which Bangladesh is a signatory along with 178 countries, states, "In order to achieve sustainable development, environmental protection should constitute an integral part of the development process and cannot be considered in isolation from it".

Convention on Biological Diversity, 1992

The Convention on Biological Diversity, Rio de Janeiro, 1992 was adopted on 5 June 1992 and entered into force on 29 December 1993. Bangladesh ratified the Convention on 20 March 1994.

The Contracting Parties of the Convention have committed to:

Introducing appropriate procedures requiring environmental impact assessments of its proposed projects that are likely to have significant adverse effects on biodiversity, with a view to avoiding or minimizing such effects, and where appropriate allow for public participation in such procedures; and

Introducing appropriate arrangements to ensure that environmental consequences of its programs and policies, that are likely to have significant adverse impacts on biodiversity, are duly taken into account.

Obligation has been placed on State parties to provide for environmental impact assessments of projects that are likely to have significant adverse effects on biological diversity (art. 4).

Convention on Wetlands of International Importance Especially as Waterflow Habitat, Ramsar, 1971

This convention is also known as the Ramsar Convention. It was adopted 2 February 1971 and entered into force on 21 December 1975. Bangladesh has ratified the Convention 20 April 2002. This provides a framework for national action and international cooperation for the

conservation and wise use of wetlands and their resources. There are 127 Parties with 1085 wetland sites designated as Wetlands of International Importance'.

This is an intergovernmental treaty, which provides the framework for international co-operation for the conservation of wetlands habitats. Obligations for Contracting Parties include the designation of wetlands to the "List of Wetlands of International Importance', the provision of wetland considerations within their national land use planning, and the creation of Natural Reserves. A part of Sundarbans Reserved Forest (Southwest of Bangladesh) is one of the Ramsar Site.

United Nations Convention on the Law of the Sea, Montego Bay, 1982

This Convention was adopted on 10 December 1982 at Montego Bay, Jamaica. Bangladesh has ratified this Convention.

Main objectives of the convention are:

• To set up a comprehensive new legal regime for the sea and oceans, as far as environmental provisions are concerned, to establish material rules concerning environmental standards as well as enforcement provisions dealing with pollution of the marine environment; and

• To establish basic environmental protection principals and rules on global and regional cooperation, technical assistance, monitoring, and environmental assessment, and adoption and enforcement of international rules and standards and national legislation with respect to alternate sources of marine pollution.

UNESCO World Heritage Convention

Convention concerning the Protection of the World Cultural and Natural Heritage, Paris, 1972: This convection has been ratified by 175 states. This defines and conserves the world's heritage by drawing up a list of natural and cultural sites whose outstanding values should be preserved for all humanity. Of the 730 total sites, there are currently 144 natural, 23 mixed and 563 cultural sites that have been inscribed on the World Heritage List (distributed in 125 State parties). These are the 'Jewels in the Crown' of conservation.

The Sundarbans is declared as the World Heritage Site. Therefore, the provision of this convention regarding protection of World Heritage Site is very much relevant for the proposed intervention.

The proposed project intervention should be carried out in such a manner that the above-mentioned provisions of the multilateral environmental agreements are not violated and many not cause adverse impact on the natural resources.

Development Agency's Health and Safety Guidelines

Under the study health and safety guidelines of few development agencies has been reviewed. This included ADB is Social Safeguard Policy and the World Bank's Environmental Process.

Social Safeguard Policy of ADB and World Bank

ADB has had environment assessment requirements for more than 20 years and own safeguard policy framework, which is currently taken to consist of three operational policies, namely the Environment Policy (2002), the Policy on Indigenous Peoples (1998), and the Policy on Involuntary Resettlement (1995), together with their respective operations manual sections and guidelines. In 1989 the World Bank adopted Operational Directive (OD) 4.00, "Annex A: Environmental Assessment". EA became standard procedure for Bank financed investment project. In 1991 the directive was as OD 4.01, which has subsequently been changed to operational policy OP 4.01 in January 1999 and the operational policy statement has been updated in March, 2007. EA is designed to be a flexible process that part of project preparation allows environmental issues to be addressed in a timely and cost-effective way during project preparation and implementation.

ADB's safeguard policies are central to achieving sustained development impact and poverty reduction. The objective of these policies is to avoid, minimize or mitigate adverse environmental impacts, social costs to third parties or marginalization of vulnerable groups that may result from development projects. Safeguard policies prescribe; "do no harm" requirements that must be met for all ADB projects. Regarding the resettlement plan of a project ADB provides that 'A satisfactory resettlement plan must include all eleven essential elements'. The safeguard policies are at the front line of ADB's accountability mechanism and compliance review process, since these policies, if properly implemented, help ensure that third parties do not incur material damages, either directly or through environmental media, and thus have no basis for complaint.

All three-safeguard policies involve a structured process of impact assessment, planning and mitigation to address the adverse effects of projects and programs throughout the project cycle. The safeguard policies require that: (i) impacts are identified and assessed early in the project cycle; (ii) adverse impacts are avoided, minimized, or mitigated; and (iii) affected people are consulted.

In July 2009, ADB's Board of Directors approved the new Safeguard Policy Statement (SPS) governing the environmental and social safeguards of ADB's operations. The SPS aims to avoid, minimize, or mitigate harmful environmental impacts, social costs, and to help borrowers/clients strengthen their safeguard systems. The SPS builds upon ADB's previous safeguard policies on the environment, involuntary resettlement, and Indigenous Peoples, and brings them into one consolidated policy framework with enhanced consistency and coherence, and that more comprehensively addresses environmental and social impacts

and risks. The SPS also provides a platform for participation by affected people and other stakeholders in project design and implementation.

Compliance with World Bank Environmental Assessment (EA) Process

The primary responsibility for the Environmental Assessment process lies with the borrower. The Bank's role is to advise borrower throughout the process, to confirm that practice and quality are consistent with Environmental Assessment requirements and to ensure that the process feeds effectively into project preparation and implementation.

The 2001 Environment Strategy for the World Bank emphasizes the importance of integrating or mainstreaming environment into country development programs, sector strategies, and investments and underpinning sustainable development. We introduced environmental policies and procedures to integrate good environmental management into our operations, and we have also developed environmental assistance programs to help client countries integrate environmental issues into their development process, to address their pressing environmental challenges.

In addition to efforts identified in the 2001 Strategy, the Bank has adopted a set of operational policies and procedures that deal with the Bank's core development objectives and goals, the instruments for pursuing them, and specific requirements for Bank financed operations.

World Bank seeks to ensure that -supported infrastructure and other development projects take into account the conservation of biodiversity, as well as the numerous environmental services and products which natural habitats provide to human society. The policy strictly limits the circumstances under which any Bank-supported project can damage natural habitats (land and water areas where most of the native plant and animal species are still present).

Specifically, the policy prohibits Bank support for projects which would lead to the significant loss or degradation of any Critical Natural Habitats, whose definition includes those natural habitats which are either:

- Legally protected,
- Officially proposed for protection, or
- Unprotected but of known high conservation value.

In other (non-critical) natural habitats, Bank supported projects can cause significant loss or degradation only when

i) there are no feasible alternatives to achieve the project's substantial overall net benefits; and
ii) Acceptable mitigation measures, such as compensatory protected areas, are included within the project.

(Operational Policy 4.04)

The Bank's current forests policy aims to reduce deforestation, enhance the environmental contribution of forested areas, promote afforestation, reduce poverty, and encourage economic development.

Combating deforestation and promoting sustainable forest conservation and management have been high on the international agenda for two decades. However, little has been achieved so far and the world's forests and forest dependent people continue to experience unacceptably high rates of forest loss and degradation. The Bank is therefore currently finalizing a revised approach to forestry issues, in recognition of the fact that forests play an increasingly important role in poverty alleviation, economic development, and for providing local as well as global environmental services.

Success in establishing sustainable forest conservation and management practices depends not only on changing the behavior of all critical stakeholders, but also on a wide range of partnerships to accomplish what no country, government agency, donor, or interest group can do alone.

The new proposed forest strategy suggests three equally important and interdependent pillars to guide future Bank involvement with forests:

- Harnessing the potential of forests to reduce poverty,
- Integrating forests in sustainable economic development, and
- Protecting vital local and global environmental services and forest values