NORTH-WEST POWER GENERATION COMPANY LIMITED

NORTH-WEST POWER GENERATION COMPANY LTD., DHAKA
(AN ENTERPRISE OF BPDB)

FINAL REPORT

on

Environmental Impact Assessment (EIA) Study

of

SIRAJGANJ 225 MW COMBINED CYCLE POWER PLANT PROJECT (2ND UNIT- DUAL FUEL), SAYDABAD, SIRAJGANJ

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Submitted by:

ENGINEERS ASSOCIATES LIMITED

1/3, ASAD GATE ROAD, BLOCK– A
MOHAMMADPUR HOUSING ESTATE, DHAKA-1207
TEL.: 880-2-9111358, 880-2-8117246, FAX.: 880-2-8118512
E-MAIL: engineers.associates@gmail.com
WEB: www.ealbd.com

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ABBREVIATIONS USED

ADB	-	Asian Development Bank
BBS	-	Bangladesh Bureau of Statistics
BIWTA	-	Bangladesh Inland Water Transport Authority
BOD	-	Biochemical Oxygen Demand
BPDB	-	Bangladesh Power Development Board
BWDB	-	Bangladesh Water Development Board
CC	-	Compensation Committee
CCPP	-	Combined Cycle Power Plant
CO	-	Carbon Monoxide
COD	-	Chemical Oxygen Demand
DA	-	District Administration
DO	-	Dissolved Oxygen
DoE	-	Department of Environment
DPP	-	Development Project Proforma
EIA	-	Environmental Impact Assessment
EMP	-	Environmental Management Plan
ETP	-	Effluent Treatment Plant
FGD	-	Focused Group Discussion
FPCO	-	Flood Protection
GOB	-	Government of Bangladesh
GRC	-	Grievance Redress Committee
IAM	-	Impact Assessment Matrix
IECs	-	Important Environmental Components
IEE	-	Initial Environmental Examination
IUCN	-	International Union for Conservation of Nature
JBIC	-	Japan Bank for International Cooperation
JICA	-	Japan International Cooperation Agency
JV	-	Joint Venture
JVT	-	Joint Verification Team
KI	-	Key Informants
KII	-	Key Information Interview
MW	-	Mega Watt
NETL	-	National Energy Technology Laboratory
NO_X	-	Oxides of Nitrogen
NREL	-	National Renewable Energy Laboratory
NWPGCL	-	Northwest Power Generation Company Limited
PAP	-	Project Affected People
PD	-	Project Director
PEIA	-	Post Environmental Impact Assessment
PGCB	-	Power Grid Company of Bangladesh

ABBREVIATIONS USED

PSMP	-	Power System Master Plan
PVAT	-	Project Value Assessment Team
R&R	-	Resettlement & Rehabilitation
RAP	-	Rehabilitation Action Plan
RMS	-	Reducing Metering Station (Gas)
SOx	-	Oxides of Sulfur
SPM	-	Suspended Particulate Matter
SS	-	Suspended Solids
UC	-	Union Council
UNO	-	United Nations Organization
USA	-	United States of America
USDOT	-	United State Department of Transportation
WB	-	World Bank

EXECUTIVE SUMMARY

1.0 Introduction:

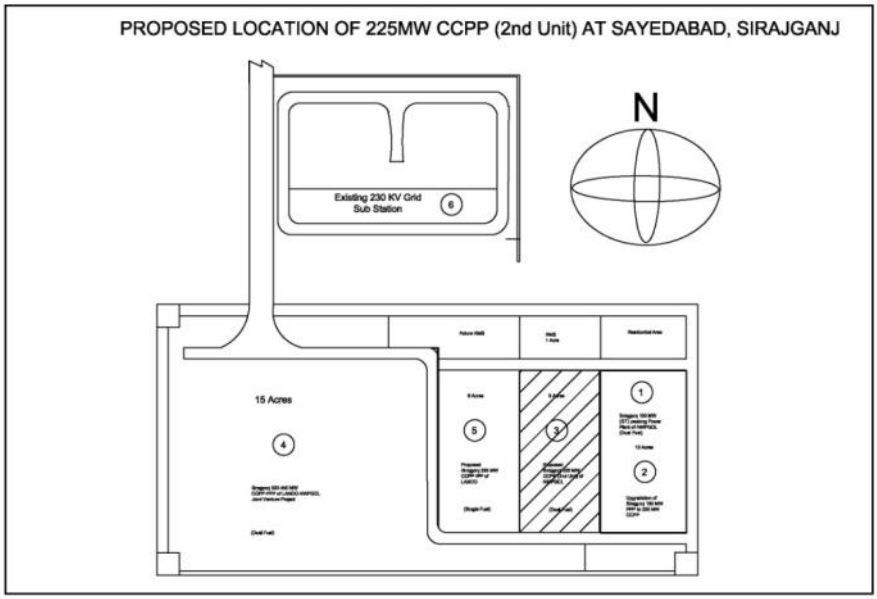
The present installed capacity of electricity in Bangladesh as of July 2013 is **8537MW** out of which maximum **6675MW** power was generated in July 2013. As per Power System Master Plan (PSMP) 2010, Country's maximum electricity demand is **8349MW in 2013**, **9,268MW in 2014** and **11,405MW in 2016**. So there is huge shortage of power in Bangladesh. According to power generation development plan of the Government of Bangladesh, NWPGCL has constructed two nos. dual fuel 150MW peaking power plants at Khulna and Sirajganj respectively with the financial assistance from Asian Development Bank (ADB). NWPGCL is also constructing one 360MW combined cycle power plant at Bheramara, Kushtia with the financial assistance from Japan International Cooperation Agency (JICA). NWPGCL has also undertaken to upgrade both 150MW Peaking power plants to 225MW Combined Cycle Power Plant. Still this is not enough to meet the increasing demand of electricity. So, NWPGCL has planned to construct another 225MW Combined Cycle Power Plant at Saydabad under Sirajganj district beside the 150MW Peaking Power Plant upgraded to 225MW CCPP with the bidder's finance.

2.0 Policy & Guidelines:

The proposed power plant to be implemented by NWPGCL requires strict compliance with laws, rules and regulations pertinent to environment The Department of Environment (DoE) of Government of Bangladesh is responsible for ensuring application of environmental laws and issuance of necessary-clearances in industrial and development activities. The procedures and requirements for EIA under the power sector foreshadowed the introduction of the **Environmental Conservation Act in 1995,** which introduced a requirement for any proposed "Industrial Unit or project'[1] to obtain prior approval from the Department of Environment (DoE).

3.0 Description of project:

The proposed 225MW Combined Cycle Power Plant project (2nd Unit-Dual Fuel) will be located beside the existing 150MW Peaking Power Plant converted to 225MW CCPP, which is situated on the bank of the Jamuna river near Bangabandhu Bridge at Sirajganj. This is located at Barashimul Mouza of Saydabad Union of Sirajganj Sadar Thana under the District of Sirajganj. This is about 15 KM south-east of Sirajganj town. . The JMB (Bangabandhu Setu) is on the north of the site, Khas Barashimul village on the south, Jamuna river on the east and Saydabad is on the west side of the power plant site. The proposed site is about **130 km** north-west of the capital city of Dhaka. This site lies between N $24^0$23'4" and N $24^0$23'16" and between E $89^0$44'33" and E $89^0$44'51". The proposed location of Sirajganj 225MW CCPP project (2nd Unit-Dual Fuel) is shown below:



The following equipment will be required for 225MW CCPP project (2nd Unit-Dual Fuel): :

1) Gas Turbine
2) Steam Turbine
3) Generators
4) Heat Recovery Steam Generator (HRSG)
5) Gas Booster Compressor
6) 230kV Switchyard in Power Plant area
7) Extension of 230kV bay at the existing Sirajganj 230kV Switching station
8) Underground 230kV transmission line for power evacuation
9) Water treatment system
10) Cooling Water System
11) Stacks (main and bypass)

Natural gas or High Speed Diesel will be used as fuel for Gas turbine which will be coupled with Generator to produce 150MW at 11kV voltage level. The exhaust temperature of gas turbine will be about 500-600 degree Celsius. The exhaust gas with high temperature will be passed through **Heat Recovery Steam Generator (HRSG)** in which **groundwater (abstracted by 4 deep tube wells)** will be fed after treatment (demineralization & desalination) to produce the steam and then the steam will be passed through steam turbine coupled with generator to produce electricity of about 75MW at 11kV voltage level. Apart from process water, groundwater will be also used for cooling purpose, firefighting, drinking and other power plant use.

The temperature of the flue gas will be about 90 degree Celsius. The flue gas will be discharged to the atmosphere through a main stack of adequate height.

The output voltage of the generators will be stepped up to 230 KV through a step-up Transformer, to be installed close to generator outlets. This high voltage (230 KV) supply will be connected to the existing 230KV Switching Station of PGCB through 230KV cables of required specifications.

The estimated cost for the proposed Sirajganj 225MW CCPP (2nd Unit) is about Bangladesh **Taka 24,868 (Twenty Four Thousand Eight Hundred Sixty Eight)** million only.

The proposed 2nd unit project will be implemented in **30 months** commencing from August 2014 and construction will be completed by January 2017. The expected date of commissioning of the plant is February 2017.

4.0 Existing Environment-Physical:

4.1 Climate:

Climatic conditions of the study area were collected from the Meteorological Department at Dhaka and Bogra.

a. Rainfall:

During the monsoon (June to September), wind direction from the southwest brings moisture laden air from the Bay of Bengal, when the heaviest rainfall occurs. .The maximum rainfall of **2157mm** occurred in the year **2004** and the maximum rainfall of **732mm** occurred in the month of **June 2007.**

b. Temperature:

Maximum temperature of **40.5^{0}C** was observed in May, 2007 and minimum temperature was **5.3^0 C** in January, 2003.

c. Relative humidity:

The maximum average Relative Humidity recorded by Meteorological Department, Bogra station was about **85%** between July and September and the minimum average Relative Humidity recorded by Meteorological Department, Bogra station was about **60%** in February and March**.**

d. Wind speed:

The maximum wind speed of **5.5 knots** prevailed during September, 2009 flowing from East to West and the minimum wind speed of **2.2 knots** in December 2010 from North West to South East.

e. Seismicity:

The proposed Sirajgonj 225MW Combined Cycle Power Plant (2nd Unit) project falls under **Zone-II (Moderate Damage), whose Seismic Factor is 0.05g.**

4.2 Topography and Drainage

The Sirajganj 225MW Combined Cycle Power Plant (2nd Unit) project area occupies the active Brahmaputra-Jamuna Flood Plain. The average elevation in the proposed location is about **16.75m**. The general slope is from west to east. However, attempts have been made to sandfill the land of the proposed Power Plant in almost the same level. Since the land adjacent to the Jamuna River is slightly at a lower level and the slope is from west to east, the floodwater does not stand resulting no water logging. The topography does not inhibit drainage in the project site area.

4.3 Geology & Soils:

Due to the erosion control and bank protection infrastructure, carried out by BWDB, the project area is free from Active Flood. All the sediments below this area are mainly sandy / silty of Brahmaputra-Jamuna Floodplain deposits. The thickness of these alluvial sediments is more than a km. The detailed investigation can provide the actual strata graphic sequences of the area.

The proposed site is located in Khas Barashimul Mouza of Sirajganj Sadar Thana in Sirajganj District. The proposed site is surrounded by the Jamuna Bridge on the north, Barashimul Panchasona Mouza and Saydabad Union on the west and Jamuna river on the east. The land of the proposed plant is now lying vacant.

According to the national classification, the proposed site is a part of the Brahmaputra-Jamuna River floodplain. In this region, the soil is predominantly sandy with fine silt.

4.4 Hydrology and Water Resources

The hydrological regime of the project area is governed by the Jamuna river. Historically, spills from this river were carried and sand deposited to the site. It is the main drainage channel of the area. The general runoff pattern is from west to east through the Jamuna river.

The mean monthly water level of the Jamuna river at Sirajganj gauge shows that there was

no major flood in the project area which may cause any damage to homesteads, agriculture, industries or infrastructure.

4.5 Air Quality:

Date	Sampling Point	Duration	SPM $\mu g/m^3$	SO_x $\mu g/m^3$	NO_x $\mu g/m^3$
25 /09/2013	ASP01 : In front of existing 150MW PPP	8 hours	144.12	23.10	28.45
25 /09/2013	ASP02 : In front of Main Gate of Complex	8 hours	133.25	16.65	22.15
Bangladesh Standard as per ECR 2005			200	120	100
Remarks			Within limit	Within limit	Within limit

4.5 Noise Level:

Date	Location	Time	dBA	
			Highest	Lowest
25/09/2013	NSP01: In front of existing 150MW PPP	2:00pm	86	82
25/09/2013	NSP02: In front of East Boundary Wall	2:20pm	73	69
25/09/2013	NSP03: In front of Main Gate of Power plant complex	2:30pm	61	56
	Bangladesh Standard (Industrial Zone)		Day – 75, Night - 70	

Note: Day 6am to 9pm. Night- 9pm to 6am

From the above test results, it is seen that noise level in the existing PPP location is above the Bangladesh Standard limit and other locations is below the Bangladesh Standard limit. In the existing power plant location, the noise level was measured very high because of ongoing construction work of combined cycle power plant at that time.

4.6 Jamuna River Water Quality:

Item/Parameter	Unit	At Surface	At 3 meter depth	Acceptable Limit According to ECR'97
		25/09/2013	25/09/2009	
Temperature	^oC	29.6	28.7	40^0C
pH		7.72	7.70	6.5-8.5
DO	mg/l	5.1	5.0	4.5 - 8
BOD	mg/l	1.0	1.0	50
COD	mg/l	12	10	200
Turbidity	NTU	44.8	46.2	
Chloride	mg/l	65	60	<150
TS	mg/l	230	220	2200
TDS	mg/l	170	170	150
SS	mg/l	60	50	150
EC	µmos/cm	328	321	1200
Remarks: All parameters are within limit				

4.7 Underground Water Quality:

Item/Parameter	Unit	25/09/2013	Acceptable Limit According to ECR'97
Temperature	^{o}C	28.5	20-30
pH		7.23	6.5-8.5
EC	µmos/cm	532	1200
DO	mg/l	5.1	6
BOD	mg/l	0.1	0.2
COD	mg/l	>4	4
TS	mg/l	320	2100
TDS	mg/l	270	-
SS	mg/l	50	150
Iron	mg/l	0.26	0.1-2.0
Arsenic	mg/l	Nill	0.05
Turbidity	NTU	8.2	10
T-Hardness	mg/l	160	200-500
Chloride	mg/l	78	150-600
Remarks: All parameters are within limit			

5.0 Existing Environment-Ecological

The project site is located in rural area. As the project area is in char land, there is no natural vegetation or forest cover within the project area. However, appropriate mitigation program should be undertaken to protect the existing ecosystem from gaseous emissions and water discharge from the proposed power plant.

Terrestrial Flora:

Terrestrial plants found during survey in and around the project area, on homesteads, roadside and agricultural lands have been listed. The project area provides major species of natural plants including herbs, shrubs, grasses and plants which are important both economically as well as for environmental sustainability of the area. The flora in and around the project area are dominated by the fruit plants, flower and ornamental plants.

The common fruits are the **mango, jackfruit, banana, papaya, guava, lemon, coconut, palm, tamarind, ata (*Anama reticulata*), karamcha (*Carissca carandas*), safeda (*Achras sapota*), wood apple, lichi, plums, watermelon, sweet melon etc. Non-fruit plants are arjun (*Terminalia arjun*), sandal tree, banayan tree, krishnachura (*Delonix regia*),** palash etc. Rose, kamini, champa (*Michelia champa*) etc. are available. The area produces good amount of vegetables and spices of which eggplant, okra, coriander, potato, pointed gourds, gourds, long beans, country beans, chilly, cabbages, bitter gourds etc. are worth mentioning.

Terrestrial Fauna

The animals found 1 km around the site include a total of **103** species -- **24** species of mammalian animals, **58** species of birds, **15** species of reptiles, and **6** species of amphibians. Of these, the animals given on the 2013 Red List of the International Union for Conservation of Nature (IUCN) contain 8 species of mammalians, 36 species of birds, 5 species of Reptiles and 4 species of Amphibians fall under the category of Least Concern (LC). 1 species of Retiles is near threatened, 1 species is Vulnerable and 1 species is Data Deficient.

Aquatic Flora

The freshwater dependant plants such as halencha (*Altermanthere philoxeroides*), kalmi (*Ipomoea aquatica*), dolkalmi (*Ipomoea fistulosa*), ichadal (*Potamo seton*) and water hyacinth (*Eichhomia crassipes*) are common in the ponds, borrowpits, ditches, canals and rivers around the project area. Khude pana (*Lemna minor*), topapana (*Pistia stratiotes*) and chaicha (*Saipus articulatus*) are also common.

Aquatic Fauna

Available fisheries resources in the Jamuna river and surrounding water bodies were assessed. In this area, several carp, catfish, perch, shrimp/ prawn species were found. Specially, presence of Gangetic River Dolphin (an highly endangered species of wildlife) in Jamuna river is reported by local people.

6.0 Existing Environment- Socio-Econimc:

The socio-economic information/data have been collected from secondary sources. Sources of secondary data are different official records and published reports of Bangladesh Bureau of Statistics (BBS), Population Census Reports and also reports of other organizations.

Total Population of Sirajgonj Sadar Upazilla is 5,55,155 out of which male 2,79,113 and female 2,76,042. Muslims are 95,16%, Hindus 4.80% and others 0.04%.

The overall literacy rate of Sirajganj Sadar upazila is **56%.**

The main occupations of the people of Sirajganj Sadar upazila are as follows:

a)	Agriculture	-	25.17%
b)	Agricultural labourer	-	15.76%
c)	Wage labourer	-	4.37%
d)	Commerce	-	16.09%
e)	Service	-	12.55%
f)	Weaving	-	6.10%
g)	Transport	-	3.53%
h)	Industrial labourer	-	4.12%
i)	Others	-	12.31%.

The proposed project site falls within the Lower Brahmaputra-Jamuna Floodplain area of National Classification. Aggricultural products have become the prime economic activity in the area. The farmers are cultivating HYV Boro and HYVT, Aman, vegetables, chilly, eggplant, beans, cauliflower, cabbage, radish, carrots etc. Banana and sugar cane are also cultivated. HYVT Aman is cultivated in Kharif season and HYV Boro in Rabi season.

Main crops are Paddy, jute, wheat, mustard seed, sugarcane, onion, garlic, potato, sweet potato, chilli and ground nut etc. and Main fruits are Mango, jackfruit, black berry, papaya, guava, coconut, palm, date, olive, bel, tetul and banana etc.

There is Sirajganj Zila Sadar Hostptal located at Sirajganj town to provide public health services in the area. Apart from this Zila Sadar Hospital, there are several health centers in Sirajganj Sadar Upazila. The other health facilities available in Sirajganj Sadar upazila are as follows:

(i)	Private hospital	-	13 Nos.
(ii)	Heart disease clinic	-	1 No.
(iii)	Palli (rural) treatment centre	-	1 No.
(iv)	Satellite clinic	-	8 Nos.
(v)	Family welfare centre	-	9 Nos.
(vi)	Mother and child welfare centre	-	1 No.
(vii)	Child hospital	-	1 No.
(viii)	Eye hospital	-	1 No.
(ix)	Diabetic clinic	-	1 No.
(x)	Private clinic	-	6 Nos.
(xi)	Sandhani donor club	-	1 No.
(xii)	Diagonistic Centre	-	17 Nos.

Different NGOs like BRAC, Proshika, NGO Forum, Manabmukti, TMSS etc. are conducting awareness raising programs on different health services as well as hygienic promotion

activities through their sanitation programs. Department of Public Health Engineering (DPHE) is providing sanitary latrines, ring slab toilets through sanitation health program from their Upazila office. They are providing arsenic free water supply to the people of the area.

Road transport, railway communication and river transport are available in the area. On the northern side of the project area Dhaka – Sirajganj - Bogra national highway, on the eastern side river communication through Jamuna River and on the western side through Saydabad railway station easy communication with the site is established. Since the Jamuna River is adjacent to the project area, the river communication is an additional advantage. In Sirajganj Sadar Upazila, there are 125 km pucca road, 345 km mud road, 15 nautical mile waterways, and 23 km railways.As a result, road, railway and river communication and consequently, transportation system with the project area is well established.

Sirajganj Sadar has one cultural heritage under Antiquities Act .XIV (1968)） *Archaeological heritage and relics* Elliot Bridge or *Lohar Poll* (iron bridge) built in 1893. Jamuna Bridge is another important heritage of the District. If evidence of any other ancient heritage or any archeological symbol is found during execution of the project, actions will be taken in accordance with relevant GOB acts and rules.

7.0 Potential Environmental Impacts and Mitigatory Measures:

a. Construction Phase:

Factor	Potential impact	Planned environmental mitigation measures
Inflow of workers	▪ Generation of sewage and refuse	▪ Installation of sewage treatment facilities ▪ Can and bottle refuse is classified and are supplied to a third party for reuse ▪ Disposal at a predetermined disposal site.
	▪ Outbreak of diseases	▪ Installation of sewage treatment facilities ▪ Installation of medical facilities and implementation of periodic health checkups ▪ Education and training on health management of the workers ▪ Prevention of epidemics among workers (HIV/AID, dengue fever, malaria, hepatitis A) ▪ Elimination of potential breeding site for harmful insects, provision of preventive medicine as necessary
	▪ Safety, accident prevention, land traffic	▪ Use of Bus for worker ▪ Avoidance of the time when students travel between school and home ▪ Reduction of vehicle speed in resident areas and close to schools ▪ Observation of traffic regulations, installation of traffic signs, and education on driving safety ▪ Implementation of safety program(traffic sign, speed limit, lighting of track, load restriction, checkup of auto parts (brake, klaxon)
	▪ Employment, income, livelihood, vulnerable groups, uneven distribution of benefit	▪ Priority of employment for local residents, development of employment standard ▪ Utilization of local service (cleaning, catering, materials) ▪ Implementation of the preliminary education and training programs with local authority
	▪ infrastructure	▪ Installation of medical facilities
Installation of	▪ Safety, accident prevention,	▪ Avoidance of the school commuting time ▪ Reduction of vehicle speed in resident areas and close to schools

Factor	Potential impact	Planned environmental mitigation measures
construction equipment	land traffic	▪ Observation of traffic regulations, installation of traffic signs, and education on driving safety ▪ Implementation of safety program(traffic sign, speed limit, lighting of track, load restriction, checkup of auto parts (brake, klaxon)
	▪ Noise	▪ No traffic at night
	▪ Gas emission, flying sand and dust particles from vehicles	▪ Periodic inspection and maintenance management ▪ Periodic check of the concentration of vehicle emissions based on laws and regulations ▪ Stop the engine when idling ▪ Use of a cover to protect against dust, and periodic washing of vehicles ▪ Periodic cleaning of the surrounding roads ▪ Monitoring of resident areas
	▪ River traffic	▪ BIWTA will be consulted to determine appropriate safety and/or scheduling standards to be followed.
Excavating work and operation of construction equipment	▪ Emission gas from machinery/sand and dust dispersion	▪ Periodic watering of sediment disposition site and such ▪ Monitoring in residential area
	▪ Noise	▪ Operation in daytime only in principle ▪ Use of low-noise machinery (silencer, muffler) ▪ Construction of temporary fence around Project site ▪ Restriction of worker's prolonged exposure to noise ▪ Use of Personal Protective Equipment (PPE)
	▪ Construction debris	▪ Waste management program consisting of reduction, reuse, and recycling of materials. ▪ Prohibition on dumping of any contaminating material ▪ Appropriate segregation of waste and disposal into designated disposal site
	▪ Soil runoff, turbid water, waste water from equipment cleaning	▪ Installation of temporary settling tanks and sediment fencing ▪ Water used for equipment cleaning is collected in the temporary tank and treated before discharge ▪ Monitoring at the water outlet
	▪ Leakage of harmful substances	▪ Mitigation measures to prevent leakage, installation of cleaning facility
	▪ Loss of habitat of flora and fauna	▪ Installation of green buffer
	▪ Income, livelihood, vulnerable group	▪ The agricultural products growing on the site is compensated according to the Bangladesh regulation. ▪ Explanation of the construction extent and procedure in the early stage. ▪ Preferentially employ local people predicting decrease in income.
	▪ Safety, accident prevention, land traffic, infrastructure	▪ Develop a safety management plan and rules ▪ Swift transport to medical facility ▪ Observation of traffic regulations, installation of traffic signs, and education on driving safety ▪ Reduction of vehicle speed in resident areas and close to schools

Factor	Potential impact	Planned environmental mitigation measures
		▪ Installation of bypass for farm road and waterway within the site
Water intake	▪ Lowering of groundwater level ▪ Ground subsidence	▪ Monitoring of underground water level in the surrounding wells ▪ Dig deeper wells as necessary ▪ Monitoring of underground water level in the surrounding wells
Jetty construction	Sediment outflow, turbid water • River traffic • income, Livelihood	▪ Construction of jetty will adopt vertical piles type to minimize the dredging area ▪ Dredging activities will occur during dry season when water levels and flow are the lowest. ▪ Adoption of dredging method that minimizes environmental effect ▪ Use of the floating siltation curtains where appropriate. ▪ Dredged materials will be landed and dried on-site. ▪ Installation of sediment fencing ▪ Conduct dredging activity during dry season with less traffic ▪ Minimization of jetty construction area ▪ Explanation of the construction extent and procedure in the early stage.

b. Operation Phase:

Factor	Potential impact	Planned environmental mitigation measures
Power generation	▪ Generation of gas emissions	▪ Adoption of a high stack ▪ Installation of a continuous monitoring system for gas emissions ▪ Adoption of pre-mixing method and a low-NOx combustor ▪ Monitoring of atmospheric air ▪ Periodic maintenance and management
	▪ Generation of cooling and waste water	▪ Construction of open channel for a distance for cooling the hot water ▪ Installation of a wastewater treatment system capable of coagulation sedimentation, neutralization, and oil separation ▪ Monitoring of waste water ▪ Monitoring of the river or local water ▪ Blow-off water from cooling tower is cooled by dilution
	▪ Generation of noise and vibration	▪ Planting trees around the power plant ▪ Adoption of low-noise type machinery and installation of soundproofing covers ▪ Installation of low-vibration type machinery and the use of rigid foundations ▪ Periodic maintenance and management ▪ Monitoring around the border of the site and residential area ▪ Distribution of ear protectors to employees
Water intake	▪ Lowering of Groundwater level ▪ Ground subsidence	▪ Monitoring the underground water level in the surrounding wells ▪ Did wells of appropriate deepness as necessary
Generation of waste	▪ Generation of sludge from the	▪ Waste management program consisting of reduction, reuse, and recycling of materials. ▪ Systematic collection and protected-storage on-site

Factor	Potential impact	Planned environmental mitigation measures
	wastewater treatment system ▪ Generation of waste oil ▪ Generation of domestic waste	▪ Prohibition on dumping of any contaminating material ▪ Waste away from the site and their appropriate disposal in a designated municipal dumping site.
Presence of power plant, inflow of workers	▪ Loss of habitat of flora and fauna ▪ Employment, livelihood, vulnerable people, uneven distribution	▪ Provision of vegetated buffer ▪ Preferential employment of local people ▪ Utilization of local service (cleaning, catering) and materials ▪ Implementation of the preliminary education and training programs with local authority
	▪ Land traffic	▪ Use of Bas for worker ▪ Observation of traffic regulations, installation of traffic signs, and education on driving safety ▪ Speed limit in residential- and school area
	▪ Social foundation ▪ Diseases	▪ Provision of emergency medical facility ▪ Medical facility and periodical health checkup ▪ Education and training on health management of the workers
	▪ Accident and safety management	▪ Tank storage areas will be equipped with oil spill bank and countermeasure for underground oil seepage and designed as physical containment area. ▪ Implement gas leakage prevention procedures and have available on-site all preventive equipment and materials as part of the process of developing emergency plan. ▪ Fire protection equipment and facilities shall be made available at suitable locations in power plant including fixed fire protection system, fire hydrants, portable fire fighting equipment, fire vents, alarm system, fire compartments and fire exit signs. Preparation of safety standard.
Presence of jetty	▪ River traffic, land use, livelihood	▪ Develop an appropriate maintenance and management schedule

8.0 Environmental Management Plan (EMP) and Monitoring Plan:

a. Construction Phase:

Item	Parameter	Place	Frequency
Air quality	SPM, SO_2, NO_2	Residential areas and schools	Monitor SPM every two weeks, and SO_2 and NO_2 every two months.
Water quality	TSS	Drain outlet	Every month
Noise	Noise level	Residential areas and schools	Every week when the amount of construction work is maximized
Underground water	Underground water level Water temperature, heavy metals, As, etc.	Residential area	Twice/year (dry season and rainy season)

b. Operation Phase:

Item	Parameter	Place	Frequency
Gas emission	SPM, SO_2, NO_2	Flue	Monitor SO_2 and NO_2 on a continuous basis (by a continuous monitoring system), and SPM every month.
Air quality	SPM、SO_2, NO_2	Residential areas and schools	Monitor SO_2 and NO_2 every month, and SPM every two months.
Waste water	Water temperature, DO, SS, oil, BOD, and heavy metals	Drain outlet	Every two months
Water quality	Water temperature, DO, SS, oil, BOD, and precious metals	River	Twice a year (dry and rainy seasons)
Noise	Noise level	On the border of the site and in the residential areas	Twice a year
Underground water	Underground water level Water temperature, heavy metals As, etc.	Residential area	Twice/year (dry season and rainy season)

9.0 Risk Assessment and Management:

Risk Assessment:

The process of electricity generation from oil or gas is by no means risk free because of high temperature and pressure conditions within the plants, rotating machineries and high voltages involved. Apart from risks associated with emissions, noise generation, solid waste, hazardous waste and wastewater disposal as a result of construction and operation, the oil/gas fired power plants put human beings and the environment inside and outside of the plant to a certain degree of risk of accident and sometime loss of life. It is therefore essential that a risk management plan should be devised in order to both reduce risk of accident and to take the correct action during accidents. Important risks of accidents in thermal power plants leading to disasters or emergency situations may occur during following events:

- Risks during emergency: Fire, Explosion, Oil/acid spillage, Toxic chemical spillage, Electrocution
- Risks due to natural disasters: Flood, Cyclone, Earthquake, Storm, Lightning,
- Risks due to external threats: Sabotage, War situation, Water/food poisoning

In power plants, accidents can occur at two different levels. First, these may occur due to fires, explosions, oil or chemical spillage and spontaneous ignition of inflammable materials. In such events, operators working inside the plant and at various strategic hazard locations will be affected.

Second, risks are also associated with external threats of sabotage. Failure of automatic control/warning systems, failure of fuel oil storage tanks and chemical release from acid and alkali stores and handling also pose great degree of associated risks.

Risk Management:

As mentioned earlier, in order to reduce the risks associated with accidents, internal and external threats, and natural disasters, a risk management program is essential. Risk management planning can be done during design and planning stage of the plant as well as during plant operation. While risk management is mainly preventive in nature during the plant operation stage, the design and planning stage of the plant can incorporate changes in basic engineering to include safety design for all processes, safety margins for equipment, and plant layout. The following steps among others are important in managing the risks mentioned.

- Gas storage is to be designed with adequate precautions in respect of fire hazard control.
- Storage of hazardous substances such as acids and alkalis should be sited in protected areas.
- With respect to plant operation, safe operating procedures should be laid down and followed to ensure safety, optimum operation and economy.
- A fire fighting group with adequate manpower and facilities such as water tank of sufficient capacity, C02 tank, foam tank, portable fire extinguishers should be provided and facilities located at strategic locations e.g. generator area, high voltage panel, control rooms, and fuel tank area.
- Regular checks on safe operating practices should be performed.

In order to achieve the objective of minimizing risks at the Sirajganj power plant , the unit will be trained to act in a very short time in a pre- determined sequence to deal effectively and efficiently with any disaster, emergency or major accident to keep the loss of life, human injury, material, plant machineries, and impacts on the environment to the minimum.

10.0 Public Consultations:

Survey has been conducted in the adjoining areas of the proposed site for new power plant in two ways – i. Quantitative approach and ii. Qualitative approach. For quantitative approach, standard questionnaire (socio economic and environmental issues) has been used for interviewing randomly selected respondents in the proposed area. On the other hand, for qualitative approach, focus group discussion guidelines have been followed.

For Quantitative approach, 150 respondents have been randomly selected from the adjacent villages, Char Panchasona, Char Bara Simul, Punarbashan and North Saydabad of Saydabad union under Sirajgonj Sadar upazila.

For Qualitative approach, two Focus Group Discussions – one for adjacent villagers and another for community leaders were conducted in the proposed area. Apart from FGDs, in-depth interview was conducted with local administrative authorities and public representative.

Findings of General Interview:

- Crops get affected due to air pollution (no fruits are produced)
- Noise/vibration from the existing power plant makes sleeping problem at night
- Exhaust gas emissions from the existing power plant causes respiratory diseases
- It will be better if the new power plant is established..
- The wastes have to be managed properly so that there are no negative impacts on the water or to the environmental.
- The authority must make sure that the local people get a good supply of electricity.
- As the rate of electricity generation will increase, the rate of load shedding will decrease.

Findings of FGD:

The respondents addressed that there is a severe case of noise pollution from the 150 MW Peaking Power Plant. This is the reason why people cannot sleep properly at night. This also causes seismic movements of the lands. Emitted smog from the power plant mixes with the air and causes air pollution as well. They complained that they cannot directly use the generated electricity from this power plant. They also added that if their area gets sufficient supply of electricity then there will be a rapid economic growth in their area. Their embroidery sector is not getting sufficient electricity from the Polli Biddut, so they think that if this sector gets sufficient supply of electricity, then it will flourish and will bring about a rapid and positive economic change to their area.

In recent times, the number of trees and plants in this area is beyond the level of satisfaction, because the people of this area are very interested in planting trees and keeping it "green." Currently, the number of trees are more compared to what was found nearly 15-20 years back, and the reason behind this is because there were less number of people living in this area at that moment. As the number of population increased, the number of trees also increased over the years. Mango, Jaam, Jackfruit, Papaya, Mahogany, Eucalyptus and Guava are found in huge quantities at the moment.

But, some trees have decreased in this area, like the Taal Gaach. The use of mammals like Buffalo and Horses does not exist over here at the moment .Siting of birds like vulture, owl and eagle are rare these days. In case of fishes, the numbers of kaunia and pabda fish have decreased.

At the end of the meeting the respondents added that they don't want any negative environmental impacts in their area. They want the authority to keep a close eye on the fact that there is no possible air or water pollution from the power plant site. However, they are really looking forward to the establishment of this power plant, because there still is a major lacking of electricity in this country.

Findings of In-Depth Interview:

a. Local administrative officials:

All the officers of Sirajgonj Sadar Upazilla have come into an agreement to generate more power in Saydabadh. They also added that Sirajganj 225 MW CCPP (2nd Unit) will further enhance the national power grid supply which will be beneficial for the people. The reason behind this energy supply is "to stay in accordance with the technically updated world". "Nothing is possible to achieve without electricity in this digital era, "All the resources of our country rely on electricity". "It is very important to establish new power plants in order to improve the current situation of the people in our country". Everyone agreed in terms for the establishment the power plant. And lastly they also reassured that there are no presence of any environmental hazards; emitted from the power plants.

b. Local Public representatives

Sirajgonj Sadar upazilla chairman, chairman of Union parishad, member of Union parishad, is the peoples representative and an NGO representative. All of them are residents of the local area. According to them if another 225MW CCPP (2nd Unit) is constructed in Saydabad Area, this will increase the national grid power supply and this grid electricity can be supplied to any region of the country if required. As a result, the entire nation will be benefited. This will improve our current issue regarding load shedding. This electricity can also be used in various small, medium and large industries. As a result our economic condition will improve. This area is rich in the art of embroidery. So, if this electricity can be utilized for further enhancement in the field of embroidery. then more people can be employed. If more power is produced, then this will create more opportunities for the people to get employed. But this is true that till now, the plants, animals and aquatic mammals of this area are free from any environmental hazards. Any sort of negative environmental impact is yet to take place in this area. They also added that, in this technologically modern era, it is quite impossible to develop our economic condition without electricity. In order to maintain the on going development process, electricity is very important so more power plants needs to be established. We also have to keep in mind that this project does not affect the environment by any means. They also added that the waste should not pollute the water as well.

11.0 Conclusions & Recommendations:

Conclusions:

In this study, the effects of the project activities on physico-chemical, ecological and socio-economic (i.e., human interest related) parameters during both construction and operation phases have been assessed. The impacts have been identified, predicted and evaluated, and mitigation measures suggested for both construction and operation phases of the proposed power plant. The important physico-chemical environmental parameters that are likely to be affected by the project activities include air and noise pollution.

The study suggests that most of the adverse impacts on the physico-chemical environment are of low to moderate in nature and therefore, could be offset or minimized if the mitigation measures are adequately implemented. Since the project site is located in a developed area that does not appear to be very sensitive ecologically, the impact of project activities on most ecological parameters (e.g., wet lands, homestead vegetation, forest cover, bushes and trees, wild life, species diversity) are mostly insignificant.

Some adverse impact during the operation phase of the plant will come from NO2 and SO_2 emission from the power plant. However, the effect of increased NO2 and SO_2 in the ambient air due to emission from the proposed power plants will not be very significant.

Noise level has been identified as significant potential impact of the proposed power plant during both the construction and operation phases. The noise generated from construction activities during the construction phase might become a source of annoyance at the residential area close to the project site. However, since residential areas are located away from the site and the trees and boundary walls will have some damping effect, the noise level is expected to come down to tolerable levels within residential area

It is concluded from ground water modeling study that the natural aquifer condition in the study area would be suitable for supplying 30000 m^3/day of water continuously without any permanent lowering of groundwater table and environmental degradations. Jamuna River invariably fully recharges the aquifer in the wet season of each year preventing any adverse effect on the natural condition of the project area.

There is no need for land acquisition. Additionally, there is no settlement in this designated area. Therefore, no population will be displaced and no resettlement will be required for the construction of the power plant.

During operation phase, no significant negative impact is anticipated on socio-economic environmental parameters.

During public consultations carried out as a part of the EIA study, people welcomed the proposed power plant project at Sirajganj. However, they recommended installing a plant of good quality, which will be able to provide uninterrupted power during peak hours and will be able to keep anticipated air and noise pollution to a minimum level.

Recommendations

The environmental assessment carried out for the proposed Sirajganj CCPP (2nd Unit) suggests low to moderate scale of adverse impacts, which can be reduced to acceptable level through recommended mitigation measures as mentioned in the EMP. It is therefore recommended that the proposed Combined Cycle Power Plant may be installed, provided the suggested mitigation measures are adequately implemented. It is also recommended that the environmental monitoring plan be effectively implemented in order to identify any changes in the predicted impacts and take appropriate measures to off-set any unexpected adverse effects.

Apart from risks associated with emissions, noise generation, solid waste, hazardous waste, cooling and wastewater disposal as a result of construction and operation activities, the power plant put human beings and the environment inside and outside of the plant to a certain degree of risk of accident and sometime loss of life. An emergency response plan (ERP) for the proposed power plant has been developed listing various actions to be performed in a very short period of time in a pre-determined sequence if it is to deal effectively and efficiently with any emergency, major accident or natural disaster.

CHAPTER 1: INTRODUCTION

1.1 Background

Under Power Sector Reform Program, generation, transmission and distribution branches are being separated from the mother organization, Bangladesh Power Development Board (BPDB), and in the process, North West Power Generation Company Limited (NWPGCL) has been created for construction, operation and maintenance of power generation facilities in the North-Western Zone of the country.

The present installed capacity of electricity in Bangladesh as of July 2013 is **8537MW** out of which maximum **6675MW** power was generated in July 2013. As per Power system Master Plan (PSMP) 2010, Country's maximum electricity demand is **8349MW in 2013**, **9,268MW in 2014** and **10,283MW in 2015**. So there is huge shortage of power in Bangladesh. According to power generation development plan of the Government of Bangladesh, NWPGCL has constructed two dual fuel 150MW peaking power plants at Khulna and Sirajganj respectively with the financial assistance from Asian Development Bank (ADB). NWPGCL is also constructing one 360MW combined cycle power plant at Bheramara, Kushtia with the financial assistance from Japan International Cooperation Agency (JICA). Both 150MW Peaking Power Plants have been converted into 225MW combined cycle power plant. Still this is not enough to meet the increasing demand of electricity. So, it is advisable to install another 225MW combined cycle power plant (2nd unit) at Saydabad, Sirajganj beside 150MW Peaking power Plant converted into 225MW combined cycle power plant for minimizing the power shortage.

Keeping this in mind, NWPGCL has planned to construct another 225MW Combined Cycle Power Plant (2nd Unit) at Saydabad under Sirajganj district beside the 150MW Peaking Power Plant upgraded to 225MW CCPP with the bidder's finance.

In order to implement this plan, NWPGCL requires to conduct the Environmental Impact Assessment (EIA) to comply with the Environmental Laws of Bangladesh. As the first step of the project development, an Initial Environmental Examination (IEE) and Environmental Impact Assessment (EIA) will be required to be completed to comply with Environmental Laws of Bangladesh. Also ADB Environment Policy 2002 and ADB Environmental Assessment Guidelines 2003 should be followed for assistance for this project.

Presently, environmental conservation is being given top priority worldwide. In Bangladesh also, for any new project, as well as plants under operation, it is mandatory to obtain environmental clearance from the Department of Environment (DoE), under Environment Conservation Act 1995, amended from time to time. According to Bangladesh Environment Conservation Rules 1997 (ECR), power plants come under the Red category, so far as environmental impact is concerned. Initial Environment Examination (IEE) followed by Environmental Impact Assessment (EIA), including Environmental Management Plan (EMP) are required for these types of installations for getting environmental clearance from DoE.

NWPGCL has initiated the environmental clearance from DoE and in the process, the company has applied to DoE to exempt IEE study and approve the TOR for EIA study. DoE has exempted IEE study and approved the TOR for Envirnmental Impact Assessment (EIA) for the proposed 225MW combined cycle power plant (2nd unit-duel fuel) at Saydabad under Sirajganj district. (Please refer to **Annex-1.1** for exemption of IEE studies and approval of TOR for EIA study). NWPGCL has engaged **Engineers Associates Limited (EAL),** an experienced firm for such

activities, for preparation of EIA for the project in accordance with the Terms of Reference given in **Annex-1.1.**

1.2 Brief Description

The configuration of the proposed Sirajganj 225MW Combined Cycle Power Plant (2nd Unit-Dual Fuel) is multi shaft 1:1:1 consisting of one gas turbine, one HRSG and one steam turbine with by-pass stack for GT single operation. Natural Gas is the main fuel and HSD oil as alternative fuel. The net output of the power plant will be from 200MW to 250MW.

The following equipment will be required for 225MW CCPP project (2nd Unit-Dual Fuel):

1) Gas Turbine
2) Steam Turbine
3) Generators
4) Heat Recovery Steam Generator (HRSG)
5) Gas Booster Compressor
6) 230kV Switchyard in Power Plant area
7) Extension of 230kV bay at the existing Sirajganj 230kV Switching station
8) Underground 230kV transmission line for power evacuation
9) Water treatment system
10) Cooling Water System
11) Stacks (main and bypass)

Natural gas or High Speed Diesel will be used as fuel for Gas turbine which will be coupled with Generator to produce 150MW at 11kV voltage level. The requirement of Natural Gas for this proposed Power Plant is about **35mmcfd.** Natural Gas will be supplied to the proposed power plant by Paschimanchal Gas Distribution Co. Ltd. of Petrobangla.

The exhaust temperature of gas turbine will be about 500-600 degree Celsius. The exhaust gas with high temperature will be passed through **Heat Recovery Steam Generator (HRSG)** in which groundwater will be fed after treatment (demineralization & desalination) to produce the steam and then the steam will be passed through steam turbine coupled with generator to produce electricity of about 75MW at 11kV voltage level. The temperature of the flue gas will be about 90 degree Celsius. The flue gas will be discharged to the atmosphere through a main stack of adequate height.

The output voltage of the generators will be stepped up to 230 KV through a step-up Transformer, to be installed close to generator outlets. This high voltage (230 KV) supply will be connected to the existing 230KV Switching Station of PGCB through 230KV cables of required specifications.

Schematic diagram of a typical combined cycle power plant is shown in **Figure-1.2.**

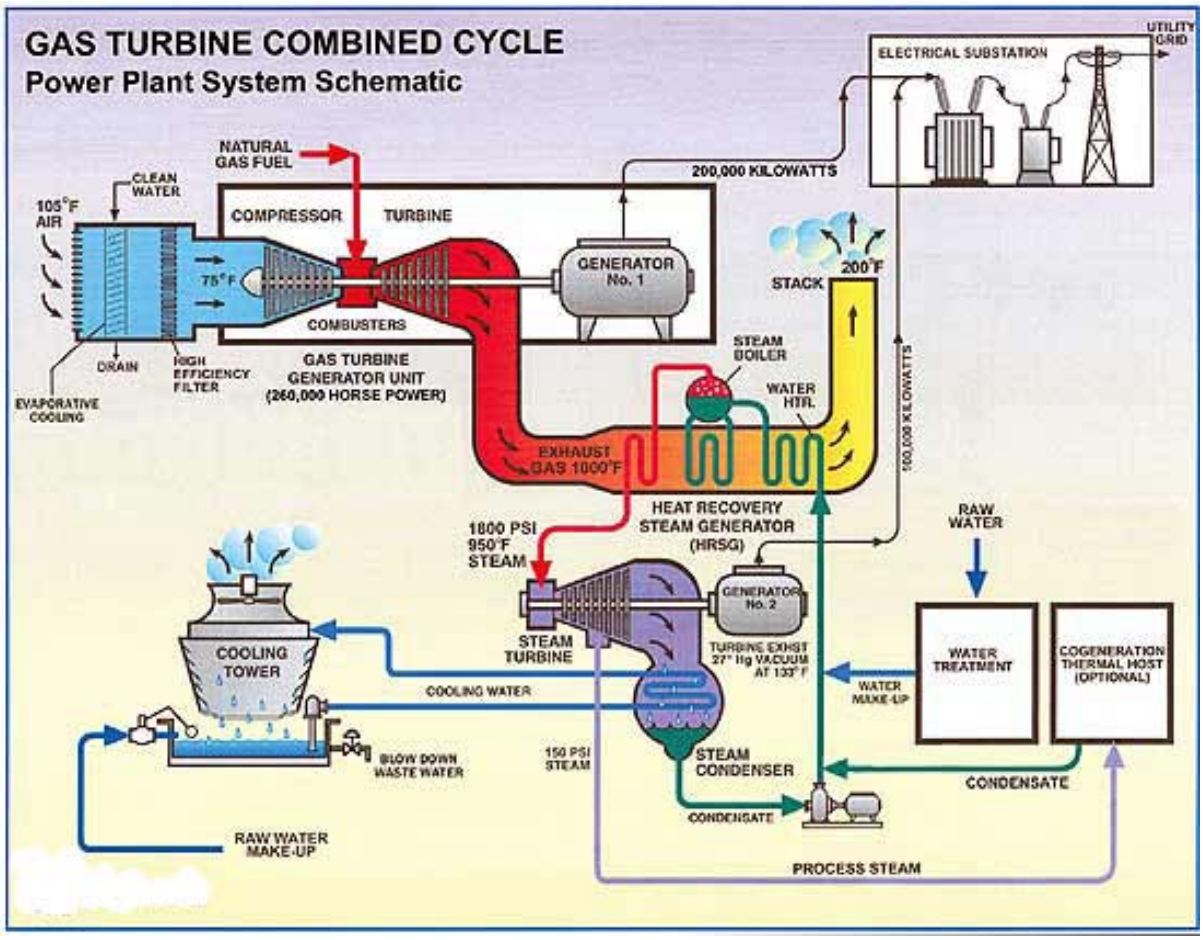


Figure 1-2: Schematic diagram of a typical combined cycle power plant

Total Water requirement (process water, cooling water etc.) of this proposed power plant is about **600m3/hour**. It is intended to abstract ground water to meet water requirement of the power plant.

1.3 Scope of Study

Department of Environment, (DoE), Bangladesh has categorized Power plant as Red category industry, which requires Environmental Impact Assessment (EIA) Study to assess the impacts of the power plant in the surrounding area of the plant and suggest the mitigation measures, environment Management / Monitoring Plan etc. So, the scopes of this study include but not limited to the following:

- Study of the relevant documents on policy, legal and administrative framework and their review, particularly on environmental aspects and effluent discharge limits, health and safety requirements, identification of sensitive areas and endangered species, land use etc.
- Carrying out an environmental baseline survey covering areas in and 2 km around the project site i.e. Study Area.
- Identification of major project activities, both during construction and operational phases of the project.

- Identification and prediction of environmental impacts of project activities on the surrounding environment, including cumulative impacts of the proposed power plant and the existing and ongoing projects/industries on selected environmental attributes.
- Identification of the most significant environmental and social impacts and suggestions for mitigation measures in order to reduce/eliminate negative impacts and to enhance positive impacts.
- Arrangement of public consultation meetings to consult with potentially affected people.
- Development of Environmental Management Plan (EMP) for both construction as well as operational phases of the project.
- Development of Corporate Environmental Policy for the project authority regarding environmental protection and sustainability.
- Identification of environmental and health risks associated with major accidents, natural disasters and external threats and recommendations for measures to be taken for reduction of these risks.

1.4 Study Area

The proposed Sirajganj 225MW Combined Cycle Power Plant (2nd Unit- Dual Fuel) is located in Barashimul Mouza of Saydabad Union of Sirajganj Sadar Thana under the District of Sirajganj. The area is located about 15 KM south-east of Sirajganj town. The Jamuna Multipurpose (Bangabandhu) Bridge is on the north of the site, Khas Barashimul village on the south, Jamuna river on the east and Saydabad is on the west side of the power plant site. The site is about **130 km** north-west of the capital city of Dhaka. Map of Bangladesh showing location of the proposed power station is given in **Figure-1.4(1).**

Figure-1.4(1) : Map of Bangladesh Showing Location of Proposed Power Station

The EIA study covered an area of about 2 km around the site, where the proposed plant is expected to be located. The study area is shown in **Figure -1.4(2)**

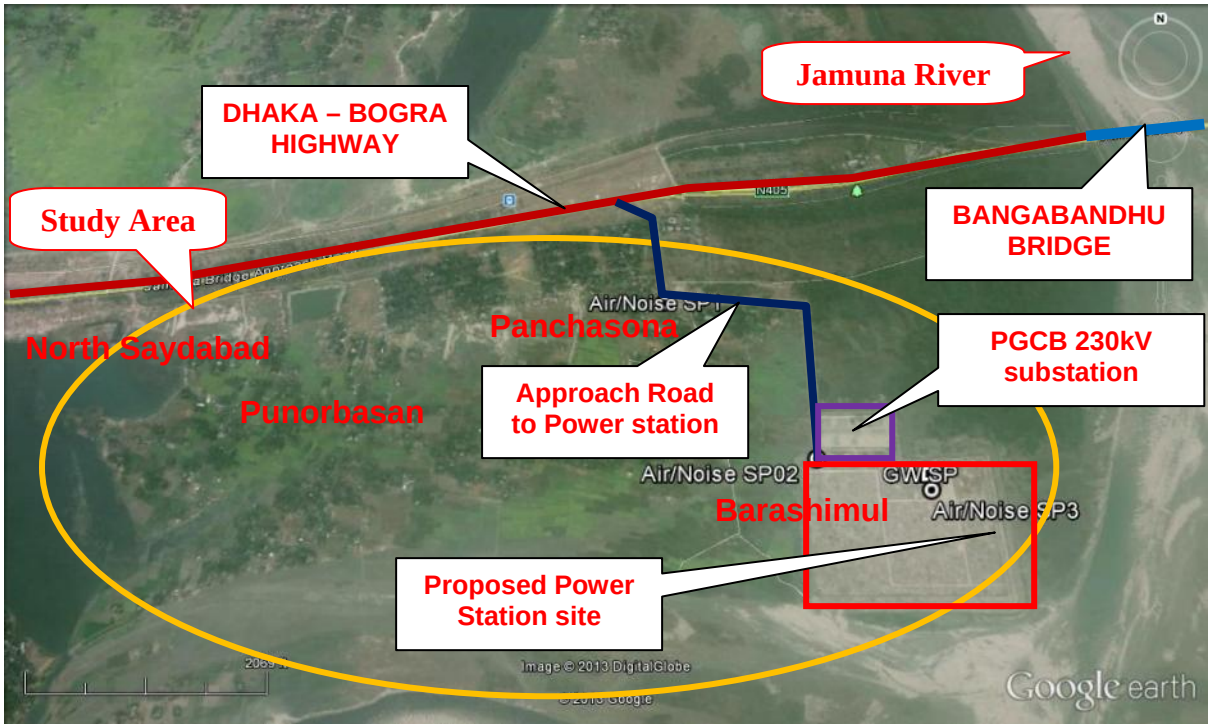


Figure 1-4(2): Satellite Image showing the Study Area

1.5 Methodology

For Environmental Impact Assessment study, the following major activities are required to be undertaken:

(a) Study of the relevant documents on policy, legal and administrative framework and their review, particularly on environmental aspects and effluent discharge limits, health and safety requirements, identification of sensitive areas and endangered species, land use etc.

(b) Carrying out an environmental baseline survey covering areas in and 2 km around the project site i.e. Study Area.

(c) Identification of major project activities, both during construction and operational phases of the project.

(d) Identification and prediction of environmental impacts of project activities on the surrounding environment, including cumulative impacts of the proposed power plant and the existing and ongoing projects/industries on selected environmental attributes.

(e) Identification of the most significant environmental and social impacts and suggestions for mitigation measures in order to reduce/eliminate negative impacts and to enhance positive impacts.

(f) Arrangement of public consultation meetings to consult with potentially affected people.

(g) Development of Environmental Management Plan (EMP) for both construction as well as operational phases of the project.

(h) Development of Corporate Environmental Policy for the project authority regarding environmental protection and sustainability.

(i) Identification of environmental and health risks associated with major accidents, natural disasters and external threats and recommendations for measures to be taken for reduction of these risks.

1.6 Study Team and Their Tasks

Study Team

A Study Team was constituted comprising of specialists on various aspects for conducting the environmental impact assessment of the project. The list of team members is given in the following table:

Sl. No.	Name of Specialist	Position
1.	Engr. Obaidul Alam, B.Sc. Engg. (EE)	Team Leader
2.	Dr. Khairul Bashar, Ph.D (Geology))	Environmental Expert-A (Natural Environment)
3.	Engr. Rama Nath Roy, Master of Engg.(EE)	Environmental Expert-B (Air, Water, Noise)
4.	Mr. Mizanur Rahman Khan	Social Environmental Expert-A (Social Environment Study)
5.	Mr. Swapan Kanti Poddar, M.Sc. (Environmental Science)	Social Environmental Expert-B (Social Investigation)

Tasks assigned

Tasks assigned to the individual experts are as follows:

Team Leader

(i) Monitor the activities of Social Environmental survey.
(ii) Monitor the activities of Natural Environmental survey.
(iii) Supervise the preparation of survey reports
(iv) Liaison with Project Director (PD) of the project.
(v) Attend meetings with concerned authorities.

Environmental Expert-A

(i) Guide the Natural Environmental survey team in conducting the survey.
(ii) Investigate and study the relevant documents.
(iii) Compile the results of Natural Environmental survey and document investigation and study.
(iv) Prepare Natural Environmental survey reports.
(v) Attend meetings with the concerned authorities.
(vi) Report to the Team Leader.

Environmental Expert-B

(i) Supervise the measurements of air quality, water quality and noise level in and around the Study Area.

(ii) Guide the Natural Environmental survey team in conducting the survey.

(iii) Compile the results of air quality, water quality and noise level.

(iv) Prepare Natural Environmental survey reports.

(v) Attend meetings with concerned authorities.

(vi) Report to the Team Leader.

Social Environmental Expert-A

(i) Discuss the outcome of all survey results with all Team Members and concerned authorities.

(ii) Summarize all survey reports.

(iii) Attend meetings with concerned authorities.

(iv) Report to the Team Leader.

Social Environmental Expert-B

(i) Develop questionnaire for social survey.

(ii) Organize Focused Group Discussions (FGD) in the project area.

(iii) Train the field supervisors and field investigators in conducting social survey.

(iv) Supervise social survey activities.

(v) Compile the results of survey and prepare survey reports.

(vi) Attend meetings with concerned authorities.

(vii) Report to the Team Leader.

1.7 Report Structure

This EIA report for Sirajganj 225MW Combined Cycle Power Plant (2nd Unit-Dual Fuel) has been prepared after survey of natural and social environments of the Study Area, following the Guidelines for Industries, 1997, issued by DoE and in accordance with Environmental Conservation Act and Rules. The report contains all the elements of an EIA report as required by DoE, along with some additional elements to suit the requirements of the present study.

The report is divided into the following 11 Chapters:

Chapter 1: Introduction

This chapter presents the background and a brief outline of the proposed power plant project. The chapter provides a brief description of the area covered by the present study and the methodology adopted for environmental assessment of the proposed project.

Chapter 2: Legislative, Regulation and Policy Consideration

This chapter provides a brief description of the policy and legal framework with regard to the environmental aspects of the project in the context of Bangladesh, where the regulatory requirement of conducting an environmental assessment of the proposed project has been discussed.

Chapter 3: Description of the Proposed Project

This provides a description of the different aspects of the proposed project, including project location, site development and construction activities, equipment and processes to be employed, electricity generation and transmission, gas transmission, water management,

waste and emission management, fire fighting and operation and maintenance. An environmental baseline survey has been carried out within the Study Area as part of the present study. During the baseline survey, detailed information on the existing physical, ecological and socio-economic condition of the Study Area were collected.

Chapter 4: Existing Environment - Physical

This chapter provides a description of the existing physical environment of the Study Area. The elements of the physical environment of the Study Area described here include climate, topography and drainage, geology and soils, hydrology and water resources, air quality, noise level and water quality.

Chapter 5: Existing Environment - Ecological

It describes the existing ecological environment, including the terrestrial and aquatic eco system of the Study Area and the presence of rare and endangered species.

Chapter 6: Existing Environment – Socio-Economic

The existing socio-economic condition of the Study Area has been summarized in this chapter. It provides description of the land use and utilities, demographic characteristics, education, employment and economics of the Study Area. It also briefly describes the industry, agriculture, public health and transport issues of the Study Area.

Chapter 7: Potential Environmental Impacts and Mitigation Measures

This describes the potential environmental impacts of the proposed power plant project and the mitigation measures to reduce or eliminate adverse impacts, along with measures to enhance and monitoring positive impacts. For this purpose, the project activities have been divided into two phases – construction phase and operation phase. The major environmental impacts of the project activities during each phase have been identified. This chapter then provides an evaluation of these potential impacts and presents suggested measures to reduce or eliminate adverse impacts and enhance positive impacts. An economic assessment of the impacts has also been presented at the end of the chapter.

Chapter 8: Environmental Management Plan and Monitoring

It presents the environmental management and monitoring plan for the proposed project, both during the construction and operation phases. Among other issues, it addresses the detailed monitoring plan (including monitoring parameters, monitoring schedule and resource requirements), occupational health and safety issues and institutional arrangement.

Chapter 9: Risk Assessment and Management

This chapter identifies common risks in a power plant associated with accidents that may occur, natural disasters and external threats and outlines important measures to minimize those risks.

Chapter 10: Public Consultations

It presents the findings of various consultations carried out as part of the environmental assessment, including consultation with statutory and non-statutory bodies and public consultations.

Chapter 11: Conclusions and Recommendations

This chapter presents the conclusions and recommendations of this environmental assessment study.

CHAPTER-2 : LEGISLATIVE, REGULATION AND POLICY CONSIDERATION

2.1 Overview

The proposed power plant to be implemented by NWPGCL requires strict compliance with laws, rules and regulations pertinent to environment The Department of Environment (DoE) of Government of Bangladesh is responsible for ensuring application of environmental laws and issuance of necessary-clearances in industrial and development activities.

The procedures and requirements for EIA under the power sector foreshadowed the introduction of the Environmental Conservation Act in 1995, which introduced a requirement for any proposed "Industrial Unit or project'[1] to obtain prior approval from the Department of Environment (DoE).

The Environmental Conservation Act has classified projects to be assessed (by the DoE) in three categories (Green, Amber and Red). Power development projects are allocated to the Red category, which triggers an automatic requirement for an Initial Environmental Examination (IEE) followed by a full EIA. Subject to a satisfactory review of the environmental assessment, the DoE issues an authorization for the project to proceed. The authorization consists of two parts: a "technical clearance" which approves the content of the project, and a "site clearance", which gives approval to the site proposed for the project,

NWPGCL as project proponent is responsible for carrying out an EIA study of proposed project. NWPGCL therefore, administer the environmental assessment process with the consultants and reviews the findings, then submits the documents to the DoE for review.

A key requirement of the EIA, for projects classified in the Amber and Red categories is an Environmental Management Plan (EMP). The function of the EMP is to enable the project proponent NWPGCL to show the DoE how it will deliver the environmental performance assessed in the EIA (to which DoE approval is sought). The EMP must describe in detail organization and management responsibilities, give details of how mitigation measures identified in the EIA will be implemented and explain how monitoring will be carried out.

Possession of "clearance" from the DoE does not relieve the developer of a project from the requirement to comply with other environmental regulations. In particular. Bangladesh National Environmental Quality Standards (EQS) for industrial effluent have been set and compliance is mandatory. In addition, there are statutory instruments applicable to power development project, which are not primarily environmental but which influence environmental impacts. Compliance with such statutory instruments is mandatory.

2.2 Procedure for Obtaining Site/Environmental Clearance

2.2.1 Requirement for Initial Environment Examination (IEE) Report

All industries and project in Red category have to conduct IEE which helps in understanding the potential extant of environment changes, and in finding ways to mitigate by considering the available information, of past experience or standard operating practices. The steps for conducting IEE are:

- Collection of baseline information in respect of the project and the environmental setting of the project and its site.

- Setting of boundaries of an IEE by identifying the -significant issues.
- Impact assessment suggesting mitigation measures, Environmental Management Plan (EMP) or alternative sites or other project modifications.
- In the event IEE of the project or industry reveals that further investigation is to be carried out then the sponsors will have to carry out a detailed EIA.

2.2.2 Procedure

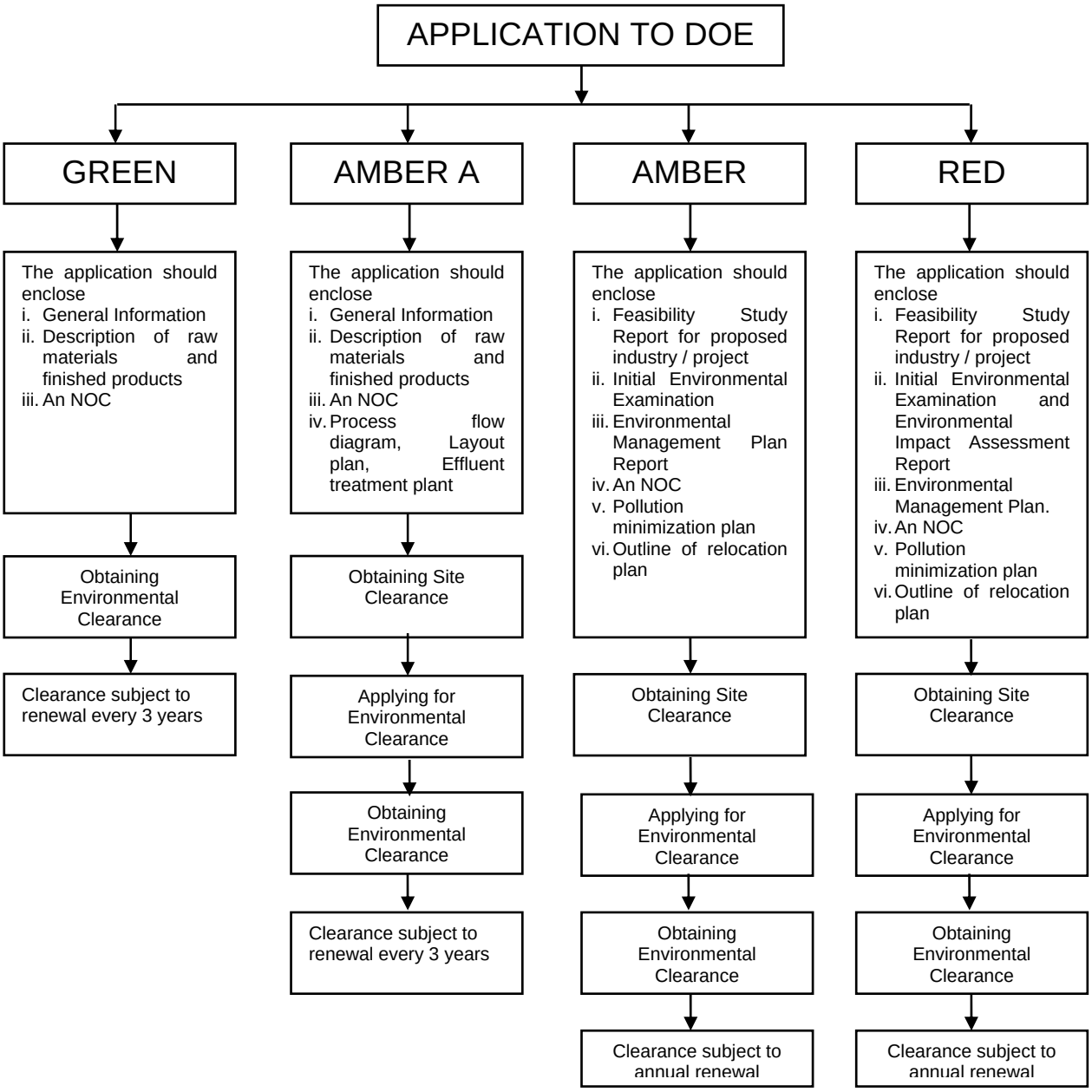
After completion of IEE Report the project proponent should apply to the DOE in the prescribed format for site/ environmental clearance. The application for environmental clearance for the project classified in the Red Category should be accompanied by the following documents:

- Feasibility Study Report of the industry' (project)
- IEE report
- An NOC (No Objection Certificate) from the local authorities concerned
- Pollution minimization plan including emergency plan for mitigation of adverse environmental impacts
- Outline of relocation plans (where applicable)
- Other information as deemed necessary'

It is also mentioned in the Environment Conservation Rules that the Director General of the Department of Environment can issue environmental clearance directly without issuing any site clearance to any industry or project if he (the Director General) finds appropriate reason for doing so.

As the proposed power plant project falls under "Red" category, so all necessary requirement mentioned above will be adopted for the project.

Figure-2.1 shows the activities involved in environmental clearance.



NOC = No Objection Certificate, usually obtained from local government.

Note: 1. These requirements vary from those of the DoE (1997) in requiring EMPs for proposed, as well as current, projects.

2. Procedure of obtaining Environmental Clearance:

a) For Green Category Projects the gestation period for granting Environmental Clearance has been fixed at within 15 days;

b) For Orange A, Orange B and Red Category Projects at first Location Clearance and thereafter Environmental Clearance will be granted. The gestation period for Location Clearance is within 30days for Orange A. and within 60days for Orange B and Red Category Projects.

Source: Adapted from the Environmental Guidelines for Industry (DoE, 1997)

Figure 2.1: DoE Environmental Clearance Procedures

2.3 Organization related with Enforcement of Environmental Standards

The roles and responsibilities of different ministries and departments under those but related with enforcement of environmental requirements is given in brief below :

2.3.1 Ministry of Environment and Forest (MoEF)

The Ministry of Environment and Forest (MoEF) is the key government institution in Bangladesh for all matters relating to national environmental policy and regulatory issues. Realizing the ever-increasing importance of environmental issues, the MoEF was created by replacing Ministry of Forest in 1989 and is at present a permanent member of the Executive Committee of the National Economic Council. This group is the major decision-making body for economic policy issues and is also responsible for approving all public investment projects. The MOEF oversees the activities of the following technical/implementing agencies:

- Department of Environment (DoE)
- Department of Forest (DoF)
- Forest Industries Development Corporation (FIDC)

Department of Environment (DoE)

In order to expand the scope of environmental management and to strengthen the powers for achieving it, the Government issued the Environmental Pollution Control Ordinance in 1977. The ordinance provided for the establishment of an Environmental Pollution Control Board, which was assigned with the responsibility formulating policies and proposing measures for their implementation. In 1982 the board was renamed as Department of Environmental Pollution Control (DEPC). Six divisional offices were established in Dhaka. Chittagong, Khulna, Barisal, Sylhet and Rajshahi.

A special presidential order again renamed the DEPC to the Department of Environment (DOE) and placed under the newly formed ministry of Environment and Forest (MoEF) in 1989.

The DOE is a department of the Ministry of Environment and Forest and is headed by a Director General (DG). The DG has complete control over the DOE. The power of the DG, as given in the Act may be outlined as follows:

- The DG has the power to close down the activities considered harmful to human life or the environment. The operator has the right to appeal and procedures are in place for this. However, if the incident is considered an emergency, there is no opportunity for appeal.
- The DG has the power to declare an area affected by pollution as an ecologically critical area. DOE governs the type of work or process, which can take place in such an area.
- Before going for any new development project, the project proponent must take Environmental Clearance from DOE. The procedures to take such clearance are in place.

Failure to comply with any part of Environment Conservation Act (ECA) 1995 may result in punishment by a maximum of 5 years imprisonment or a maximum fine of Tk. 1,00,000, or both.

Department of Forest

This Department under the Ministry of Environment and Forest is responsible for protection and management of all Reserve Forests of the country. The personnel of the department extend down to the union level in areas where there are Reserve Forests. It has recently started some agro forestry programs. The Forestry Department officers are also responsible for protection of wildlife in the forests.

Related Other Organizations

There are several other organizations, which are related with certain social and environmental functions. These organizations include:

- Ministry of Land: Land Reform and Land Acquisition Directorate
- Ministry of Water Resources: Bangladesh Water Development Board (BWDB)
- Ministry of Fisheries and Livestock: Directorate of Fisheries

2.4 Relevant National Policies and Legislation Relevant to Environment

National Strategies, Policies, Acts and Rules related with environment include the following:

National Environmental Policy, 1992

The government adopted the National Environmental Policy in 1992, appended with an implementation program. Considering the necessity to address existing problems along with issues concerning to improvement of environment in an integrated manner, government prepared this environment policy. The objectives of the policy are: (a) to maintain natural balance through environmental conservation and sustainable development, (b) to protect the nation from all kinds of natural hazards, to identify and control all kinds of pollution, (c) to ensure environmentally sustainable development in all sectors (d) to ensure effective, long term and sustainable of natural resources; and (e) to engage in all types of international initiatives related to environment.

This policy embraces 15 development sectors which includes agriculture, industry, health *&.* Sanitation, energy, water, land, forest & biodiversity, fisheries & livestock, food, coastal & marine environment, transport & communication, urbanization, population, education and science & technology. The policy has defined the environmental issues in all sectors and given guidelines for implementation programs.

Following this policy, Environmental Conservation Act, 1995 and Environmental Conservation Rules, 1997 was enacted. Also environmental assessments of different development project are being implemented in some sectors.

National Conservation Strategy (NCS), 1992

National Conservation Strategy, 1992 was prepared under a project of Government of Bangladesh in the Ministry of Environment and Forest, and coordinated by Bangladesh Agricultural Research Council with financial assistance of International Union for Conservation of Nature and Natural Resources (IUCN). With understanding the increasing environmental pollution and natural resources degradation, the National Conservation strategy was adopted. Following this strategy the Government of Bangladesh prepared the National Environment Policy in 1992, and revised the old law by enacting the Bangladesh Environment Conservation Act. 1995.
Bangladesh has completed the first phase of a national conservation strategy aimed

at integrating conservation goals with national development objectives and overcoming identified obstacles to sustainable development. Some twenty sectors in the Third Five-Year Plan were identified for critical analysis during a second phase, including the conservation of genetic resources, and wildlife management *and* protected areas. The Bangladesh Agricultural Research Council, Ministry of Agriculture is the lead agency for the implementation of Phase n which began in October 1989.

Bangladesh Environmental Conservation Act (ECA), 1995

The Bangladesh Environmental Conservation Act of February 1995 was enacted for conservation, improvement of quality standards, and control and mitigation of pollution of the environment. This act has given power to Department of Environment (DoE) to implement the environmental laws and regulations. It states the specific authorities of controlling, monitoring and supervision. It also stated the penalty, appeal procedures and obligation of the respective authorities engaged in environmental degradation. This act is supported by the Environmental Conservation Rules (ECR). 1997.

Environmental Conservation Rules (ECR), 1997

As empowered by section 20 of the Bangladesh Environment Conservation Act, 1995 (Act 1 of 1995), the Government has made the Environmental Conservation Rules (ECR) 1997. The ECR states the rules of declaring ecologically critical area, taking environmental clearance from DoE for each development projects and monitoring of pollution emission sources. The major focus of the ECR is environmental clearance of development activities. All the development projects are categorized into four: Green Category, Orange A, Orange B and Red in this ECR. It also incorporated the environmental quality standards for every sectors in Bangladesh such as:

- Standards for inland surface water;
- Standards for drinking water;
- Standards for Sound;
- Standards for Sound originating from Motor Vehicles or Mechanized Vessels;
- Standards for Emission from Motor Vehicles;
- Standards for Emission from Mechanized Vessels:
- Standards for Odor;
- Standards for Sewage Discharge:
- Standards for Waste from Industrial Units or Projects Waste;
- Standards for Gaseous Emission from Industries or Projects; and
- Standards for Sector-wise Industrial Effluent or Emission: Fertilizer Plant. Composite textile plant and large processing unit (in which capital investment is more than thirty million Taka), Pulp and Paper Industry. Cement Industry. Boiler of Industrial unit. Nitric Acid Plant. Distillery'- Sugar Industry. Tannery Industry, Food Processing, Fish Canning, Dairy, Starch and Jute Industries. Crude Oil Refinery.

The ECR also includes the fees for environmental clearance certificate, air water, quality testing, etc.

The 1997 EIA (Environmental Impact Assessment) Guidelines for Industries, issued by the DoE Department of Environment)

The Department of Environment (DoE) has prepared 'EIA Guideline for Industries' 1997 under the project entitled "To Develop and Apply Sector wise Industrial Guidelines and Standards and lo Monitor Compliance" as well as on the requirements of the Environmental Conservation Rules, 1997. According to this guideline, even industrial project should take care about specific environmental issues depending on type of waste emission, possible environmental and social effects and available mitigation technologies. This guideline states the process of environmental impact assessment, key issues related to specific industries, format of checklist and EIA report including environmental management plan.

Environmental Court Act, 2000

The Environmental Court Act, 2000 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.

2.5 Relevant acts related with Environment

Other relevant acts related with environment include:

2.5.1 Bangladesh Wildlife Preservation Act (1973; Amended in 1974)

The Bangladesh Wildlife (Preservation) Act of 1973 provides for the presentation, conservation and management of wildlife in Bangladesh. The earlier laws on wildlife preservation, namely, the Elephant Preservation Act 1879, the Wild Bird and Animals Protection Act 1912, and the Rhinoceros Preservation Act 1932 have been repealed and their provisions have been suitably incorporated in this law.

2.5.2 Forest Policy (1994)

The National Forest Policy of 1994 is the amended and revised version of the National Forest Policy of 1977 in the light of the National Forestry Master Plan. The major target of the policy is to conserve the existing forest areas and bring about *20%* of the country's land area under the forestation Program and increase the reserve forest land by 10% by the year 2015 through coordinated efforts of GO-NGOs and active participation of the people.

2.6 Policy Related with Energy Development

2.6.1 Power Policy, 1995

This is presently an integral part of the national energy policy 1995 like the petroleum policy. This has different policy statements on demand forecast, long-term planning and project implementation, investment and lending terms, fuels and technologies, power supply to the west zone, isolated and remote load centers, tariff, captive and stand by generation, system loss reduction, load management and conservation, reliability of supply, system stability, load dispatching, institutional issues, private sector participation, human resource development. Regional / international cooperation, technology transfer and research program, environment policy and legal issues.

As the proposed project is a power plant project, so all necessary' requirement mentioned above will he adopted for the project.

2.6.2 Energy- Policy (1996)

The National Energy *Policy* provides for utilization of energy for sustainable economic growth, supply to different zones of the country, development of the indigenous energy sources and environmentally sound sustainable energy development Programs. The Policy highlights the importance of protecting the environment by requiring an EIA for any new energy development project, introduction of economically viable and environment friendly technology.

2.6.3 Industrial Policy (1999)

The National Industrial Policy, 1999 aims to ensure a high rate of investment by the public and private sectors, a strong productive sector, direct foreign investment, development of labor intensive industries, introduction of new appropriate technology, women's participation, development of small and cottage industries, entrepreneurship development high growth of export, infrastructure development and environmentally sound industrial development. WTO guidelines have been proposed to be followed in the Industrial Policy.

2.6.4 The Electricity Act (1910)

Electricity Act was enacted in 1910 to amend the laws relating to the supply & use of electrical energy. Under this act, any person can get a license to supply energy & to lay down or place electric supply lines for the conveyance *&* transmission of energy. The licensee can open & break up the soil & pavement of any street, railway or tramway and can lay any line or do other works near other utility services (like gas, T&T, water Sewer etc.) provided that prior permission is taken from respective authority, as staled in section 12 - 18 of this act.

According to section 19(1) of this act, the licensee shall make full compensation for any damage detriment or inconvenience caused by him or by any one employed by him. Subsection (1) of section 52 of the Electricity Rules 1957; advise that the licensee should take precautions to lay electric supply line near or where crossed any metallic substance or line to avoid charged,

2.6.5 Petroleum Policy, 1993

The Petroleum Policy was formulated with the primary objective of promoting, monitoring, and regulating all activities in the oil and gas sector in relation to exploration, development, refining, marketing and export.

2.7 Compliance with ADB EIA Guidelines

ADB has issued Guideline for Selected Industrial and Power Development Projects, which was published in 1990. Recently ADB has published Environment Policy 2002 and ADB Environmental Assessment Guideline 2003 for development projects. According to ADB Environmental Assessment Guideline 2003, thermal power development projects fall in Category – A, which require IEE and EIA. The present study is carried out considering the ADB guidelines along with Bangladesh rules and regulations.

2.8 Compliance with International Requirements

Bangladesh has acceded to, ratified or signed a number of major international treaties, conventions and protocols related to environment protection and conservation of natural resources.

2.8.1 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 alone with a total of 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".

2.8.2 Convention on Biological Diversity. Rio de Janeiro, (I992)

The Convention on Biological Diversity, Rio de Janeiro, 1992 was adopted on 05 June, 1992 and entered into force on 29 December 1993. Bangladesh ratified the Convention on 20 March, 1994. This is the overarching framework for bio-diversity and the signatories are required to develop a National Bio-diversity Strategy and Action Plan that incorporates the articles of the convention into national law and statutes.

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.

2.8.3 Convention on Wetlands of International Importance Especially as Waterfowl Habitat, Ramsar (1971)

The convention is also known as the Ramsar Convention. It was adopted or. 02 February 1971 and entered into force on 21 December 1975. Bangladesh has ratified the Convention on 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 cooperation for the conservation of wetland habitats. Obligations for Contracting Parties include the designation of wetlands to the "List of Wetlands of International Importance', the provision of wetland consideration within their national land use planning, and the creation of Natural reserves.

Bangladesh has two Ramsar sites-Parts of Sundarban Reserved Forest (Southwest of Bangladesh) and Tanguar Haor (Northeast of Bangladesh). The proposed Project (installation of sales gas pipeline and condensate pipeline project) will not affect on these two Ramsar sites.

2.8.4 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.

2.8.5 Others (Conventions and Agreements)

The following conventions and agreements may include provisions relevant to different aspects of oil and gas operations for environmental management, nature protection and biodiversity conservation:

- Convention relative to the Preservation of Fauna and Flora in their Natural State 1933; International Convention for the Protection of Birds, Paris.1950;
- International Plant Protection Convention. Rome. 1951:
- Convention concerning the Protection of the World Cultural and Natural Heritage, Paris, 1972 has been ratified by 175 states. This defines and conserves me 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;

- Convention on International Trade in Endangered Species of Wild Fauna and Flora, Washington. 1973 (Popularly known as CITES): This provides a framework for addressing over harvesting and exploitation patterns which threaten plant and animal species. Under CITES governments agree to prohibit or regulate trade in species which are threatened by unsustainable use patterns; and
- Convention on the Conservation of Migratory Species of Wild Animals, Bonn. 1979 (Amended 1988): This provides a framework for agreements between countries important to the migration.

2.9 Compliance with BPDB HES Requirements

BPDB administer workers health and safety issues through Directorate of Labor, BPDB. BPDB has its own policy and requirements to ensure compliance relating to environment, health and safety issues for its operations. The company is committed to managing its operations in a safe, efficient and environmentally responsible manner.

2.10 Building Construction (Amendment) Act 1990 and Building Construction Rules 1996

Building Construction Act dates back to early fifties of the last century. Documents, however, indicate the existence of the Government Buildings Act. 1899, which is to provide for the exemption from the operation of municipal building laws of certain building and lands, which are the property or in the occupation, of the Government and situated within the limits of a municipality. The provision of Municipal Building laws to regulate the creation, recreation, construction, alteration or maintenance of buildings within the limits of any municipality has been superseded by this act. Afterwards the essence of enactment to provide for the prevention of haphazard construction of buildings was thus felt by the East Bengal Legislative Assembly in 1952. Accordingly the "Building Construction Act, 1952" was promulgated on 21 March 1953 as the Fast Bengal Act II of 1953.

The B.C. Act 1952 was importantly conceived lo enforce the activities towards streamlining the planned development and beautification program of the government.

Since its promulgation in .953 the ACT was in force with very little or no amendment up to 1986 when s very important modification of far-reaching effect was added through proclaiming an ordinance titled. "the building Construction (Amendment) Ordinance, 1986 (Ordi. No. LXXII of 1986)" by the then government, Later m 1987, the National Assembly in its session in the month of March adopted the ordinance for enactment at "The Building construction (Amendment) Act. 1987 (Act No. 12 of 1987)". The preamble to stale the objectives of the amendment reveal that "although the trial court has the power to order removal of unauthorized construction after passing the order of conviction under section 12, this power has been found to be insufficient, as a criminal case can not normally be finally disposed of quickly, besides even after disposal of the criminal case by the trial court, the prosecution is lingered by way of appeals". To take steps to prevent unauthorized construction or to remove such construction, the authorized officer has been empowered through this amendment so that he/she can take necessary action in this respect without intervention of the court.

The Act was subjected to another amendment in 1990 allowing some power to the A.O issuing limited sanction to cut or raze any hill within the area 10 which this Act applies.

To support the implementation of the provisions laid down in the B.C. Act. 1952, the Government made the B.C. Rules, 1953. This was superseded by the Imarat Nirman Bidhimalas. 1984. Later in 1996 the Government has framed the Imarat Nirman Bidbimala, 1996 (Building Construction Rules, 1996). The Rules are more comprehensive to take care of the present day circumstances and issues of building construction and other related development activities

2.11 Land Acquisition Rules and Regulations;

The acquisition of immovable property rules,1982 (No. S. R. O. 172-U82) The Government made these rules in exercise of the powers conferred upon by section 46 of the Acquisition and Requisition of Immovable Property Ordinance, 1982 (Ordi, No. II of 1982). The rules spell out the procedural details required for the acquisition of immovable properties in the following sub-heads:

a) Proceedings for acquisition.

b) Notices under section 3, 6, and 7.

c) Declaration of acquisition and possession,

d) Declaration of abatement and revocation of proceedings.

e) Transfer of acquired land,

f) Assessment of compensation, and

g) Unutilized acquired property,

Forms A, B, C, D, E, F, G, and H, which needs to be appended to these rules, has also been specified. Consequent upon these rules the Ministry of lands has issues several circulars to regulate the land acquisition process. The circular No. 4/95 issued on 14/03/1995 specifies some actions required to be taken to process the land acquisition cases.

2.12 Rules and policies in Related Fields

In addition to the policies, rules and regulations related environment and energy the following rules and regulations, listed in Table-2.1 are to be checked for compliance for maintaining sustainable environment.

Table 2.1: Environmental Laws. Regulations and Standards of Bangladesh

Year	Title	Objectives
1950	East Bengal protection and conservation of fish act	Conservation and development of fisheries resources
1985	The protection and conservation of fish rules	Prevention of harming fisheries resources and fisheries habitat in coastal and inland waters
1953	Town Improvement Act	Improvement and Development of Dhaka City
1958	Antiquities Act	Protection and Preservation of Archaeological and historical artifacts
1960, 1966	Port Rules , shipping operation	Control of discharges in ports; waterway rules
1965	Factories act	Industrial workers' health and working conditions.
1971	Pesticide ordinance.	Pesticide use, production, selection and importation.

Year	Title	Objectives
1976	Antiquities (Amendment) Ordinance.	Protection and prohibition export of archaeological artifacts.
1977	Municipal ordinance.	Municipal activities in health, sanitation, water supply, drainage, etc. in the city.
1979	Factory rules.	Disposal of wastes and effluents.
1980	Agricultural pesticides (Amendment) act.	Selection, use and handling of pesticides in the agricultural sector.
1982	Municipal act.	Drainage, sewerage, water supply and sanitation.
1982	Acquisition and requisition of immovable property ordinance.	The acquisition of immovable property rules, 1982 (No. S, R. 0. 172-U82) The Government made these rules in exercise of the powers conferred upon by section 46 of the Acquisition and Requisition of Immovable Property Ordinance. 1982 (Ordinance No. II of 1982).
1983	Agricultural pesticides (Amendment) ordinance.	Revised agricultural pesticides ordinance.
1985	The pesticide rules.	Pesticide selling, use and safety measures.
1990	Bangladesh standard specification for drinking water.	Formulation and revision of national standards.
1860	The penal code.	This contains several articles related with environmental protection and pollution management.
1996	Building construction (Amendment) act and building construction rules.	The Rules are more comprehensive to take care of the present day circumstances and issues of building.

CHAPTER 3: DESCRIPTION OF THE PROPOSED PROJECT

3.1 Project Location

The proposed 225MW Combined Cycle Power Plant (2nd Unit-Dual Fuel) will be located beside the existing 150MW Peaking Power Plant converted into 22MW CCPP, which is situated on the bank of the Jamuna river near Bangabandhu Bridge at Sirajganj. This is located at Barashimul Mouza of Saydabad Union of Sirajganj Sadar Thana under the District of Sirajganj. This is about 15 KM south-east of Sirajganj town. . The JMB (Bangabandhu Setu) is on the north of the site, Khas Barashimul village on the south, Jamuna river on the east and Saydabad is on the west side of the power plant site. The proposed site is about **130 km** north-west of the capital city of Dhaka. This site lies between N $24^0$23'4" and N $24^0$23'16" and between E $89^0$44'33" and E $89^0$44'51". The location of the proposed power station shown on the map of Sirajganj district is given in **Figure-3.1(1).**

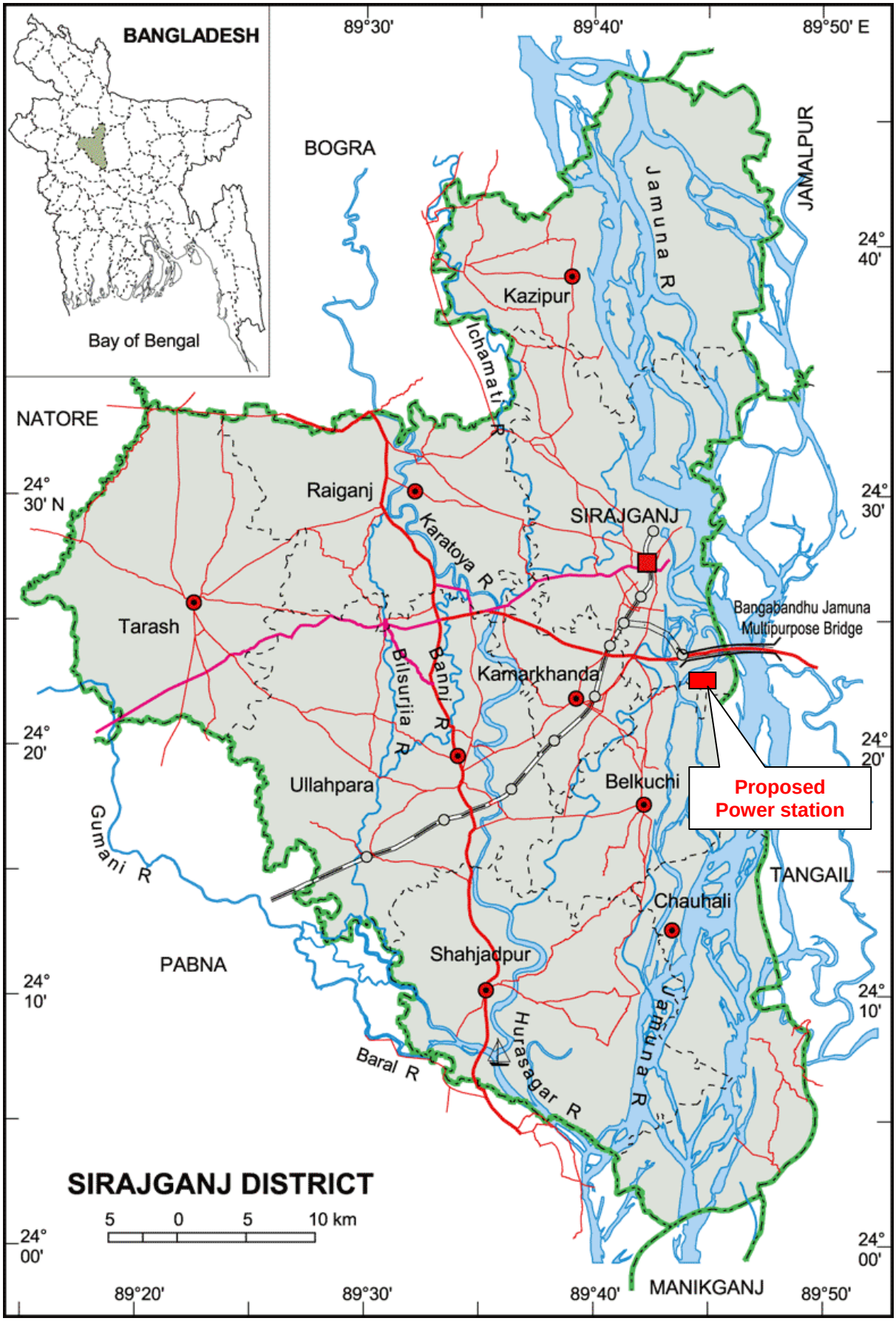


Figure-3.1(1) : Map of Sirajganj district showing location of proposed power station

The satellite image of the proposed power station site is given in **Figure-3.1(2).**

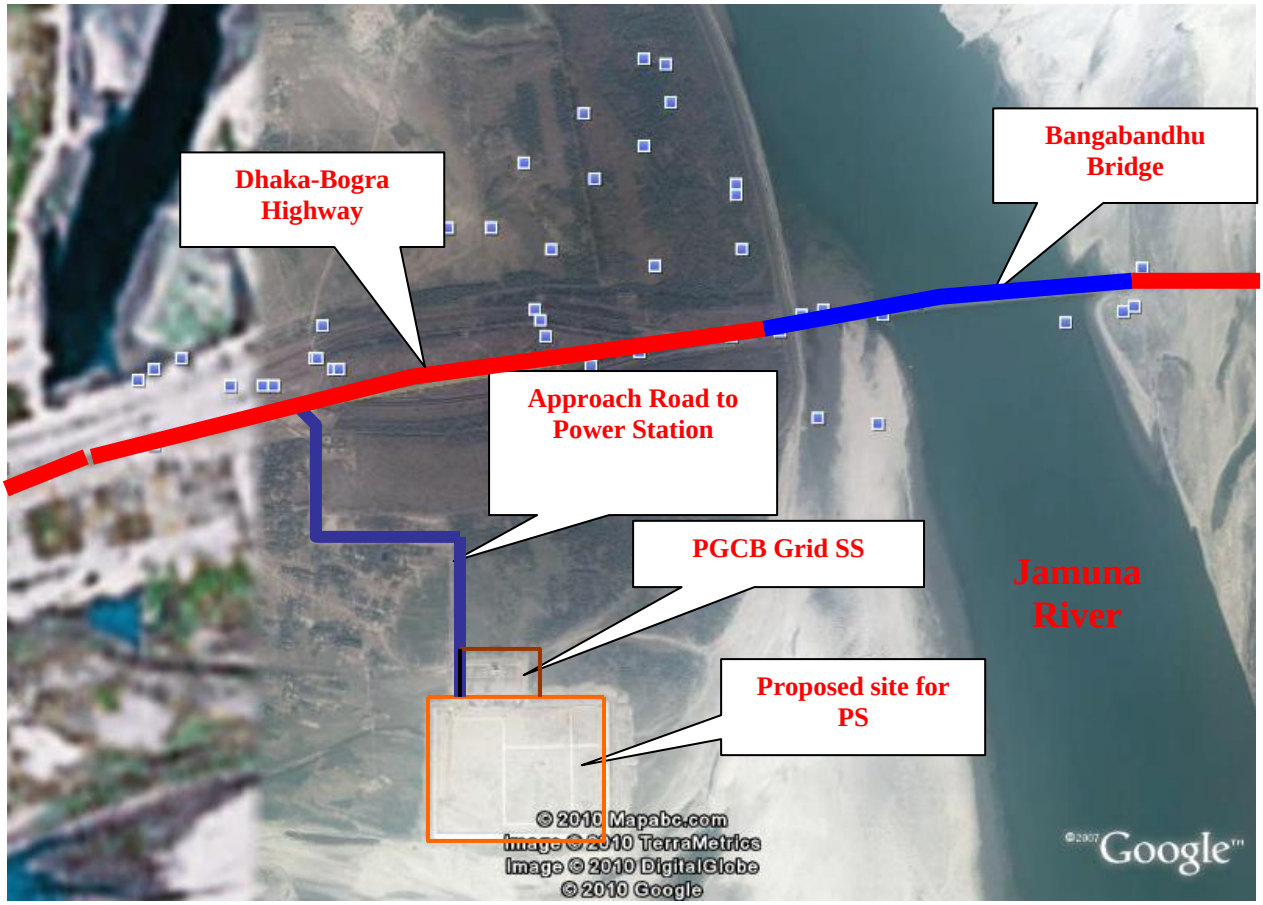


Figure-3.1(2): The Satellite image of location of Proposed Power Station

The proposed location of Sirajganj 225MW CCPP (2nd Unit-Dual Fuel) project shown in **Figure-3.1(3).**

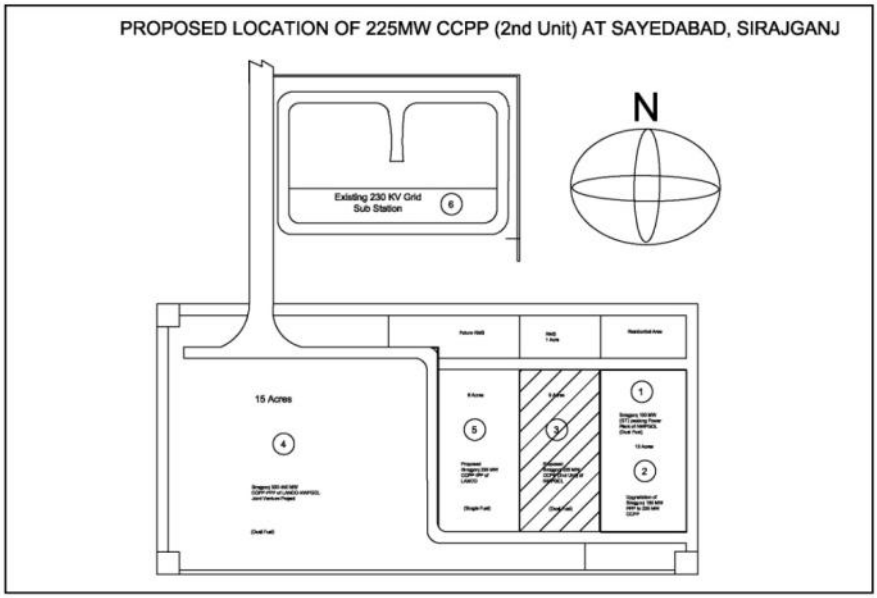


Figure-3.1(3): Proposed location of Sirajganj 225MW CCPP(2nd Unit) project

3.2 Site Development and Construction

No land development for the proposed power plant will be required as Land development in the project area has been completed by BPDB initially and then NWPGCL during construction of 150MW peaking power plant..The main components e.g. Gas Turbine, HRSG, Steam Turbine, Generator and Power Transformer etc. will be assembled overseas and delivered to the site using river routes. The remaining plant and equipment will be erected at the site. For the construction and erection of the plant, heavy equipment, like cranes etc will also be utilized. For unloading heavy equipment, a suitable jetty has to be constructed.

3.3 Equipment and Processes

The following equipment will be required for the proposed Sirajganj 225MW CCPP (2nd Unit-Dual Fuel) :

i. Gas Turbine
ii. Heat Recovery Steam Generator
iii. Steam Turbine
iv. Generator
v. Power Transformer
vi. Cooling water system
vii. Stack (Main/ Bypass)

Natural gas or High Speed Diesel will be used as fuel for Gas turbine which will be coupled with Generator to produce 150MW at 11kV voltage level. The requirement of Natural Gas for this proposed Power Plant is about **35mmcfd.** Natural Gas will be supplied to the proposed power plant by Paschimanchal Gas Distribution Co. Ltd. of Petrobangla.

The exhaust temperature of gas turbine will be about 500-600 degree Celsius. The exhaust gas with high temperature will be passed through **Heat Recovery Steam Generator (HRSG)** in which groundwater will be fed after treatment (demineralization & desalination) to produce the steam and then the steam will be passed through steam turbine coupled with generator to produce electricity of about 75MW at 11kV voltage level. The temperature of the flue gas will be about 90 degree Celsius. The flue gas will be discharged to the atmosphere through a main stack of adequate height.

The output voltage of the generators will be stepped up to 230 KV through a step-up Transformer, to be installed close to generator outlets. This high voltage (230 KV) supply will be connected to the existing 230KV Switching Station of PGCB through 230KV cables of required specifications.

In order to cool the steam out from steam turbine, recirculating wet cooling tower will be used. Groundwater will be used in the cooling tower and steam cycle for makeup water after proper treatment. Water flow schematic is shown in **Figure-3.3.**

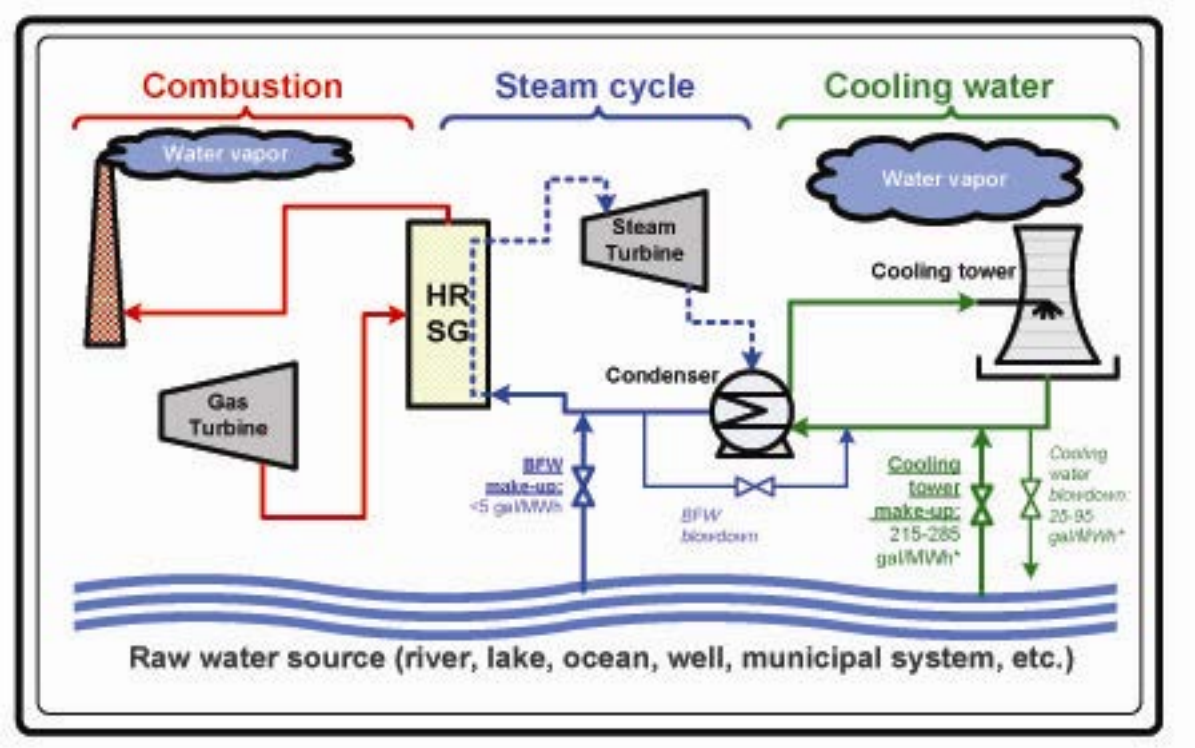


Figure-3.3: Water Flow Schematic utilizing wet Cooling Tower

From the study report of NETL, USA, water requirement for combined cycle power plant is **190gal/MWh= 0.72m^3/hr per MW**. This water requirement includes makeup water for steam cycle and cooling tower. The makeup water is estimated roughly from evaporated water and blow down water in the cooling tower. From this base data, the water requirement for 225MW CCPP will be about **200m^3/hr.** However, the water supply system will contains industrial use and makeup water supply for cooling tower basin. Hence the estimated water requirement for the plant is about **600m^3/h.** In order to meet the water requirement of the power plant, Four deep tube wells having discharge capacity of about 125m^3/h each may be installed. According to the study of DPHE, there is huge aquifer of adequate depth below 6m from ground level. Moreover, groundwater level was observed about 20feet during survey and this was confirmed by the local people during interview. Apart from this, Jamuna river is passing through nearby the proposed power plant. Hence, there will be no adverse impact if the above amount of groundwater is withdrawn for power plant use. Ground water modeling has been carried out to find the impact of abstraction of ground water for the power plant for the next 20 years.

A conceptual model was developed taking into consideration of the hydrostratigraphy of the study area. Model area was chosen carefully so that the stresses to the system provided by the pumping wells at the project site do not reach the boundary. A three layer transient groundwater flow model was set up with time steps of a month using MODFLOW. Layer 1 comprises low permeability clays and silts. Layer 2 comprises moderately permeable very fine sand to fine sand. Layer 3 comprises medium to coarse sand and gravel. Different hydrogeological parameters were assigned for each of the modelled layer. River, recharge and evapotranspiration boundaries along with municipal and irrigation pumping wells were incorporated to the model. The model was then calibrated by matching the observed head at different parts of the modelled area with the calculated head and the sensitivity analysis was conducted.

After calibration 10 pumping wells with a discharge of 1240 m^3/hour were introduced in the model at the project site. Two model scenarios were considered. In the first scenario the pumping wells were arranged in line over a distance of 1 km. In the

second scenario the pumping wells were arranged in cluster over a distance of 400m.

For both the scenarios the model was run for twenty years maintaining projected future increase in groundwater abstraction. The modelled minimum elevation of groundwater table occurs in the month of May. The River Jamuna is influent in the dry season. Due to lowering of the head, water from the river bed passes into the aquifer in areas adjacent to the pumping wells. The modelled maximum elevation of groundwater table occurs in the month of September. The pumping wells in the proposed power plant will get plenty of water supplies from the river and water level in the pumping well will rise substantially. It has been found that the Jamuna River lying in the eastern side of the project site acts as a recharge boundary for the aquifer system in both dry and wet season.

For the first scenario about 3 km^2 area surrounding the pumping wells of the proposed power plant water level may decline by 0.5 to 1 m from the existing water level. As the cone of depression is elongated in the direction of the river, the river water from a large area will infiltrate into the aquifer due to enhanced vertical head gradient.

For the second scenario about 3 km^2 area surrounding the pumping wells of the proposed power plant water level may decline by 0.5 to 1.5 m from the existing water level. The cone of depression is circular and covers a shorter part of the river. The infiltration of river water from a small area will infiltrate into the aquifer.

The modelling study confirms that the water abstracted from wells in the project site mostly come from the river in both dry and wet seasons. Over the past 50 years the Jamuna river flow at Bahadurabad (SW-46) in the wet period varied between 30000 and 50000 m^3/s and in the dry period 3000 and 12000 m^3/s (Rajib et. al. 2011). The average discharge of the river is about 20,000 m^3/s (Bristow, 2009; Gupta, 2008; Schumm and Winkley, 1994). It could be assumed that the minimum and maximum discharge of Jamuna River varies between 3000 m^3/s and 50000 m^3/s near Bangabandhu Jamuna Bridge. To satisfy the need of water of the power plant for a day, a fraction of a second to maximum 10 second's discharge of the Jamuna River is quite sufficient.

Taking into consideration of the model predictions it has been recommended from this study that a number of pumping wells of cumulative discharge of 1240 m^3/hour can be set up in a one kilometre or longer line parallel to the river Jamuna, so that the catchment of the pumping wells spread mostly on the river.

It is concluded from this study that the natural aquifer condition in the study area would be suitable for supplying 30000 m^3/day of water continuously without any permanent lowering of groundwater table and environmental degradations. Jamuna River invariably fully recharges the aquifer in the wet season of each year preventing any adverse effect on the natural condition of the project area.

The MODFLOW results generated through this modeling effort reflect only assumed conditions based on site data, collected data or literature values. It is also assumed that the rainfall, river water level and other climatic factors would not change in the next 20 years. However, recent studies indicate that the rainfall in Bangladesh and surrounding areas in increasing due to climate change (UK Met Office 2011) which would obviously contribute to enhance recharge to the aquifer in the projected period.

The study report on ground water modeling in the project area is enclosed under **Annex- 3.3**.

However, Jamuna river water may also be used for power plant use..

3.4 Electricity Generation and Transmission

Electricity will be generated in the proposed power plant at 10 – 11 KV, which is the normal voltage for such generators. The voltage will be stepped up to 230 KV through a step-up Transformer, to be installed close to generator outlets. This high voltage (230 KV) supply will be connected to the existing 230KV Switching Station through 230 kV underground cables. Schematic diagram of 230kV network for power evacuation is given in **Figure-3.4.**

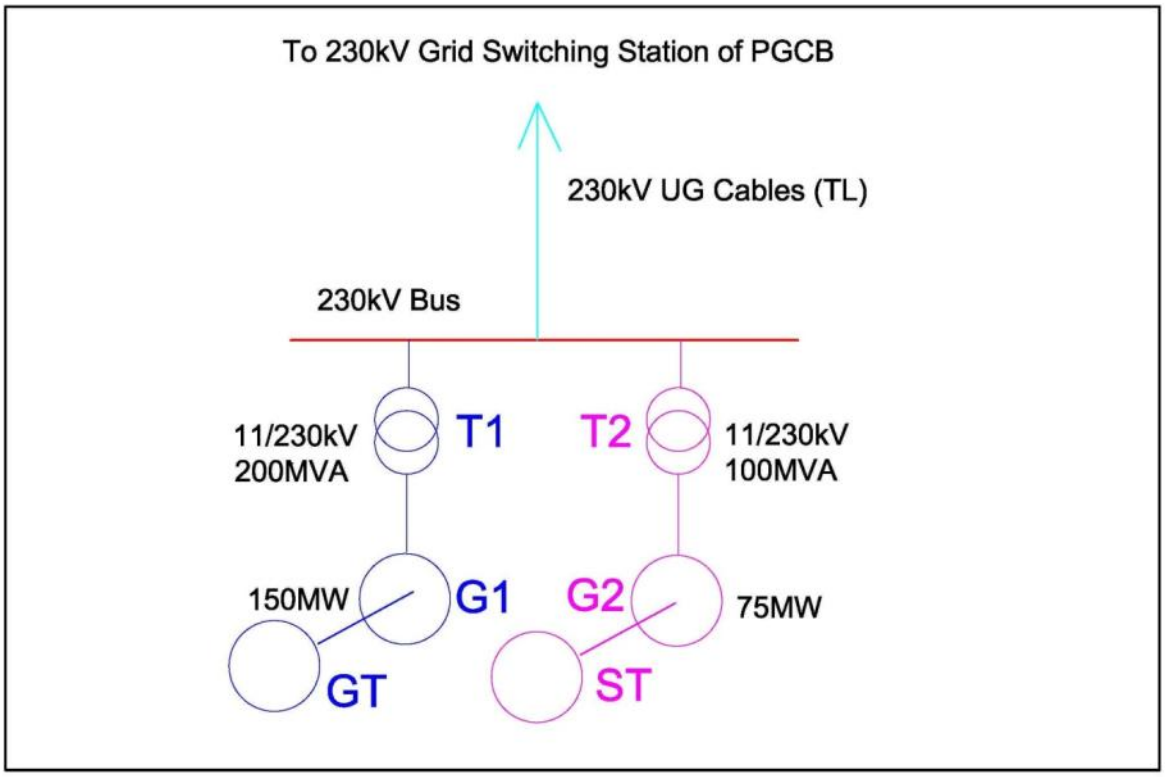


Figure-3.4: Schematic Diagram of 230kV Network for Power Evacuation

3.5 Gas Pipe Line for Power Generation

It is expected that natural gas will be used as main fuel for the proposed 225MW CCPP (2nd Unit). The requirement of natural gas for the proposed power plant is about **35mmcfd.** This natural gas will be supplied by Paschimanchal Gas Distribution Co. Ltd. of Petrobangla. A CGS has been installed by the gas company, near the power station to measure the volume of gas supplied to the power plant..

The gas pipe line from the downstream side of the CGS to the proposed Power Plant will be laid. The CGS inlet pressure is expected to be 1,000 psig and the outlet pressure between 300 and 350 psig. The gas pressure at the plant site is, therefore not expected to be higher than 350 psig, which is much lower than the pressure required by the power plant. A Gas Pressure Booster will be installed near the proposed power plant.

3.6 Water Management

Potable and sanitary water will be supplied from a deep water pump and overhead tank to be constructed. Deep water (ground water) may also be used for cooling/process water for the plant, fire fighting water and water for miscellaneous services. Total requirement of water for the proposed power plant is about **600m3/hr.** This water requirement can be met by abstracting groundwater through installing 4 (four) deep tube wells in the project area. A conceptual flow diagram of Water Supply & Discharge system and Chemical system is shown in **Figure--3.6**.

Jamuna river water may also be used for cooling/process of the power plant as the Jamuna

River is very adjacent to the power plant by dredging a canal from the mainstream of the Jamuna River up to the power plant.

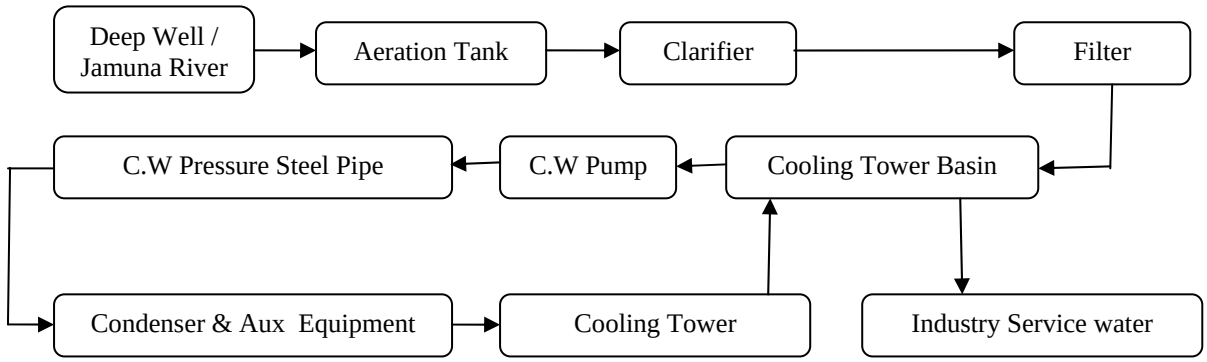


Figure-3.6: Conceptional Flow Diagram of Water Supply & Discharge System and Chemical System

3.7 Waste and Emission Management

Waste generated during the construction phase of the project include construction debris and wastes (e.g. scrap iron, steel, wood, piping etc.) and some other solid wastes (e.g. from labor sheds), human wastes from people working at the project site and some liquid wastes from construction processes. Emissions would include those from operations of construction equipment and machineries, vehicles carrying construction materials to the site and taking construction debris out of the site. If construction equipment, such as stone crushers, are used at the site, this may result in significant emission of particulate matters during its operation. Since construction of the proposed power plant would most likely involve significant earthwork, increase in particulate matters in the air from wind-blown dust is also a concern, especially considering the close proximity of the residential area to the project site. Noise pollution from movement of vehicles and operation of construction equipment is also a concern for the same reason.

The proposed Power Plant is of relatively cleaner technology for production of electricity. Emission from the plant is expected to produce minimum impact on the surrounding environment, other than temperature.

The appropriately designed wastewater disposal facilities of the proposed power plant will take care of human wastes to be produced within the plant. Solid wastes from offices of the power plant, to be generated during the operation of the plant would not be significant.

Management of wastes and emissions generated during the construction and operation phases of the project is a very important issue, details of which have been discussed in Chapter 8 of this report. In general, construction debris and other solid wastes generated at the construction site should not be mixed with domestic solid wastes generated within the complex. These solid wastes should be handled separately. It should be the responsibility of the contractor to properly store these wastes at the project site and then dispose them off in an appropriate manner (e.g. in a municipal land fill/waste dumping ground) outside the complex. Human wastes e.g. those generated in the labor sheds should be appropriately disposed off, e.g. through construction of septic tank system.

Appropriate measures, as detailed in Chapter 8 should be taken to minimize generation of air pollutants during construction phase. Such measures may include, among others, controlled movement of vehicles and operation of equipment considering school hours, covering of construction materials (e.g. sand) and keeping exposed land surface wet to limit wind-bound dust concentration, no or limited operation of equipment producing excessive noise during school hours and late at night etc. Measurement of air quality and noise level during both

construction and operation phases would also be part of the waste and emission management scheme (see details in Chapter 8).

3.8 Fire Fighting and Protection System

3.8.1 Fire Safety Philosophy

The proposed power Plant will be designed and built with the provision of a safe operating environment both for plant and personnel. This will be achieved by separation and segregation of equipment with sufficient distances and by selection of suitable materials and equipment.

Hazardous areas will be designated and suitable equipment will be selected for use in these. Different fire fighting systems will be installed depending on the operational characteristics of the equipment, area and building to be protected. The capacity of the proposed fire fighting plant will be such that it can operate continuously for 2 hours according to NFPA 850 and will be of a minimum of 300m^3 and pressure of approximately 10 bars (Table 3.8.1).

The proposed plant will have its own water system for fire fighting, with a pump house. The fire water will be provided from the raw water tanks.

The new pump house will consist of :

- One (1) 100% electric jockey pump
- One (1) 100% electric driven main pump and
- One (1) 100% diesel engine driven main pump.

The water demand and required pressure under the worst condition will be ensured by electrically driven main pump. The diesel engine driven pump shall be on stand-by, for the case of main supply failure. The engine driven pump will be of the same capacity as the electric driven main pump.

Table 3.8.1: List of Protected Areas and Types of Fire Fighting and Detection System

Sl. No.	Building or Area	Fire Fighting System
1.	Gas/ Steam Turbine	CO_2 extinguishing system
2.	Generator Unit, Auxiliary and Step up Transformer	Spray water dry type
3.	Oil Tanks	Foam system, Dike protection
4.	Control Room	Cable basement: sprinkler system Control room: argonite or similar
5.	Electrical/Switchgear	Sprinkler system, if required and portable fire extinguisher
6.	Yard	Hydrants
7.	Common	Protective signaling for fire and gas detection systems with main panel in the control room

3.8.2 Fire Fighting System Description

The fire protection system of the proposed Sirajganj 225 MW Combined Cycle Power Plant (2nd Unit) will be provided for the plant as described in the following paragraphs. The fire protection system will generally follow the applicable stipulations of NFPA codes.

Extinguishers will be sized, rated and spaced in accordance with NFPA 10. Local buildings fire alarms, automatic fire detectors and the fire signaling panel will be in accordance with NFPA 72.

It will be assured that a dedicated two (2) hour fire water supply to cover the system design flow rate is available for the facility in accordance with NFPA.

A main firewater pipeline will be provided to serve strategically placed yard hydrants and supply water to the sprinkler and spray system.

The firewater distribution system will incorporate sectionalizing valves so that a failure in any part of the system can be isolated while allowing the remainder of the system to function properly.

Fuel oil tanks are furnished with foam fire fighting systems.

3.9 Operation and Maintenance

Major equipments of the power plant are gas turbine, HRSG, Steam Turbine, generator, sub-station equipment etc. Generally gas turbine has the most frequent failure among such major equipments. Therefore, the maintenance quality for the gas turbine makes great influence on the availability of the power plant.

During the operation of the gas turbine, consequently the degradation / damage of blades are more severe than any other part and it requires more frequent interval for inspection / repair / replacement. The expected life of those hot parts of gas turbine is specified by the original equipment manufacture (OEM) and the specified inspection / repair are required up to the life end. **Table 3.9.1** shows the example of the inspection interval.

Generally there are three types of inspection according to the equivalent operating hours.

Table 3.9.1: An example of inspection interval

Type of Inspection	Inspection Interval / Equivalent Operating Hours
Combustion Inspection	8,000 hours
Turbine Inspection	16,000 hours
Major Inspection	48,000 hours

3.10 Others

3.10.1 Facilities for Construction

(a) Jetty and Crane

A suitable jetty has to be constructed at the site, equipped with cranes of suitable capacities, for unloading of equipment and materials during construction as well as operation of the plant.

(b) Storage Yards

Storage yards are very important for construction of a plant. There is sufficient space for storage of power plant equipment as well as civil construction materials at the same time. It will, therefore, be not necessary to schedule the construction in such a way that civil construction e.g. machinery foundation and building works are completed just before the arrival of power plant equipment and remaining civil construction materials are removed from the site to make room for equipment storage.

3.11 Estimated Cost:

The estimated cost for the proposed Sirajganj 225MW Combined Cycle Power Plant (2nd Unit) is **Bangladesh Taka 24,868.00 (Twenty Four Thousand Eight Hundred Sixty Eight) million** only. The breakup of the estimated cost is given in **Table-3.11.**

Table-3.11: Estimated cost for Sirajganj 225MW CCPP(2nd Unit))

Sl. No.	Item description	Estimated Cost in Million Taka (2017 constant price)
1	Plant & Equipment Cost	17,393
2	RMS Cost	465
3	Consultancy Services	338
4	Civil Works (Vehicles, Transport etc.)	99
5	Field Establishment Cost	99
6	CD, Vat, IT	1,643
7	IDC & Others	1,546
8	Export Credit Agency (ECA) charge	2,222

9	Contingency	1,063
Grand Total (Taka)		**24,868**

3.12 Implementation Schedule:

The proposed Sirajganj Combined Cycle Power Plant (2nd Unit) project will be implemented in **30 months** commencing from August 2015 to January 2017.

CHAPTER 4: EXISTING ENVIRONMENT: PHYSICAL

4.1 Introduction

A baseline survey was carried out in areas surrounding the proposed up-gradation project site for the purpose of ascertaining Physical Environmental conditions. This has been done in order to gather information on the existing physical environment of the areas in and around the project site. During the survey, air and water samples were collected from pre-determined points in the area and analyzed in laboratory. Noise levels were also measured at definite points.

Relevant information on climate, drainage, hydrology and water resources were also collected.

The data collected on different items, results obtained from laboratory tests and measurements made are detailed in this Chapter. It describes the existing physical environment of areas in and around the project site based on the baseline survey and other studies carried out as a part of the present study. Air quality, noise level, water quality and other physical environmental conditions of the project site, as have been described in this Chapter, are very important in obtaining clearance from DoE. These are also very essential for designing the equipment for the project.

4.2 Climate

Bangladesh, a small country with generally low lying area, is located at the central part within the Asiatic monsoon region where the climate is tropical. Its climate has moderate variation in terms of temperature, rainfall, relative humidity and wind speeds.

There are two marked seasons in Bangladesh, the rainy season from May to October, during which more than 85% of the total annual rainfall occurs and the dry season from November to April. The beginning and ending of the rainy season vary from year to year. Heavy rains may commence anywhere between mid April and early June and may end anywhere between the end of September and mid November.

Climatic conditions of the study area were collected from the Meteorological Department at Dhaka and Bogra. Rainfall, temperature, relative humidity and wind speed are described in the following paragraphs.

4.2.1 Rainfall

During the monsoon (June to September), wind direction from the southwest brings moisture laden air from the Bay of Bengal, when the heaviest rainfall occurs. Average monthly rainfall values for the study area are given in **Table 4.2.1**.The maximum rainfall of **2157mm** occurred in the year **2004** and the maximum rainfall of **732mm** occurred in the month of **June 2007.**

Table 4.2.1: Rainfall characteristics of the study area, 2003-2012

Station : Bogra Monthly & Yearly Total Rainfall (mm)

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Year Total
2003	4	53	72	113	214	364	219	220	156	264	0	13	1692
2004	0	0	45	90	137	638	529	261	206	251	0	0	**2157**
2005	5	9	58	72	138	130	471	328	356	523	0	1	2091
2006	0	0	12	143	193	184	192	138	174	69	1	0	1106
2007	0	18	25	28	92	**732**	320	256	302	131	15	0	1919
2008	27	0	22	20	213	393	474	374	109	159	0	0	1791
2009	0	3	3	49	205	128	194	570	169	89	0	0	1410
2010	0	0	0	29	185	286	92	225	244	190	2	20	1274
2011	1	0	7	145	194	193	175	606	389	0	11	0	1721
2012	19	0	0	74	94	147	186	164	345	74	36	1	1140

Source: Bangladesh Meteorological Department, Dhaka

4.2.2 Ambient Air Temperature

Monthly Maximum & Average temperature of the project area for the period of year 2003-2012 recorded at Bogra Meteorological Station are given in **Table 4.2.2(1)** and Monthly Minimum & Average temperature of the project area for the period of year 2003-2012 recorded at Bogra Meteorological Station are given in **Table 4.2.2(2).**

Table 4.2.2(1): Monthly Max. & Av. Temp. at Bogra, 2003-2012

Year	Item	Monthly Temperature in Degree Celsius											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003	Maximum	28	30.5	34.6	36.8	38.7	36.2	37.5	35.8	35.8	34.3	32	29.8
	Average	21.3	26.9	29	33.2	33.3	31.6	33	33.1	32.4	30.7	29.9	26.3
2004	Maximum	26	33	35.6	38	40.1	36	34.2	34.7	34.7	34.3	31.5	29.7
	Average	****	27.9	32.1	32.1	35	32.5	31.5	33	31.1	30.8	29.7	26.8
2005	Maximum	27	31.7	34.4	36	38.7	37.7	34.5	35.4	36.6	34.2	32	29.8
	Average	24.2	28.1	31	33.4	32.7	34.1	32	32.7	33.5	30.1	29.3	27.2
2006	Maximum	28.6	34.8	37	36.3	37.3	36.6	37	37	35.7	34.6	32.2	29.5
	Average	24.2	30.1	32.3	32.5	33.7	33.1	33.3	33.5	32.6	32.7	29.4	26.9
2007	Maximum	28.9	30	35.2	36.5	**40.5**	38.2	35.4	37.4	36	35.5	33.1	28.4
	Average	24.2	25.9	30.2	32.9	35.6	32.4	32.2	32.9	32.6	32	30.6	26.1
2008	Maximum	28	30	35.2	37.5	36.4	35.6	34.5	36.3	36	34.8	32.7	30
	Average	24	25.9	31	34	34.4	32.1	31.8	32.2	33.1	31.9	30.3	25.6
2009	Maximum	27.5	32.2	34.3	39.1	39.0	38.2	36.0	34.5	36.0	35.7	34.2	29.5
	Average	24.8	29.2	31.7	34.5	33.1	34.6	33.6	32.2	33.3	32.7	30.3	25.6
2010	Maximum	28.7	31.2	36.8	38.0	40.0	37.0	35.5	36.6	34.8	36.0	34.2	30.4
	Average	22.9	28.5	33.5	34.3	34.3	33.2	33.5	33.3	32.9	32.8	30.7	26.5
2011	Maximum	27.0	30.5	35.4	35.6	35.4	37.1	35.8	37.0	37.4	36.0	32.7	32.0
	Average	22.2	28.3	31.6	33.1	33.0	33.3	32.9	32.1	32.9	33.8	29.9	24.4
2012	Maximum	27.2	32.0	36.4	38.4	39.3	37.8	35.0	35.5	38.2	35.5	31.8	28.6
	Average	23.9	28.1	32.6	33.4	35.2	33.4	32.0	33.3	33.0	33.3	29.3	23.1

Station: Bogra, BMD

Table 4.2.2(2): Monthly Min. & Av. Temp. at Bogra Station, 2003-2012

Year	Item	Monthly Temperature in Degree Celsius											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003	Minimum	**5.3**	12.7	12	19.8	20.7	22.5	24	25.5	24.5	22	12.6	10.7
	Average	9.5	15.2	18.4	23.1	23.9	25.7	26.8	26.8	26.1	24.1	18.1	14.6
2004	Minimum	8.6	9.3	14.2	19.8	21.4	22.5	23	24.5	22.4	19.3	15.2	8.4
	Average	11.7	14.4	20.9	22.7	25.1	25	25.8	26.6	25.4	22.5	17.5	14.5
2005	Minimum	8.5	10.3	17.2	19.4	19.6	23	24	24.4	24	20.5	14.7	10.6
	Average	12.1	16	20.6	22.8	23.2	26.3	26.2	26.7	26.2	23.5	18.1	13.9
2006	Minimum	9	14	15.5	18.5	21.4	22.8	25.4	23.4	23.7	20.3	11	11.2
	Average	11.9	17.9	19.3	22.4	24.4	26.1	26.8	26.5	25.8	23.4	18.4	14.1
2007	Minimum	7	11.5	13	18.4	21	21.2	24.5	24.6	24.2	21	16	9.3
	Average	10.7	15.5	17.8	23.3	25.3	25.4	26.3	26.7	26.1	23.8	19.1	12.9
2008	Minimum	8	7.6	15	18.9	20.7	22.8	25	24.8	23.7	18.8	14.4	11.6
	Average	12.5	13	20.5	23.2	24.4	25.8	26.1	26.4	26.1	23	17.9	16.1
2009	Minimum	9	10.5	13.6	20.4	20.5	22.4	25.2	23.9	24.6	18.8	12.9	8.5
	Average	13.1	13.9	19.1	23.7	24.1	26	26.7	26.2	26.3	23.2	18.8	13.2
2010	Minimum	8.0	9.6	15.3	20.0	21.6	23.5	26.0	25.5	23.7	20.0	15.0	10.0

Year	Item	Monthly Temperature in Degree Celsius											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Average	10.9	14.4	20.9	24.8	25.1	26.3	27.1	26.9	26.0	23.8	19.5	13.5
2011	Minimum	5.8	10.8	13.5	19.5	20.3	24.4	24.0	24.0	25.2	18.6	14.7	9.4
	Average	10.1	14.7	20.1	22.4	23.6	26.1	26.5	26.3	26.2	24.2	18.0	13.3
2012	Minimum	8.0	9.3	15.6	19.2	20.6	22.5	24.9	25.2	24.0	19.2	12.7	8.9
	Average	12.2	13.9	19.5	22.7	25.6	26.4	26.7	26.9	26.4	22.9	17.3	13.0

Station: Bogra, BMD

Monthly variation of maximum and minimum temperatures recorded at Bogra Meteorological Station are shown in **Figure 4.2.2(1) and Figure- 4.22(2) respectively.** Maximum temperature of **40.5^{0}C** was observed in May, 2007 and minimum temperature was **5.3^0 C** in January, 2003.

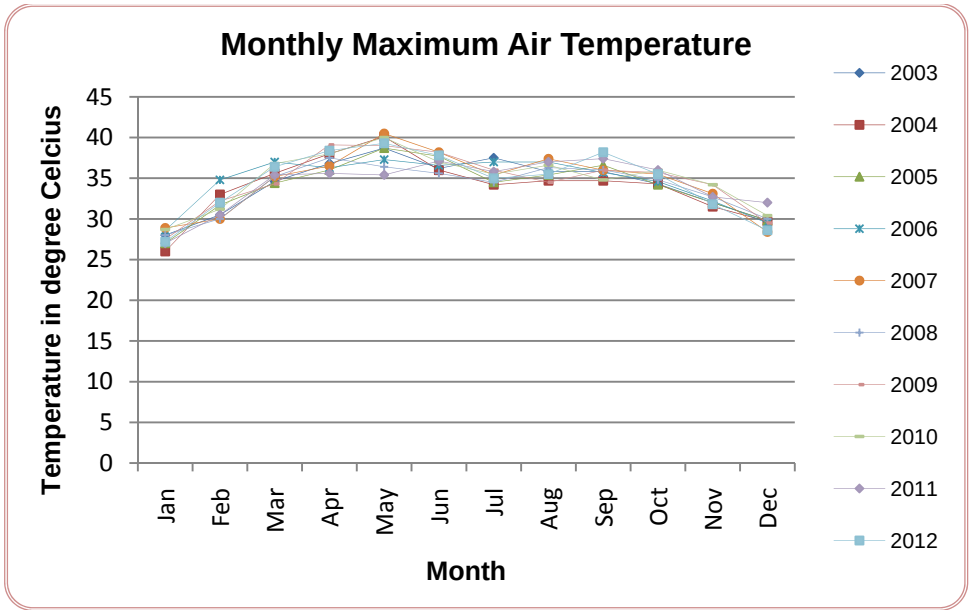


Figure 4.2.1(1): Monthly Maximum Temperature, Bogra

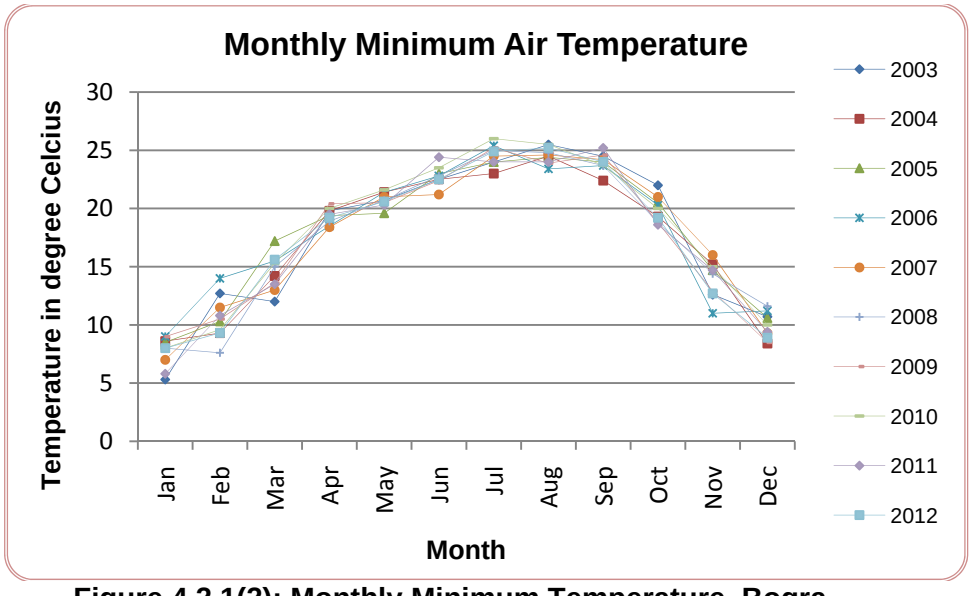


Figure 4.2.1(2): Monthly Minimum Temperature, Bogra

4.2.3 Relative Humidity

Humidity during the wet season is naturally the highest compared to those occurring at other times of the year. The monthly and yearly average relative humidity from year 2008 to year 2012 at Bogra Meteorological station are given in **Table 4.2.3.**

Table-4.2.3: Monthly & Yearly Average Humidity in % (Station: Bogra)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2008	79	72	73	71	74	84	85	84	82	81	74	82	78
2009	81	65	64	69	77	78	81	85	82	79	74	79	76
2010	80	66	64	75	74	82	81	82	83	81	74	74	76
2011	79	68	66	71	77	81	82	85	83	77	75	81	77
2012	74	63	60	70	71	80	83	82	83	78	74	84	75

Source: BMD, Dhaka

From the above table, the maximum average Relative Humidity recorded by Meteorological Department, Bogra station was about **85%** between July and September and the minimum average Relative Humidity recorded by Meteorological Department, Bogra station was about **60%** in February and March**.**

4.2.4 Wind Speeds and Direction

Wind directions at the project site are mostly from the North-West or West towards South-East or East during November to February. The wind directions are the East to the West during March to October. Yearly and Monthly Wind Speed and Direction from 2008 to 2012 are given in Table-**4.2.4(1).** Wind Rose diagram and Wind class chart in the project area from January to December are given in **Figure- 4.2.4**.

From **Table 4.2.4(1),** it was observed that the maximum wind speed of **5.5 knots** prevailed during September, 2009 flowing from East to West and the minimum wind speed of **2.2 knots** in December 2010 from North West to South East.

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-4.2.4(2).**

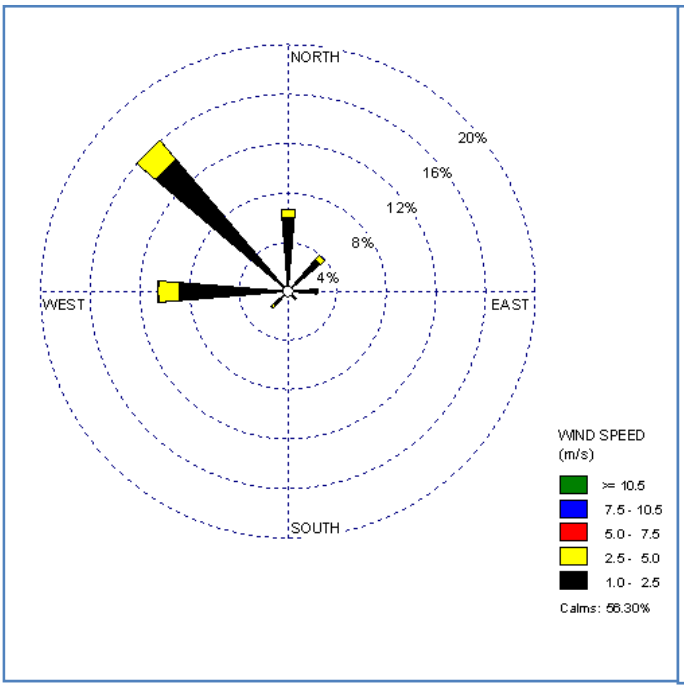
Table 4.2.4(1): Yearly and Monthly Wind Speed and Direction, 2008-2012

Unit: Spd in knots

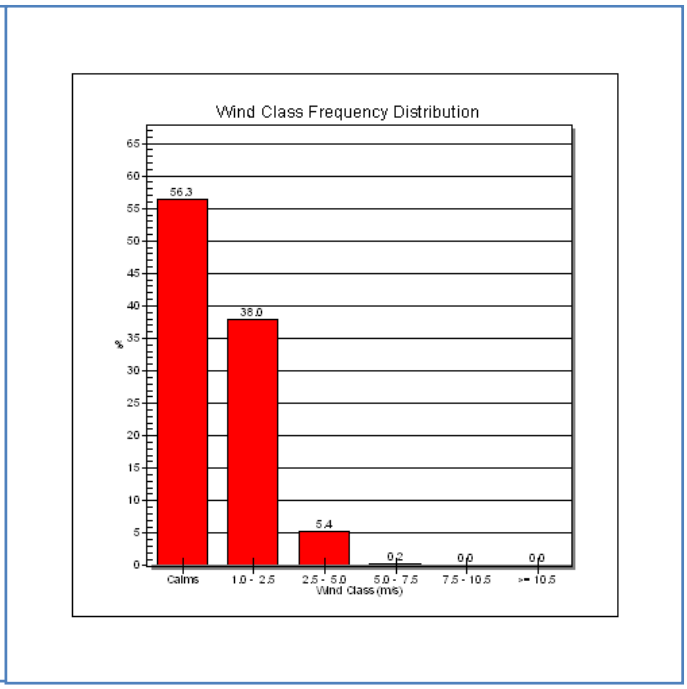
Year	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir
2008	2.9	NW	3.4	W	3.1	S	3.4	SE	3.6	SE	3.5	SE	2.9	SE	4.1	E	3.9	E	4.7	E	2.7	NW	3	NW
2009	3.3	W	3.1	W	3	W	3.4	SE	3.8	E	2.8	SE	3.9	E	3.1	SE	5.5	E	3	NW	2.8	NW	2.7	NW
2010	3.1	NW	3.5	W	4.3	SE	4	SE	3.6	SE	2.7	SE	3.9	E	2.7	SE	2.8	E	4.4	E	2.7	NW	2.2	NW
2011	2.5	W	2.8	W	3.6	S	2.7	SE	2.9	E	4.7	E	3	SE	4.8	E	3.9	SE	3	NW	2.4	NW	2.5	NW
2012	3.3	W	3.8	W	3.6	SW	3.7	SE	3.6	SE	3.4	SE	3.1	SE	3	E	3.6	E	2.5	NW	2.5	NW	2.8	NW

Station : Bogra, BMD

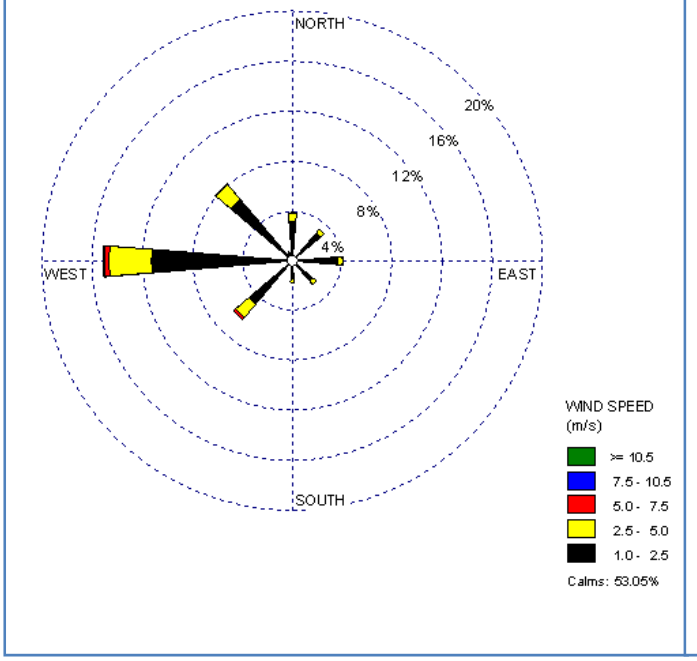
Wind Rose, January



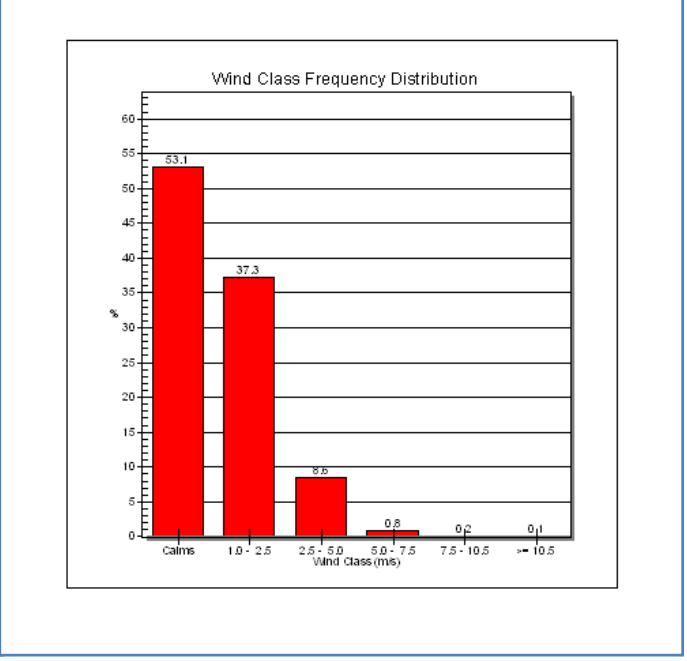
Wind Class, January



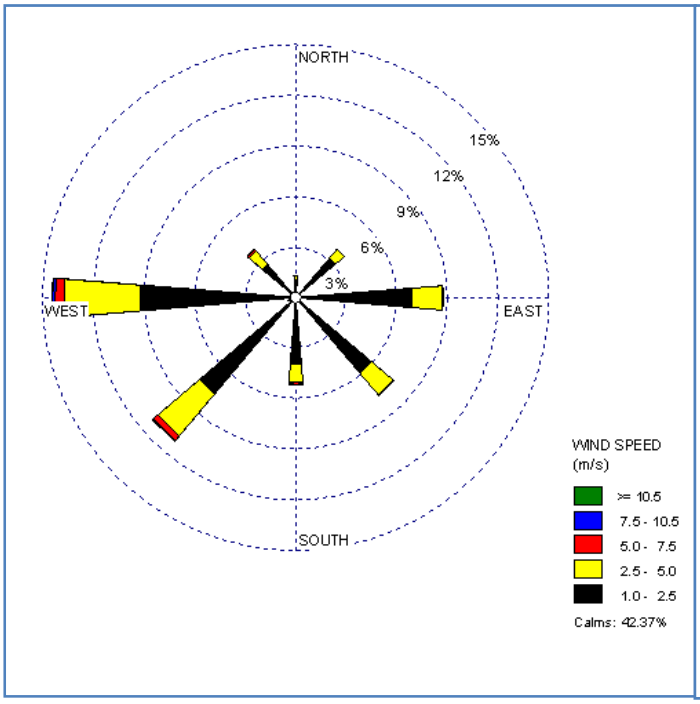
Wind Rose, February



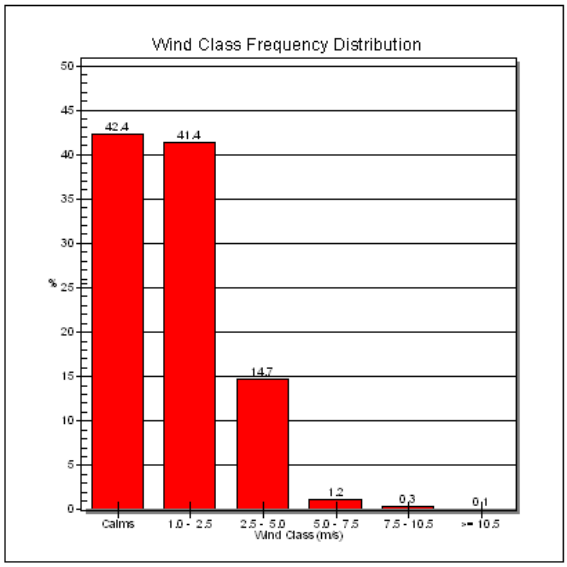
Wind Class, February



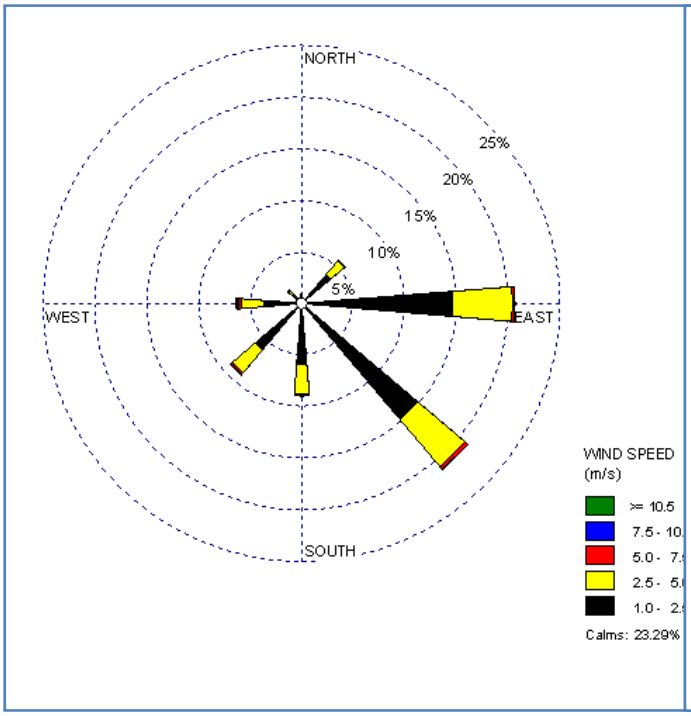
Wind Rose, March



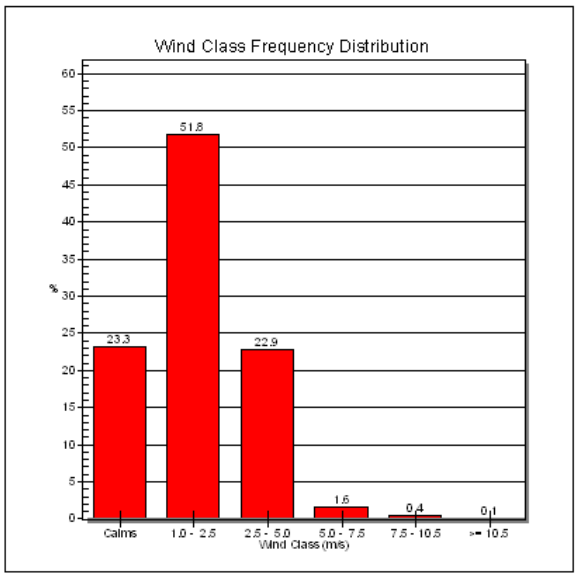
Wind Class, March



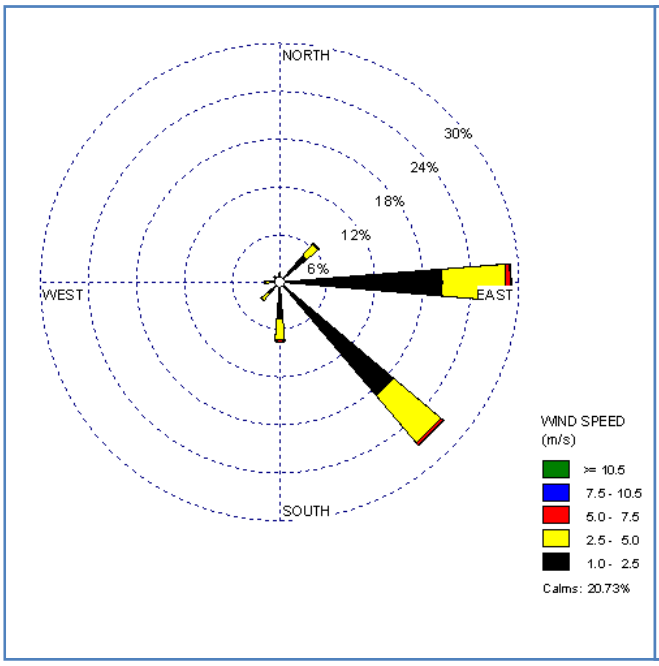
Wind Rose, April



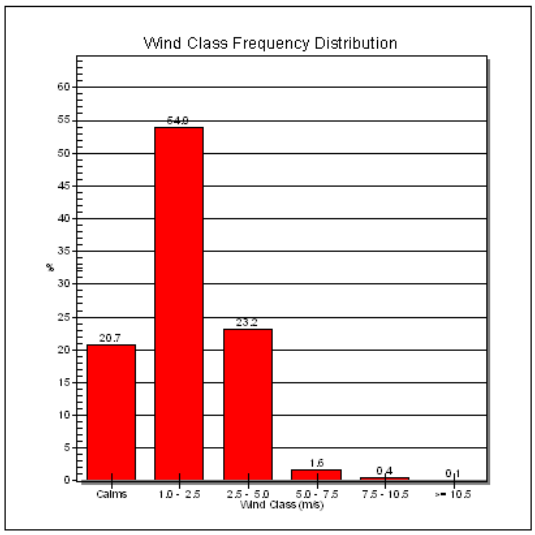
Wind Class, April



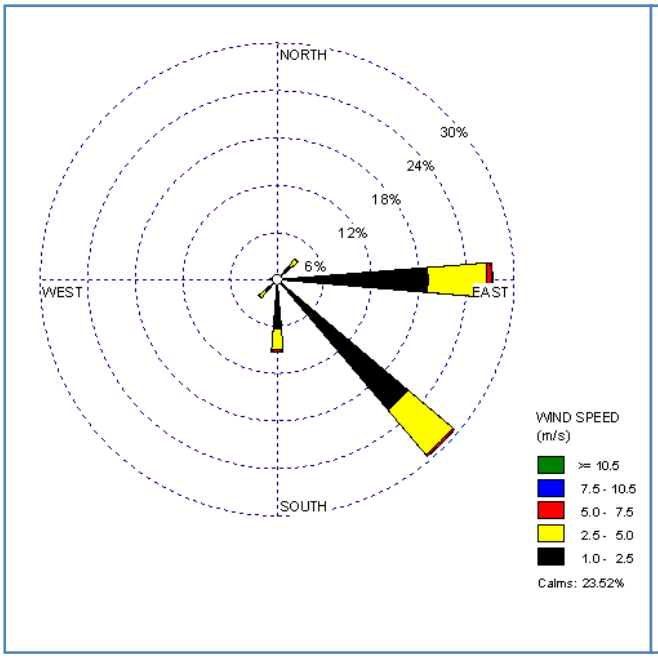
Wind Rose, May



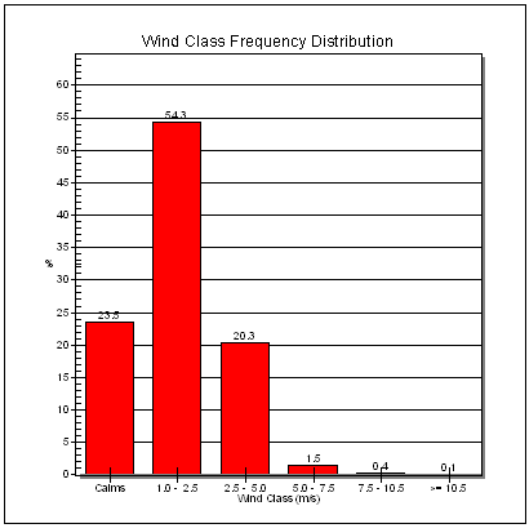
Wind Class, May



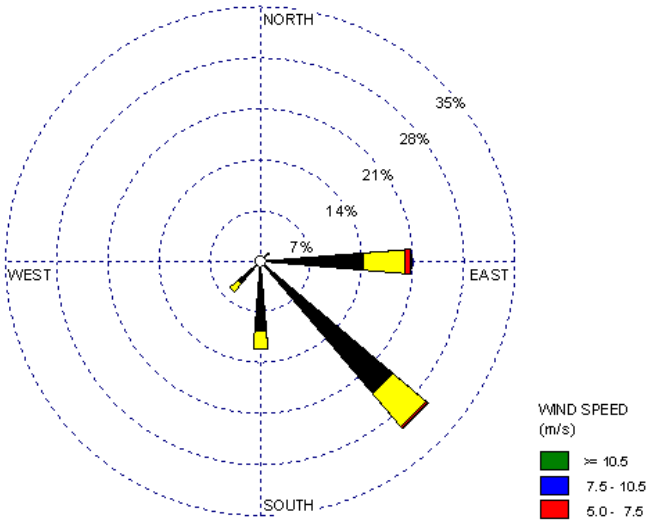
Wind Rose, June



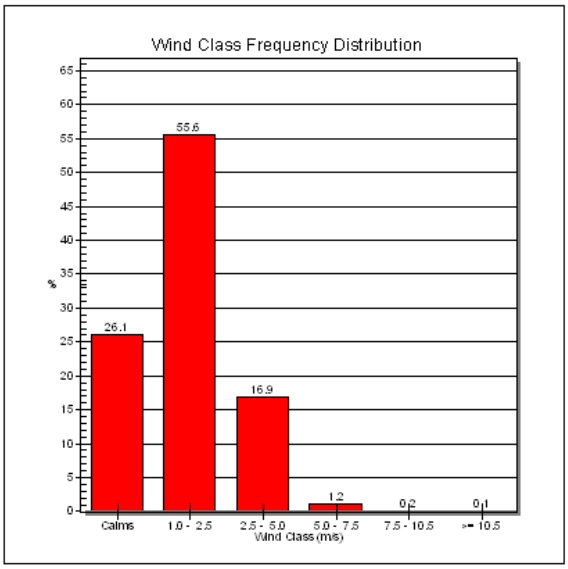
Wind Class, June



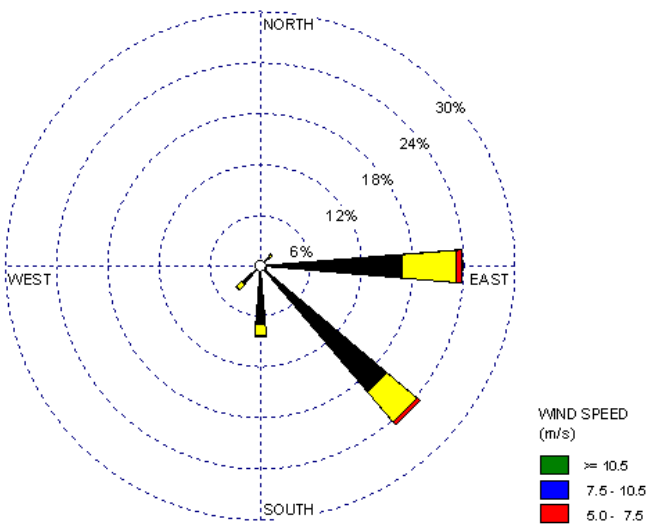
Wind Rose, July



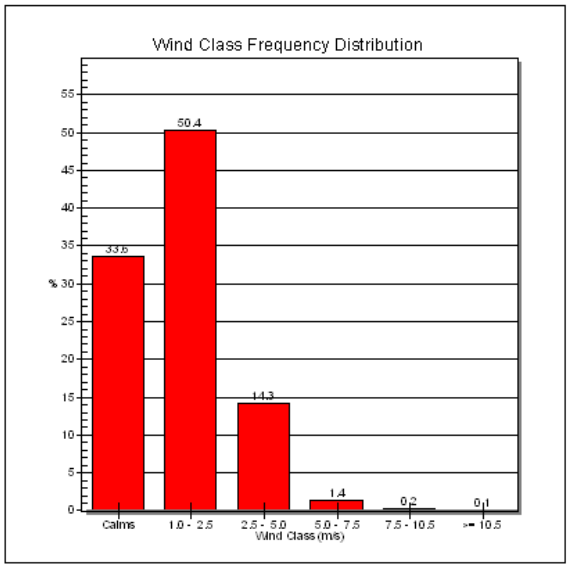
Wind Class, July



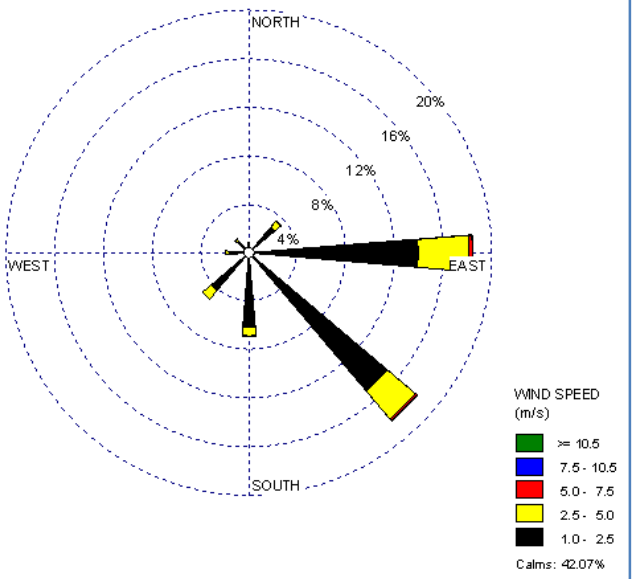
Wind Rose, August



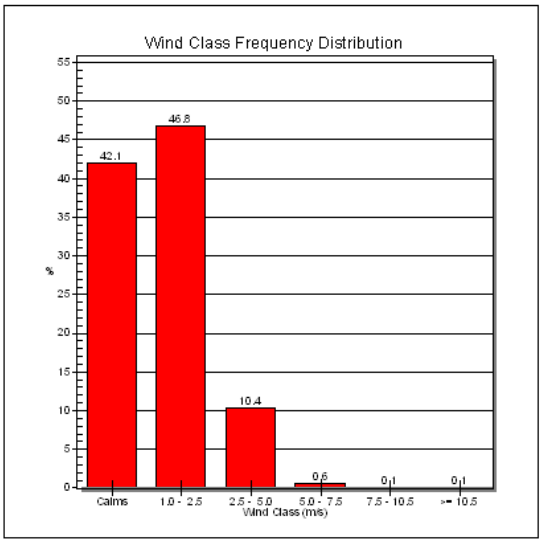
Wind Class, August



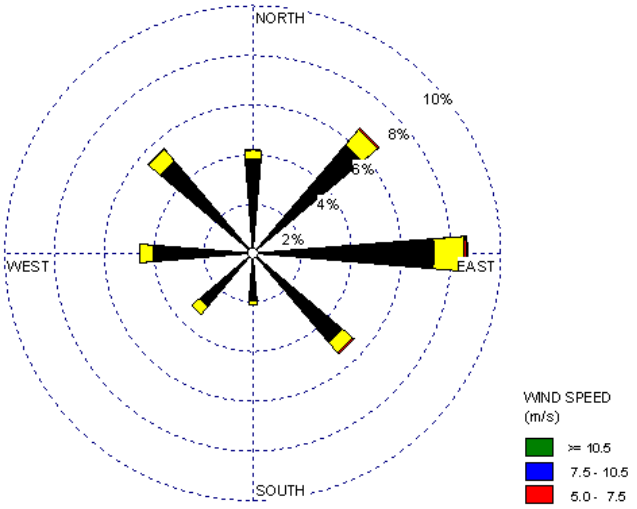
Wind Rose, September



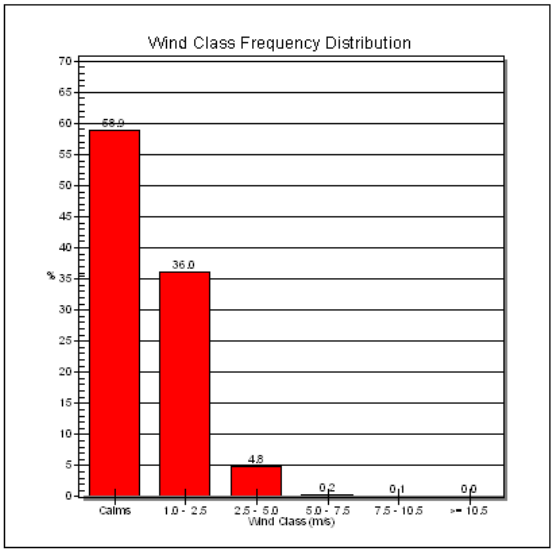
Wind Class, September



Wind Rose, October

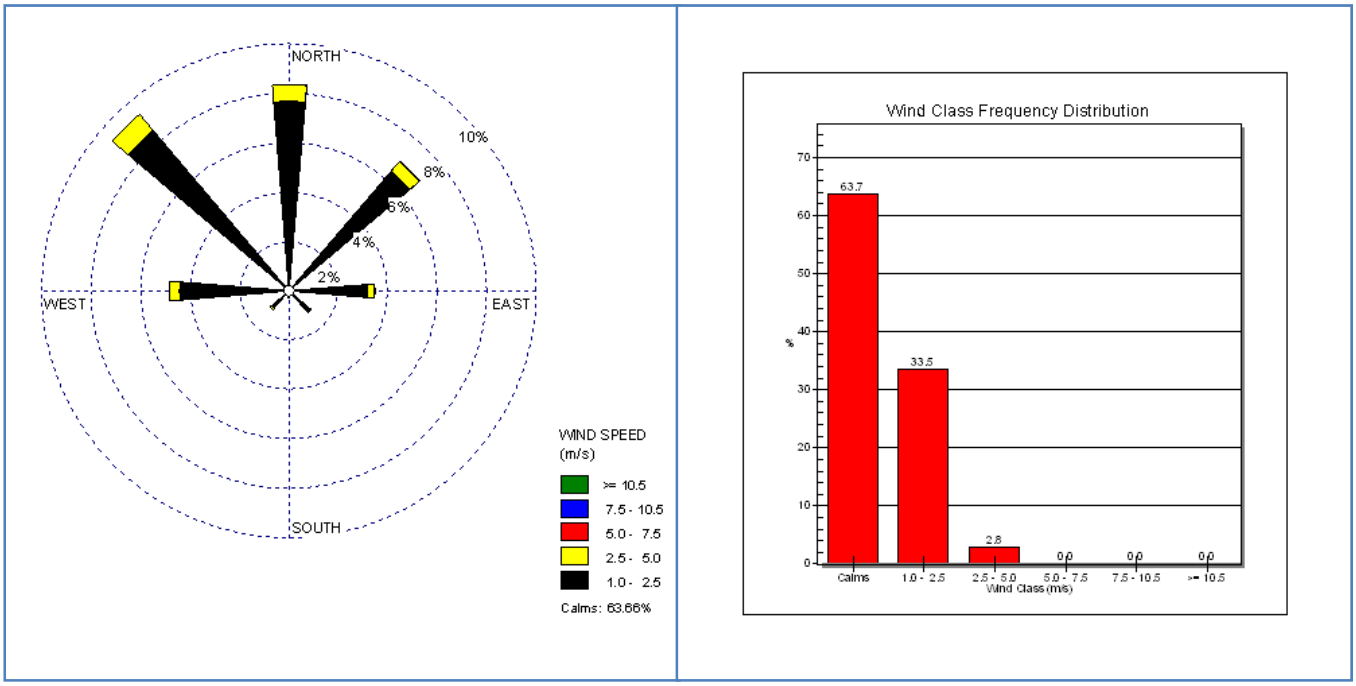


Wind Class, October



Wind Rose, November

Wind Class, November



Wind Rose, December

Wind Class, December

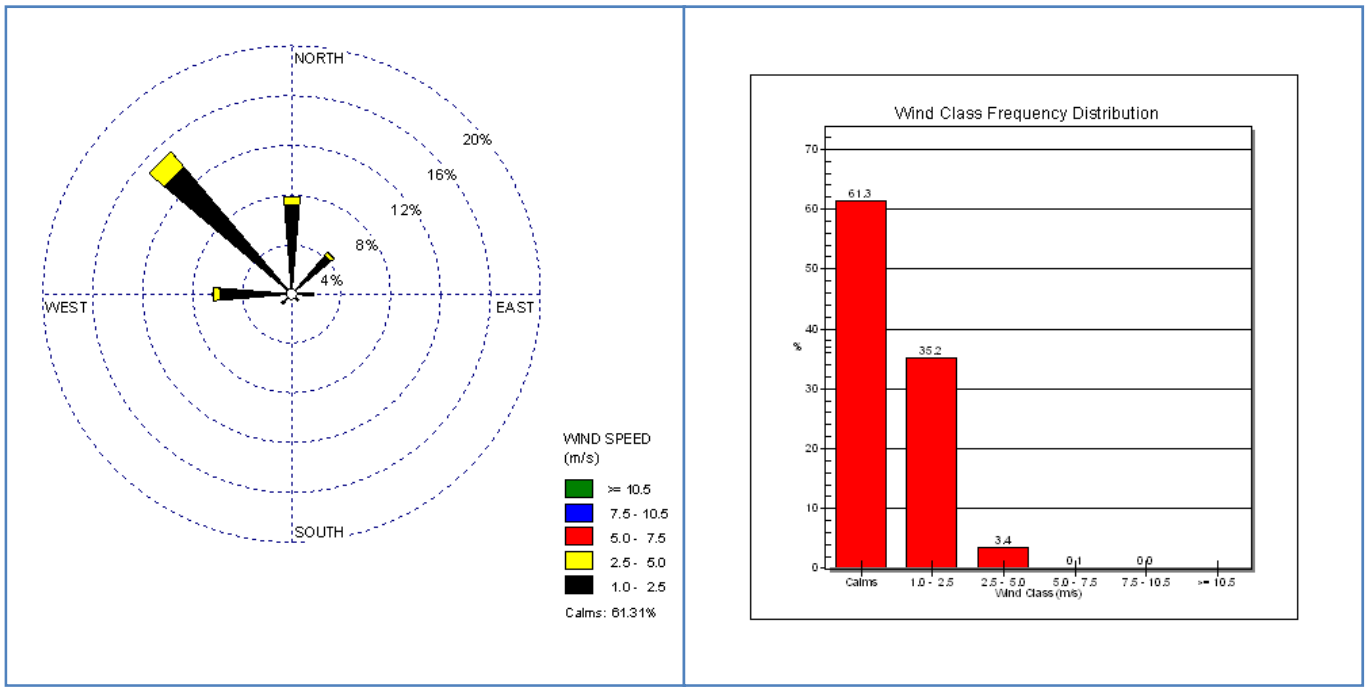


Figure 4.2.4: Wind Rose & Wind Class (January- December), Bogra

Table-4.2.4(2): List of Major Cyclonic Storms in Bangladesh from 1960 to 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	---	---
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	09	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

Date of landfall	Nature of Phenomenon	Landfall Area	Maximum Wind Speed in kph.	No. of deaths	Surge height
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	03	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	02	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 winds	Khulna-Barisal coast near Baleshwar river	223	3,363	15-20 feet
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			

Source : BMD

4.2.5 Seismic Data

Before we discuss the Seismicity of the region, we are to know the basic geological structure of the area. The Gangatic plain was originally a deep depression or trough lying between the peninsula and the mountain region. The depression was, perhaps due to a sagging or subsidence of the northern part of the peninsula. As it arrested the orogenic movement or southward advance of the Himalyan mountain waves, the depression was rapidly filled up by alluvial deposits, which have completely shrouded the old land surface to a depth of several thousand feet. The deposition of the debris and the sinking of the trough must have proceeded side by for about 30 million years, throughout the Miocene Pliocene and Pleistocene periods of Gaenozoic Era. The Bengal basin from Rajmahal Hills to Assam Hills, is, however, of latest origin.

So far as the Geology of Bangladesh is concerned, it is the part of this Bengal Basin, most of which has been slowly subsiding due to tectonic forces responsible for building the

Himalayas. The Himalayas, though the loftiest mountains of the world, have not yet attained their Maximum elevation but are syill rising. The slow subsidence is estimated to be about one inch per year in the coastal regions, as is evident from the present position of tree stumps cleared about a century back, in the Sundarban region, in the districts of Khulna and Barisal. This has practically nullified the sedimentation effect of huge amount, estimated to be about 2000 million tons per year of silt carried by the Ganges, the Jamuna and the Meghna. On the whole the coast line has not extended more than what had been mapped by James Rennel about 200 years ago in 1770. Rather a net loss of land area is observed.

This goes to show that the strata under the Himalayas and the adjoining area lying at their feet are in a state of tension and have not yet settled down to their equilibrium planee. By far the largest number of disastrous Indian earthquakes have occurred along these tracts.

Based on the seismicity, Bangladesh has been divided into three seismic zones as follows:

Zone-I : Severe (Seismic Factor - 0.08g)

Zone-II : Moderate (Seismic Factor – 0.05g

Zone-III : Minor (Seismic Factor – 0.04g)

Seismic Zones of Bangladesh are shown in **Figure-4.2.5**

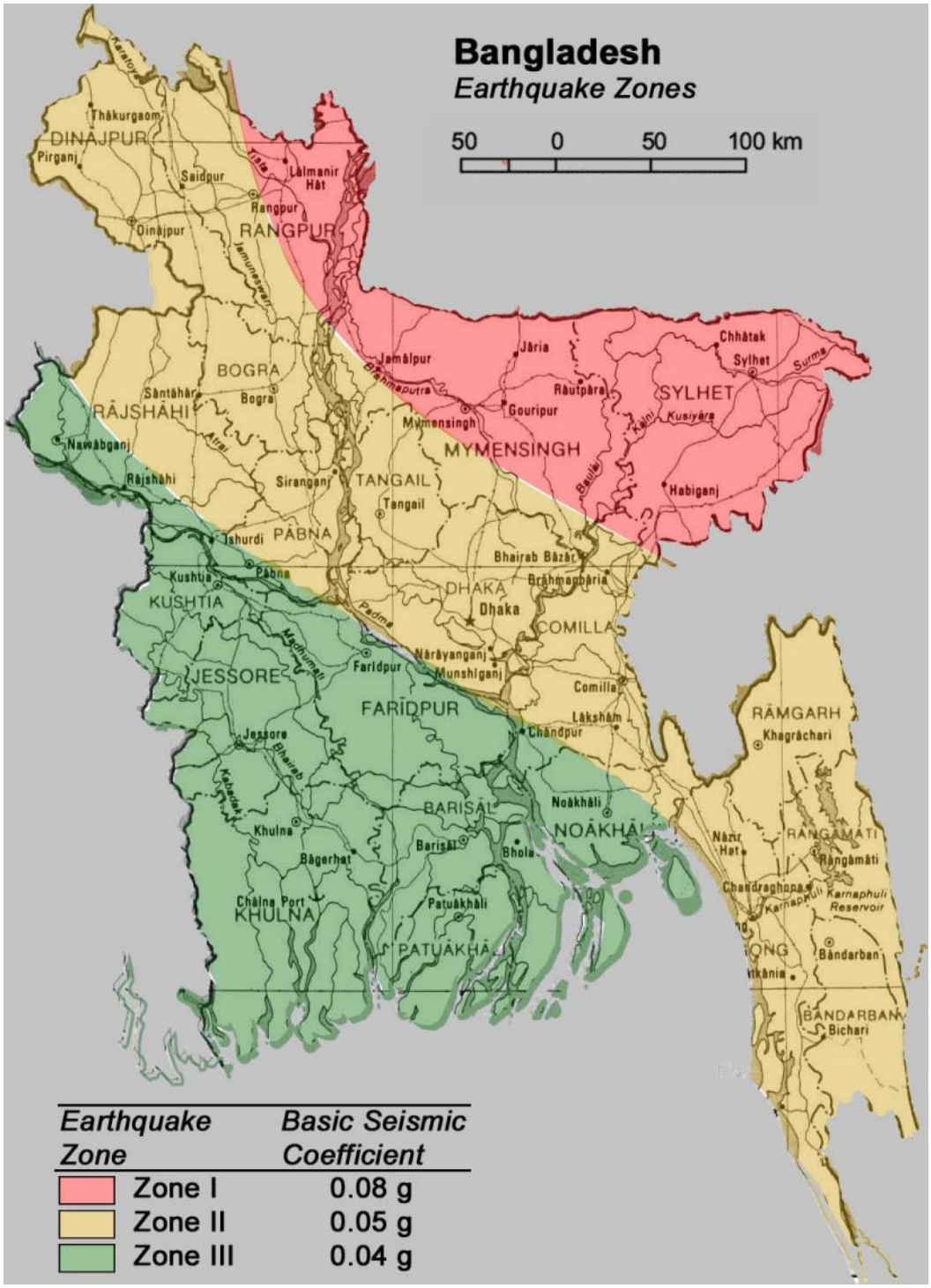


Figure-4.2.5 : Seismic Zones of Bangladesh

The proposed Sirajgonj 150 MW Peaking Power Plant up-gradation project falls under **Zone-II (Moderate Damage), whose Seismic Factor is 0.05g.**

List of earthquakes occurred around Bangladesh is given in **Table-4.2.5.**

Table-4.2.5 : List of Earthquakes

Sl No.	Date (D/M/Y)	Lat (°N)	Long (°E)	Magnitude (Richter Scale)	Location of Epicenter
1	10-01-1869	24.79	93.17	7.5	Kachar , Assam , India
2	14-07-1885	24.70	89.55	7.0	Eastern Province , Nepal
3	12-06-1897	25.84	90.38	8.8	Shilang , Meghalaya , India
4	08-07-1918	24.16	91.75	7.6	Dauki , Meghalaya , India
5	02-07-1930	25.95	90.04	7.1	Dhubri , Assam , India
6	15-01-1934	26.60	86.8	8.3	Bihar-Nepal Border
7	23-10-1943	26.80	94.00	7.2	Assam, India
8	15-08-1950	28.79	95.62	8.6	Tibet , China
9	21-03-1954	25.86	94.00	7.2	Assam , India
10	08-07-1975	25.58	92.60	6.5	Assam, Sillon
11	06-08-1988	25.13	95.15	6.6	Manipur-Myanmar Border
12	21-11-1997	22.07	92.75	8.5	Arakan , Myanmar
13	11-08-2009	15.01	92.30	7.8	Andaman Islands

Source : BMD

4.3 Topography and Drainage

The proposed Sirajganj 225MW Combined Cycle Power Plant (2nd Unit-Dual Fuel) project area occupies the active Brahmaputra-Jamuna Flood Plain. The average elevation in the proposed location is about **16.75m**. The general slope is from west to east. However, attempts have been made to sandfill the land of the proposed Power Plant in almost the same level. Since the land adjacent to the Jamuna River is slightly at a lower level and the slope is from west to east, the floodwater does not stand resulting no water logging. The topography does not inhibit drainage in the project site area.

No settlements were observed in the project area during the survey. However there is population, on the western side of the project site, but outside the proposed power plant area.

The land types in Bangladesh are flood depth phases of flood plain soils and are designated according to the maximum depth prevailing for a minimum three-day period during the peak season and occurring with an annual probability of about 1.5 (FPCO, 1992). According to the previous 30 years of flood record in the Jamuna River, it indicates that no large floods occurred in this area.

The drainage pattern of the project area follows the land gradient, sloping from west to east, towards the Jamuna River. As the general slope of the project area is gradually from west to east, it (the slope) allows rapid drainage during the monsoon and post-monsoon periods.

4.4 Geology and Soils

4.4.1 Geology

Geology of Bangladesh is generally dominated by poorly consolidated sediments deposit over the past 10,000 to 15,000 years (Holocene age). The geology of the study area consists of Quaternary deltaic sediments, which have been strongly influenced by tectonic movements on deep-seated faults. The area lies on a tectonic block, which has been uplifted relative to the surrounding areas. In terms of crop production, the soils of Bangladesh can be categorized into three main classes: floodplain, terrace and hill soils. The proposed site is on a floodplain or alluvial soils. This type of soil mainly comprises sandy barns and sandy clay barns and tends to be gray to dark gray in poorly drained basins and brown on higher and better drained land.

Due to the erosion control and bank protection infrastructure, carried out by BWDB, the project area is free from Active Flood. All the sediments below this area are mainly sandy / silty of Brahmaputra-Jamuna Floodplain deposits. The thickness of these alluvial sediments is more than a km. The detailed investigation can provide the actual strata graphic sequences of the area.

The project area falls in the seismic **Zone-II**. This is major affecting zone. The seismic co-efficient or load factor of this zone is **0.05 g**. The texture of soils of the project area is silt loam to sandy loam.

(Source: Geological Survey of Bangladesh)

4.4.2 Soils

The proposed site is located in Khas Barashimul Mouza of Sirajganj Sadar Thana in Sirajganj District. The proposed site is surrounded by the Jamuna Bridge on the north, Barashimul Panchasona Mouza and Saydabad Union on the west and Jamuna river on the east. The land of the proposed plant is now lying vacant.

According to the national classification, the proposed site is a part of the Brahmaputra-Jamuna River floodplain. In this region, the soil is predominantly sandy with fine silt.

Soil investigation in the proposed site is to be conducted. Regarding the subsoil formation of the project area, the followings soil conditions are required to be determined:

a. Whether the layers of soil are found regular in between the Boreholes.

b. Whether the entire sub soil formation of the project site, thorough out up to the depth of the investigation, is of non-plastic nature.

c. Whether these non-plastic soil comprises of silty soil, sand-silt mix or silty fine sand up to the depth of the investigation.

d. Whether the top layer of the non-plastic silty soil, extending roughly to the depth of 8.0m generally are in a very loose to loose state.

e. Further below, whether the layers of the non-cohesive silty soil & sand-silt mix extending to a variable depth of 8.0m to 19.0m generally are in a medium dense and occasionally in a loose state.

f. Whether the subsequent deep layers of the non-cohesive sand-silt mix and silty fine sand generally are in a dense and very dense state.

g. Whether due to the poor relative density as well as the poor bearing capacities of the investigated soils roughly up to the depth of 4.0m 8.0m measured from the EGL, providing shallow foundations are feasible or not, for the existing subsoil condition.

4.5 Hydrology and Water Resources

The hydrological regime of the project area is governed by the Jamuna river. Historically, spills from this river were carried and sand deposited to the site. It is the main drainage channel of the area. The general runoff pattern is from west to east through the Jamuna river.

The mean monthly water level of the Jamuna river at Sirajganj gauge shows that there was no major flood in the project area which may cause any damage to homesteads, agriculture, industries or infrastructure.

4.5.1 River Water

4.5.1.1 River Network

The Jamuna river, flowing along the eastern side of the proposed power plant site, is a combination of the rivers of Brahmaputra and Jamuna, **both tributaries of the Padma,** which is one of the three major river systems in Bangladesh. The river has no tidal effect. It meets the **Padma River at Goalanda about 40km south** of the site, which in turn ultimately goes to the Bay of Bengal.

4.5.1.2 River Water Level

Jamuna river Water level data of nearby **BWDB Station 49** for the period 2003-2012 is given in **Table-4.5.1.2(1).** The highest water level of **14.95m** was found in **September 2007,** whereas the lowest level of **6.19m** was found in **February 2006**. The data showed that the water levels of the river are not much influenced by tidal effect and also indicate wide variation between water levels in monsoon and dry seasons. There is rise in water level with commencement of monsoon rainfall from May/June till September/October.

Table-4.5.1.2(1) Jamuna River Water level in meter at Sirajganj (BWDB Station No. 49)

Year		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003	Max	7.94	7.44	7.92	9.15	9.71	12.88	14.34	13.1	13.25	13.03	10.83	9.13
	Min	7.45	7.35	7.33	7.86	8.94	9.75	12.68	12.57	12.63	10.9	9.15	8.3
2004	Max	8.29	7.78	8.39	10.56	12.02	13.76	14.81	13.44	13.58	13.19	10.49	8.85
	Min	7.79	7.4	7.37	8.75	9.08	10.98	12.7	12.6	11.82	10.5	8.88	8.05
2005	Max	8.04	8.05	9.33	10.22	10.45	12.43	13.14	13.3	13.31	12.05	10.16	7.9
	Min	7.58	7.37	7.92	9.13	9.55	10.34	11.85	11.81	10.5	9.86	7.92	7.05
2006	Max	7.02	6.41	7.13	9.1	9.44	12.7	12.73	12.54	12.94	11.34	9.24	7.98
	Min	6.42	**6.19**	6.41	6.47	7.93	9.45	11.91	10.72	11.2	9.28	7.93	7.2
2007	Max	7.19	6.77	6.88	9.76	11.4	13.5	14.9	**14.95**	14.71	11.97	10.4	8.73
	Min	6.65	6.59	6.67	6.87	8.84	11.04	12.34	13.09	12.05	10.47	8.78	7.71
2008	Max	7.69	7.17	7.62	9.1	10.02	12.52		14.12	14.33	11.55	10.52	8.34
	Min	7	6.85	6.71	7.67	9.06	9.98		13.1	11.59	9.67	8.36	7.41
2009	Max	7.39	6.76	7	8.48	10.27	10.73	12.87	13.68	12.9		9.41	8.3
	Min	6.78	6.4	6.4	6.8	8.51	9.61	10.9	12.55	11.21		8.24	7.33
2010	Max	7.3	6.57	7.03	11.59	12.02	13.23	13.2	13.5	13.83	12.6	10.18	8.59
	Min	6.6	6.22	6.22	7.37	9.95	11.19	12.6	12.17	12.66	10.25	8.64	7.59
2011	Max	7.56	7.07	8.37	8.9	9.88	11.59	13.42	13.33	12.48	12.28	9.14	7.85
	Min	7.05	6.79	6.69	7.75	8.59	9.77	11.64	12.63	11.23	9.19	7.89	7.13
2012	Max	7.11	6.8	7.23	9.43	10.67	13.75			13.98			
	Min	6.74	6.68	6.75	7.26	9.3	10.11			11.79			

Source: BWDB

Water level, discharge and velocity are also measured at another **BWDB station No.SW46.9L** at Bahadurabad_Transit on Jamuna river. Water level/discharge/velocity data of **BWDB Station SW46.9L** for the period 2003-2012 are given in **Table-4.5.1.2(2).**

Table-4.5.1.2(2): Jamuna River Water level/discharge/velocity at BWDB Station SW46.9L

Year	Water level (m)		Max. Discharge (cu-m/sec)	Max. Velocity (m/sec)
	Max	Min		
2003	19.86	13.28	65683.93	2.78
2004	20.1	13.04	96105.52	3.19
2005	19.45	13.225	58766.89	2.843
2006	18.625	12.95	47666.45	2.572
2007	18.85	13.305	42240.84	1.932
2008	19.6	13.405	62378.87	2.707
2009	19.215	13.155	86939.11	2.055
2010	19.515	13.03	45775.37	2.37
2011	19.565	13.265	53317.36	2.279
2012	13.4	12.62	4271.757	1.126

Source: BWDB

From the above tables, it was found that the minimum water level 12.62m and maximum water level 20.1m with lowest discharge capacity of 4272m^3/sec. So, the water requirement of the power plant can be met from the Jamuna river without any impact on the river water level.

4.5.2 Groundwater

It is proposed to utilize Ground water for domestic and office consumption, firefighting, process and cooling purposes of the proposed power plant. So a study on ground water in the project area has been conducted. It is concluded from this study that the natural aquifer condition in the study area would be suitable for supplying 30000 m^3/day of water continuously without any permanent lowering of groundwater table and environmental

degradations. Jamuna River invariably fully recharges the aquifer in the wet season of each year.

The Department of Public Health Engineeing (DPHE) has also investigated ground water at Enayetpur (89.71213^0 Longitude and 24.21168^0 Latitude) near the proposed site under Sadia Chandpur Union of Chauhali Upazila of Sirajganj district From the investigation of DPHE, the following Lithology and Hydrostratigraphy in the investigation area were found:

Lithology

Depth to Top (m)	Depth to Base (m)	Lithologic Desccription
0.00	6.10	Silty Clay
6.10	19.20	Very Fine Sand
19.20	28.65	Fine sand
28.65	37.79	Fine to Medium Sand
37.79	62.79	Medium to Coarse Sand
62.79	68.88	Medium sand
68.88	79.55	Medium to Coarse Sand

Source: DPHE

Hydrostratigraphy

Depth to Top (m)	Depth to Base (m)	Hydrostratigraphy
0.00	6.10	Aquitard 1
6.10	79.55	Aquifer 1

Source: DPHE

From hydrostratigraphy table, it is found that there is a huge aquifer with depth of about **73m** just **6m** below ground level. The average ground water level was measured by the adjacent villagers is about 6m from the ground level. Moreover, Jamuna river is located beside the proposed site. So, there will be no adverse impact in withdrawing groundwater for the proposed power plant.

4.6 Air Quality

Sirajganj Sadar Thana, particularly the project area, is not heavily industrialized. The present ambient air quality of the concerned area, as a result, is not much contaminated. However, in order to ensure safety of power source and security of living beings including human beings, air samples were collected from 2 locations; one sampling point for survey in the proposed power plant area and the other sampling point in front of main gate of power plant complex. The location of sampling points are shown in **Figure-4.6** and the coordinates of the sampling points are given in **Table-4.6(1).** The air samples were collected by DOE, Bogra and the samples were analyzed by DOE, Bogra.

Figure-4.6 : Location of Air samples on Satellite Image of Project area

Table-4.6(1): Coordinates of Air Sampling Points

No.	Location	Coordinates	
		Longitude (N)	Latitude (E)
ASP01	In front of existing 150MW PPP	$24^0$23'6"	$89^0$44'50"
ASP02	In front of Main Gate of Power plant complex	$24^0$23'15"	$89^0$44'34"

The Test results of Survey of Air quality in the Project Area is given in **Table-4.6(2).**

Table 4.6(2) : Result of Survey of Air Quality

Date	Sampling Point	Duration	SPM µg/m^3	SO_x µg/m^3	NO_x µg/m^3
25 /09/2013	ASP01 : In front of existing 150MW PPP	8 hours	144.12	23.10	28.45
25 /09/2013	ASP02 : In front of Main Gate of Complex	8 hours	133.25	16.65	22.15
Bangladesh Standard as per ECR 2005			200	120	100
Remarks			Within limit	Within limit	Within limit

Test Result of Air Quality in the project area certified by DOE is given under **Annex-4.6**

Some photographs taken during sample collections are given below:

4.7 Noise Level

Noise level were measured at three locations – 1st location in front of existing 150MW PPP, 2nd location in front of East boundary and 3rd location in front of main gate of Complex. The location of sampling points are shown in **Figure-4.7** and the coordinates of Noise measurement points are given in **Table-4.7(1).**

Figure-4.7: Location of Noise Measurement Point on Satellite Image of Project area

Table-4.7(1): Coordinates of Noise Measurement Points

No.	Location	Coordinates	
		Longitude (N)	Latitude (E)
NSP01	In front of existing 150MW PPP	$24^0$23'6"	$89^0$44'50"
NSP02	In front of East Boundary Wall	$24^0$23'11"	$89^0$44'52"
NSP03	In front of Main Gate of Power plant complex	$24^0$23'15"	$89^0$44'34"

The present situation of the noise level around the site (**September 25, 2013**) is as shown in **Table 4.7(2)**

Table 4.7(2): Result of Noise Measurement at Proposed Power Plant Site

Date	Location	Time	dBA	
			Highest	Lowest
25/09/2013	NSP01: In front of existing 150MW PPP	2:00pm	86	82
25/09/2013	NSP02: In front of East Boundary Wall	2:20pm	73	69
25/09/2013	NSP03: In front of Main Gate of Power plant complex	2:30pm	61	56
	Bangladesh Standard (Industrial Zone)		Day – 75, Night - 70	

Note: Day 6am to 9pm. Night- 9pm to 6am

From the above test results, it is seen that noise level in the existing PPP location is above the Bangladesh Standard limit and other locations is below the Bangladesh Standard limit. In

the existing power plant location, the noise level was measured very high because of ongoing construction work of combined cycle power plant at that time.

DOE's Test Result of Noise level in the project area is given under **Annex-4.7.**

Some photographs taken during Noise measurement are given below:

4.8 Water Quality

4.8.1 River Water

In order to test the quality of the Jamuna River, water samples were collected from Jamuna river proposed power plant site ($24^0$23'39"N, $89^0$45'36"E) at surface and 3 meter depth on September 25, 2013. The test was carried out by DoE, Bogra. The location of sampling point of Jamuna River water is shown in **Figure-4.8.1.**

Figure-4.8.1: Location of River Water Sampling Point on Satellite Image of Project area

The DOE test results of Jamuna River water quality is given in **Table-4.8.1.**

Table 4.8.1 : Test Report of Jamuna River Water Quality

Item/Parameter	Unit	At Surface	At 3 meter depth	Acceptable Limit According to ECR'97
		25/09/2013	25/09/2009	
Temperature	^{o}C	29.6	28.7	40^{0}C
pH		7.72	7.70	6.5-8.5
DO	mg/l	5.1	5.0	4.5 - 8
BOD	mg/l	1.0	1.0	50
COD	mg/l	12	10	200
Turbidity	NTU	44.8	46.2	
Chloride	mg/l	65	60	<150
TS	mg/l	230	220	2200
TDS	mg/l	170	170	150
SS	mg/l	60	50	150
EC	µmos/cm	328	321	1200
Remarks: All parameters are within limit				

From the test results, it is seen that all parameters are within acceptable limit.

The DOE's test Report on the river water quality is enclosed under **Annex-4.8.1.**

Some photographs taken during Jamuna river water sample collection are given below:

4.8.2 Ground Water

In order to test the quality of groundwater at power station site, water samples were collected from the existing Deep Tubewell of the 150MW PPP on September 25, 2013. The test was carried out by DoE, Bogra.

The DOE test results of groundwater quality is given in **Table-4.8.2.**

Table 4.8.2 : Test Report of Ground Water Quality

Item/Parameter	Unit	25/09/2013	Acceptable Limit According to ECR'97
Temperature	^{o}C	28.5	20-30
pH		7.23	6.5-8.5
EC	µmos/cm	532	1200
DO	mg/l	5.1	6
BOD	mg/l	0.1	0.2
COD	mg/l	>4	4
TS	mg/l	320	2100
TDS	mg/l	270	-
SS	mg/l	50	150
Iron	mg/l	0.26	0.1-2.0
Arsenic	mg/l	Nill	0.05
Turbidity	NTU	8.2	10
T-Hardness	mg/l	160	200-500
Chloride	mg/l	78	150-600
Remarks: All parameters are within limit			

From the test results, it is seen that all parameters are within acceptable limit.

The DOE's test Report on the river water quality is enclosed under **Annex-4.8.2.**

Some photographs taken during ground water sample collection are given below:

CHAPTER 5: EXISTING ENVIRONMENT: ECOLOGICAL

5.1 Terrestrial Ecosystem

In general terms an ecological system can be defined as an assemblage of organisms (plant, animal and other living organisms - also referred to as a biotic community) living together with their environment (or biotope), functioning as a loose unit. That is, a dynamic and complex whole, interacting as an "ecological unit". Ecosystems are functional units of interacting abiotic, biotic, and cultural (anthropogenic) components. All natural ecosystems are open systems where energy and matter are transferred in and out through the complex interactions of energy, water, carbon, oxygen, nitrogen, phosphorus, sulfur and other cycles.

The project site is located in rural area. As the project area is in char land, there is no natural vegetation or forest cover within the project area. However, appropriate mitigation program should be undertaken to protect the existing ecosystem from gaseous emissions and water discharge from the proposed power plant.

5.1.1 Terrestrial Flora

Terrestrial plants found during survey in and around the project area, on homesteads, roadside and agricultural lands have been listed. The project area provides the following major species of natural plants including herbs, shrubs, grasses and plants which are important both economically as well as for environmental sustainability of the area. The flora in and around the project area are dominated by the fruit plants, flower and ornamental plants.

The common fruits are the **mango, jackfruit, banana, papaya, guava, lemon, coconut, palm, tamarind, ata (*Anama reticulata*), karamcha (*Carissca carandas*), safeda (*Achras sapota*), wood apple, lichi, plums, watermelon, sweet melon etc. Non-fruit plants are arjun (*Terminalia arjun*), sandal tree, banayan tree, krishnachura (*Delonix regia*),** palash etc. Local, English and scientific names of the species found are given in the following **Table 5.1.1**.

The flowering plants are fairly common in the project area where rose, kamini, champa (*Michelia champa*) etc. are available. The area produces good amount of vegetables and spices of which eggplant, okra, coriander, potato, pointed gourds, gourds, long beans, country beans, chilly, cabbages, bitter gourds etc. are worth mentioning.

Table 5.1.1 : List of plants confirmed around the site

No.	Local Name	English Name	Scientific Name
1	Am	Mango	*Mangifera indica L.* (Anacard)
2	Jam	Black bary	Syzygium cumini skiel. (Myrtaceae)
3	Lichu	Lichi	*Lichi Chinensis Sonn*
4	Kathal	Jackfruit	*Artocarpus heterphyllus Lamk*
5	Narikel	Coconut	*Cocos nucifers L.* (Palmae)
6	Peyara	Guava	*Psidium Guajava* (*L*) Bat. (Myrtaceae)
7	Kola	Banana	*Musa Paradisica*
8	Khejur	Date Palm	*Pnoenis sylvestris*
9	Supari	Betel nut	*Areca catechu*
10	Shimul	Silk cotton tree	*Bombax ceiba L.* (Bombacaceae)
11	Kamranga	Carambola	*Averrhoa carambola*
12	Sofeda	Sopodilla	*Manilkara Zapota*
13	Kadbel	Wood Apple	*Feronia limonia* (*L.*)
14	Bel	Indian Apple	*Aegle marmelos* (*L*).
15	Tal	Palm tree	*Borassus flabellifer L.* (Palmae)
16	Krishnachura	Delonix Regia	*Delonix regia* (*Boj.*) *Raf.* (Leguminosae)
17	Bot	Banayan tree	*Ficus benghalensis L.* (Mora)

No.	Local Name	English Name	Scientific Name
18	Madar	Coral tree	*Erythriana variegata L.* var. *orientalis Merr.*
19	Jambura	Citron	*Citrus grandis*
20	Bash	Bamboo	*Podocarpus nebifolia*
21	Dumur	Fig tree	*Ficus hispida*
22	Koroi	Albizia	*Derris robusta Benth.*
23	Lebu	Lemon	*Citrus aurantifolia*
24	Mehogini	Swietenia fabrilis	*Swietenia mahagoni*
25	Neem	margosa	Melia *Azadirachta indica*
26	Mehedi	Henna	*Lawsonia inermis*
27	Arjun	Arjuna Myrobalah	*Terminalia alata*
28	Jamrul	Wax Apple	*Syzygium samarangense*
29	Chalta	elephant Apple	*Dillenia indica*
30	Boroi	Indian Jujube	*Zayphus rugosa Lam*
31	Tatul	Tamarind	*Tamarindus indicas Linn*
32	Babla	Acacia	*Acacia nilotica*
33	Pate	Jute	*Corchorus capsularis /olitorius*
34	Kadam	Kadamba	Anthocephalus A. Rich. cadamba Miq., a.k. a.
35	Tulsi	Basil	Ocimum sanctum Linn
36	Kochari pana	Water hayacinth	*Eichhornia*
37	Man Kochu	Arum	Alocasia indica
38	Rashun	Garlic	Allium sativum
39	Pepe	Papaya	Carica papaya L (caricaceae)
40	Ada	Ginger	Zingiber officinale
41	Kalmii Shák	Water spinach	Ipomoea aquatica
42	Mula	Radish	Raphanus sativus
43	Sheem	Hyacinth bean	Lablab niger
44	Barbati	String bean	Vigna sesquipedalis
45	Misti kumra	Sweet gourd	Cucurbita maxima
46	Lau	Bottle gourd	Lagenaria siceraria
47	Chal kumra	Wax gourd	Benincasa hispida
48	Shasa	Cucumber	Cucumis sativus
49	Khira	Cucumber (short)	Cucumis anguina
50	Jhingga	Ribbed gourd	Luffa acutagula
51	Dhundul	Sponse gourd	Luffa cylindrica
52	Ucche/Karala	Bitter gourd	Momordica charantia
53	Kakrol	Teasle gourd	Momordica cochinchinensis
54	Patal	Palwal	Trichosanthes dioica
55	Chichingga	Snake gourd	Trichosanthes anguina
56	Banggi	Muskmelon	Cucumis melo
57	Tarmuj	Watermelon	Citrullus lanatus
58	Alu	Potato	Solanum tuberosum
59	Begoon	Brinjal	Solanum melongena
61	Tomato	Tomato	Lycopersicon esculentum
62	Jhal marich	Chilli	Capsicum species
63	Lalshak	Red amaranth	Amaranthus gangeticus
64	Pui shak (sabuj)	Indian spinach (green)	Basella alba
65	Puishak (lal)	Indian spinach (red)	Basella rubra
66	Palonggshak	Spinach	Spinacia oleracea
67	Helencha	Marsh herb	Enhydra fluctuans
68	Misti alu	Sweet potato	Ipomoea batatus
69	Gajor	Carrot	Daucus carota
70	Thankuni	Indian penny wort	Centella japonica
71	Mukhikachu	Eddoe	Colocasia esculenta
72	Dudkachu	Tannia	Xanthosoma violaceum

No.	Local Name	English Name	Scientific Name
73	Mankachu	Giant taro	Alocasia macrorrhiza
74	Olkachu	Elephant foot aroid	Amorphophallus campanulatus
75	Shajina	Drumstick	Moringa oleifera
76	Kanchkala	Plantain	Musa paradisiaca
77	Shapla	Water lily	Nymphaea stellata
78	Dhekishak	Fern	Dryopteris filix-mas
79	Pán	Betel	Piper betle

5.1.2 Forest and Homestead vegetation

There is no natural or social forest in and around the project area. However, there are dense vegetations in areas opposite the site, on the western bank of the river Jamuna. Trees have been planted in the residential area close to the project site. Although there is no forest, but trees planted and homestead vegetation play an important role in environmental balance and economic life of the people of the project areas in terms of food and nutrition, construction material, biomass fuel, fodder, shelter and shade, windbreaks, organic matter, erosion control and balance between flood and drought.

5.1.3 Biodiversity

The project area has distinctive terrestrial and aquatic habitats. The homesteads and roads are the major components of the terrestrial habitat with flora and fauna. The aquatic habitats include mainly the river.

5.1.4 Terrestrial Fauna

The animals found 1 km around the site include a total of **103** species -- **24** species of mammalian animals, **58** species of birds, **15** species of reptiles, and **6** species of amphibians. Of these, the animals given on the 2013 Red List of the International Union for Conservation of Nature (IUCN) contain 8 species of mammalians, 36 species of birds, 5 species of Reptiles and 4 species of Amphibians fall under the category of Least Concern (LC). 1 species of Retiles is near threatened, 1 species is Vulnerable and 1 species is Data Deficient. **Table 5.1.4** shows the terrestrial animals having been found.

Table 5.1.4 : List of animals found 1 km around the site

No.	Local Name	English Name	Scientific Name	IUCN 2013 Status
Mammals				
1	Kola Badur	Leschenault's Rousette	*Rousettus leschenaulii*	
2	Chamchika	Indian Pipistrelle	*Pipistrellus coromandra*	LC
3	Beji	Mongoose	*common Dwarf Mongoose*	LC
4	Bara Beji/Neuley	Common Mongoose	*Herpestes edwardsi*	
5	Katbirali	Squirrel	*Rodentia : Sciurus*	
6	Badami Kathbirali	Irrawaddy Squirrel	*Collosciurus pygerythrus*	
7	Indur	Lesser Bandicoot Rat	*Bandicota bengalensis*	LC
8	Nengti Indur	House Mouse	*Mus musculus Linnaeus*	LC
9	Ghorer Indur	Common House Rat	*Rattus rattus*	LC
10	Shojaru	Indian Crested Porcupine	*Hystrix indica Kerr*	LC
11	Khek Shial	Bengal Fox	*Vulpes bengalensis*	LC
12	Banor	Rhesus Macaque	*Macaca mulatta*	LC
13	Kukur	Dog	*Cannis Familiaris*	
14	Chagol	Goat	*Capra Hircus*	

No.	Local Name	English Name	Scientific Name	IUCN 2013 Status
15	Bhera	Sheep	*Bovidae : Ovis*	
16	Goru	Cow		
17	Mohesh	Buffalo	*Bubalus bubalis*	
18	Ghora	Horse	*Equus caballus*	
19	Pati Shial/Shial	Golden Jackal	*canis aureus*	
20	Biral	Cat	*Felis : Catus*	
21	Ban biral/Woab	Jungle cat/Swamp Cat	*Felis chaus Schreber..... kutas*	
22	Mecho Biral/Mechho Bagh	Fishing cat	*Prionailurus viverrinus*	
23	Khorgosh	Rabbit	*Leporidae : Cuniculas*	
24	Chhoto Khorgosh	Assam Rabbit	*Caprolagus hispidus Pearson*	
BIRDS				
1	Pati Hans	Spot-billed Duck	*Anas poecilorhyncha*	
2	Rajhans	Bar-headed Goose	*Anser indicus*	
3	Shoru-thont Duburi Hans	Common Merganser	*Mergus merganser*	
4	Bali Hans/Beley Hans	Cotton Pygmy-goose	*Nettapus coromandelianus*	
5	Kaththokra	Woodpecker	*Picoides pubescens*	
6	Lalmatha Kaththokra	Redheaded Bay Woodpecker	*Blythipicus pyrrhotis*	
7	Khudey Kaththokra	Southern Speckled Piculet	*Sasia ochracea reichenowi Hesse*	
8	Machhranga	Kingfisher	*Halcyn smyrensis*	
9	Sotto Machhranga	Bengal Small Blue Kingfisher	*Alcedo atthis bengalensis*	
10	Kokil/Kuli	Asian Koel	*Eudynamys scolopaceus*	
11	Fingey Kuli	Indian Drongo Cuckoo	*surniculus lugubris dicruroides*	
12	Tia	Parakeet	*Psittacula krameri borealis*	
13	Pencha	Owl	*Nocturnalis : Strigiformes*	
14	Laxmi Pencha	Barn Owl	*Tyto alba stertens*	
15	Buno Bhutum Pencha	Forest – Eagle – Owl	*Bybo nipalensis nipalensis*	
16	Ghughu	Spotted dove	*Streptopelia chinesis*	
17	Dora Ghughu	Bar-tailed cuckoo Dove	*Macropygia unchall tusalia*	
18	Raj Ghughu/Dhobal Ghughu	Indian Ring Dove	*Streptopelia decaocto decaocto*	
19	Khudey Ghughu	Laughing dove	*Stigmatopelia senegalensis cambayensis*	
20	Dahuk/Daik	Indian White breasted Waterhen common Coot	*Amaurornis phoenicurus*	LC
21	Hot-ti-ti	Yellow wattled Lapwing	*Vanellus malabaricus*	
22	Babui Batan	Small Pratincole	*Glareola lactea Temminck*	LC
23	Gangchil	Whiskered Tern	*Chlidonias hybrida*	LC
24	Baj	North Indian Crested Goshawk	*Accipiter trivirgatus indicus*	
25	Shakoon	Rumped Vulture	*Gyps bengalensis*	LC

No.	Local Name	English Name	Scientific Name	IUCN 2013 Status
26	Chil	Pariah Kite	*Milvus migrans*	LC
27	Bhubon Chil	Black Kite	*Milvus migrans govinda*	
28	Bak	Intermediate Egret	*Mesophoyx intermedia*	LC
29	Dhushor Bok	Grey Heron	*Ardea cinerea jouyi clark*	
30	Kani Bok/Kana Bok/ Konch Bok	Indian Pond Heron	*Ardeola grayii*	LC
31	Chhoto Bok	Little Egret	*Egretta garzetta*	LC
32	Bulbuli	Brown eared/Red vented Bulbul	*Microscelis amaurotis/ Pycnonotus cafer*	
33	Pata Bulbuli/Horia	Golden –fronted Leaf Bird	*Chloropsis aurifrons*	LC
34	Kak	Crow	*Corvus splendens*	LC
35	Daar Kak	Jungle Crow	*Corvus levaillantii*	LC
36	Pati Kak.Kawa	House Crow	*Corvus splendens*	LC
37	Fingey/Kalipencha/Pakhir Raja/Dhechcha	Ashy Drongo	*Dicrurus macrocercus*	LC
38	Shalik	Indian mynah	*Acridotheres tristis*	LC
39	Badami Shalik	spot-winged starling	*Saroglossa spiloptera*	LC
40	Gobrey Shalik/Go shalik	Asian Pied	*sturnus contra Linnaeus*	LC
41	Jhuti Shalik	Jungle Myna	*Acridotheres fuscus*	LC
42	Gang Shalik	Bank Myna	*Acridotheres ginginianus*	LC
43	Bhat Shalik	Common Myna	*Acridotheres tristis*	
44	Moyna	Hill Myna/Grackle	*Gracula religiosa Linnaeus*	LC
45	Chorai	Sparrow	*Passer domesticus*	LC
46	Dhul charai	Sand Lark	*Calandrella acutirostris Hume*	LC
47	Khetkhamarer Math Chorai	Paddyfield Pipit	*Anthus rufulus vieillot*	LC
48	Babui/Baoi	Baya Weaver	*Ploceus philippinus*	LC
49	Doyel	Magpie Robin	*Copsychus saularis*	LC
50	Paira	Pigeon	*Columba livia domestica*	
51	Finge	Black Drongo	*Dicrurus macrocercus*	LC
52	Tuntuni	Tailorbird	*Orthotomus sutorius*	LC
53	Mohan Chura	Hoopoe	*Upupa epops*	LC
54	Pan kouri	Little cormorant	*Phalacrocorax niger*	LC
55	Banspaati	Green Bee-eater	*merops orientalis*	LC
56	Shamuk Khol	Open Billed Stork	*Anastomus oscitans*	LC
57	Sipahi Bulbul	Red Whiskered Bulbul	*Pycnonotus jocosus*	LC
58	Hash	Duck	*Anatidae : Anseriformes*	
REPTILES				
1	Mithapanir Kasim	Asain Leaf Turtle	*Cyclemys dentata*	NT
2	Kalo Kasim	Spotted Pond Turtle	*Geoclemys hamiltonii*	VU
3	Majhari Kaitta	Median Roofed Turtle	*Pangshura tentoria*	LC
4	Roktochusha	Common Garden Lizard	*Calotes versicolor*	
5	Chhotoleji Roktochusha	Hardwicke's Bloodsucker	*Brachysaura minor*	DD
6	Sabuj Roktochusha	Gunther	*Jerdon's Forest Lizard*	
7	Tiktiki	Lizard.	*Sauria : Lacertidae*	
8	Chhoto Tiktiki	Bowring's House	*Hemidactylus Bowringii*	

No.	Local Name	English Name	Scientific Name	IUCN 2013 Status
		Gecko		
9	Garnoter/ Dhola Tiktiki	Indo-Pacific Gecko	*Hemidactylus garnotii*	
10	Gai/Gaishap	Bengal Monitor	*Varanus bengalensis*	LC
11	Laodoga Shap/sutanoli Shap/Lokhindarer Shap	Common Vine snake	*Ahaetulla nasuta*	
12	Mete Shap/Maitta Shap	Olive Keelback	*Atretium schistosum*	LC
13	Joldhora Shap/Sibolder Joloj Shap	Siebold's Smooth Water Snake	*Enhydris sieboldii*	LC
14	Kalo Mete Dora Shap	Dark Bellied Marsh Snake	*Xenochrophis cerasogaster*	
15	Gokhra shap	Monocellate Cobra/Bengal Cobra	*Naja kaouthia Lesson*	LC
AMPHIBIANS				
1	Beng	Frog	*Anura : Ranidae*	
2	Kotkoti Bang	Common Skittering frog	*Rana Cyanophlyetis*	LC
3	Kola Bang/Sona Bang/Bhawabang	Bull Frog	*Hoplobatrachus tigerinus*	LC
4	Sabuj Pana Bang	Common Gruk Frog	*Hylarana Erythraea*	LC
5	Geso Beng	Canyon treefrog	*Hyla arenicolor Cope*	LC
6	Shuo poka	Caterpillar	*Eriogaster catax*	

Note:

NE: Not Evaluated
NT : Near Threatened
CR : Critically Endangered
DD : Data Deficient
VU : Vulnerable
EW : Exticnt in the Wild
LC : Least Concern
EN : Endangered
EX : Extinct

5.2 Aquatic Ecosystem

5.2.1 General

Bangladesh is mainly a deltaic region of the three big rivers, the Ganges, the Brahmaputra and the Meghna and their tributaries. Aquatic ecosystems perform many important environmental functions. For example, they recycle nutrients, purify water, attenuate floods, recharge groundwater and provide habitats for wildlife. Aquatic ecosystems are also used for human recreation and are very important to the tourism industry. The health of an aquatic ecosystem degrades when the ability of ecosystem to absorb a stress has been exceeded. A stress on an aquatic ecosystem can be a result of physical, chemical or biological alterations of the environment.

Fisheries resources occupy a key position in the agro-based economy of Bangladesh. Fishes are important economically, socially and nutritionally. About 80% of the animal protein in the diet in Bangladesh comes from fish. In the past there was abundance of fishes in water bodies like rivers, floodplains, beels, haors etc. While the large fish species migrate long distances in rivers for breeding, the small fishes migrate over shorter distances or reside in floodplains, beels and canals. Most inland water fishes are small. They are important for nutrition and supplemental income to the vast majority of the rural people, including the landless and the destitute. The miscellaneous species of fish and prawn are termed as "poor people's fish" and provide a support in their struggle against poverty.

During the EIA process, a baseline study of the aquatic ecosystem was undertaken to assess the existing ecological resources in the project area. Water samples at various points of the river Jamuna (near the project site) were collected and analyzed for the parameters such as temperature, pH, DO, BOD, COD, TSS, Chloride, Nitrate, Sulfate, Iron etc. The tests were carried out in the laboratory of DoE, Bogra. Information relating to different species of fish and

other aquatic organism were collected from local people.

The Jamuna river, flowing along the eastern side of the proposed power plant site, is a combination of the rivers of Brahmaputra and Jamuna, both tributaries of the **Padma,** which is one of the three major river systems in Bangladesh. The river has no tidal effect. It meets the **Padma River at Goalanda about 40km south** of the site, which in turn ultimately goes to the Bay of Bengal.

5.2.2 Aquatic Flora

The freshwater dependant plants such as halencha (*Altermanthere philoxeroides*), kalmi (*Ipomoea aquatica*), dolkalmi (*Ipomoea fistulosa*), ichadal (*Potamo seton*) and water hyacinth (*Eichhomia crassipes*) are common in the ponds, borrowpits, ditches, canals and rivers around the project area. Khuda pana (*Lemna minor*), topapana (*Pistia stratiotes*) and chaicha (*Saipus articulatus*) are also common.

5.2.3 Aquatic Fauna

Available fisheries resources in the Jamuna river and surrounding water bodies were assessed. In this area, several carp, catfish, perch, shrimp/ prawn species were found. Specially, presence of Gangetic River Dolphin (an highly endangered species of wildlife) in Jamuna river is reported by local people. A list of fisheries species is given in the following table.

No.	Local (Bangladeshi) Name	English Name	Scientific Name
1	Ilish	Hilsa	*Tenualosa ilisha*
2	Rui	*Rohu*	*Labeo rohita*
3	Katla	*Catla*	*Catla Cattla*
4	Mrigal	*Migal*	*Cirrhinus mrigala*
5	Kalibaush (kalbasu)	*Orange-fin labeo*	*Labeo calbasu*
6	Air/Aor	Long Whiskered cat fish	*Aorichthys* (*Mystus*) *aor*
7	Guijja Air	Giant River Cat Fish	*Aorichthys* (*Mystus*) *seenghala*
8	Tengra	Assamese Batasio	*Batasio Tengana*
9	Baghair	Gangetic Goonch	*Bagarius yanvelliisykes*
10	Kucha / Kuchia	Gangetic Mud Eel	*Monopterus cuchia*
11	Ritha	*Rita*	*Rita rita*
12	Bata	*Giantscale Mullet*	*Liza melinoptera*
13	Khorshula	*Corsula*	*Rhinomugil corsula*
15	Boal	*Indain Trout*	*Raiamas bola*
16	Shol	snake head murrel	*Channa striata*
17	Gojar/ Gojal	Giant snake head	*Channa marulius*
18	Pungash (river)	*Yellowtail catfish*	*Pangasius pagasius*
19	Bacha	Batchwa Bacha	*Eutropicchthys vhacha*
20	Shilong	Silondia V acha	*Silonla Silondia*
21	Bele	*Scribbled goby*	*Awaous grammepomus*
22	Banshpata	*Sind danio*	*Devario devario*
23	Bhagna	*Reba Carp*	*Cirrhinus reba*
24	Golsa/ Golsa Tengra	Gangetic Mistus	*Mystus cavaslus*
25	Kani Pabda / Boali Pabda	Indian Butter cat fish	*Ompak bimaculatus*
26	Pabda	Pabo Cat fish	*Ompak pabo*
27	Chanda / nama chanda	Elongate glass perchlet	*Chanda nama*
28	Ranga Chanda / Lal Chanda	Indian Glassi Fish	*Pseudembassis ranga*
29	Meni / Bheda/ Rayan/ Bheduri	Mottled nandus, mud perch	*Nandus nandus*
30	Napit Koi/ Koi Banedi	Dwarf Chemeleon fish Badis	*Badis badis*
31	Puti	*Fry*	*Puntius puntio* (*Hamilton*)
32	Khailsha	*Banded gourami*	*Colisa fasciata*

No.	Local (Bangladeshi) Name	English Name	Scientific Name
33	Chitol	Humped Featherback	*Nototeruse chitala*
34	Foli	Grey Featherback	*Notopterus notopterus*
35	Tatkini/Bata/Bangla	Reba carp	*Cirrhinuss reba*
36	Kala Bata	Gan Getic latia	*Crossocheilus latius*
37	Bhangon Bata/Bata	Bata labeo	*Labeo Boga*
38	Ghonia/Gonainya	Kuria baleo	*Labeo gonius*
39	Dhela/ Dipali/ ketti	Cotio	*Osteobrama cotio*
40	Sarputi / Swarnaputi	Olive barb	*Puntias Sarana*
41	Titputi	Ticto barb	*Puntias Ticto*
42	Darkina	Gangetic scissortail rasbora	*Rasbora rasbora*
43	Kajli / Banshpata	Jamua ailiz	*Ailia punctata*
44	Tara Baim	One Strip spiny eel	*Macroganthus aral*
45	Shal baim/ Baim /Bam	Tire track spiny eel	*Mastecembelus armatus*

Source: EIA Study Team

5.3 Water quality

Water quality is very important for Aquatic Ecosystem. It includes physical, chemical and biological variables that affect fish production. Fish growth is not only dependant on water and food availability but also to a great extent on the favorable water quality. Macrophytes were present in some places near shore-line, the most prominent being water hyacinth (Kochuripana). According to fishermen, water quality is satisfactory during wet season. However, the ecosystem and water quality deteriorate rapidly due to low water level during dry season. The results of analysis of river water are tabulated under **Section 4.8.1 of Chapter 4.**

5.3.1 Temperature

The growth, reproduction and other biological activities of aquatic organisms are influenced by the temperature of the external environment. Water temperature closely follows air temperature; but in a tropical climate during both dry and wet seasons, the water temperature is high enough for good growth of fish (Boyd, 1990). Temperature of Jamuna river water near the proposed power plant site were measured on **25/09/2013 and it was recorded 29.6°C on the surface and 28.7^{0}C at depth of 3 meters.**

5.3.2 Dissolved Oxygen

Dissolved Oxygen is a critical factor for the survival of fish. Success or failure in fish farming often depends upon the availability of the appropriate quantity of dissolved oxygen. Prolonged exposure to sub-lethal low concentration of dissolved oxygen is harmful to fish (Boyd, 1990). Dissolved oxygen (DO) in the samples of water collected from the Jamuna River near the project site were found about **5.1 mg/l** near the surface and **5.0mg/l** at 3meter depth, which is suitable for fish growth.

5.3.3 pH

pH is the negative logarithm of hydrogen ion concentration. It indicates whether, water is acidic or alkaline. Fish cannot survive in waters below pH 4 and above pH 11 for very long periods. The optimum pH for fish is 6.5 to 9. It was found that pH of the stretch of the Jamuna river from where the samples were collected in **September 25, 2013** varied from **7.70 to 7.72.** Hence Jamuna river water is very suitable for fish growth.

5.3.4 Transparency

Transparency, inversely related to turbidity is measured by Secchi disk to indicate light penetration into water. Turbidity refers to how opaque the water is. The greater the amount of total suspended solids (TSS) in the water, the higher the measured turbidity. The major source of turbidity in the open water zone is typically phytoplankton, but closer to shore, particulates may also be clays and silts from shoreline erosion and organic detritus from stream and/or waste water discharges. Dredging operations, canalization, increased flow rates and floods increase the turbidity of water. Very high levels of turbidity for a short period of time may not be

significant and may even be less of a problem than a lower level that persists longer. The turbidity of the Jamuna river water near the project site was found within a range from **44.8 to 46.2 NTUl,** which are within the limits suitable for fish.

5.4 Protected Area (Sensitive Area)

Four types of natural protected areas including national parks are stipulated in Bangladesh. There is no nature conservation area, conservation forest or protected forest around the Power Plant site.

From reconnaissance survey and discussion with Upazilla administration, it appeared that there **is no** protected (sensitive) area around the proposed site, except the existing Jamuna Multipurpose Bridge.

Through collection of data and information from the local people of the project and its surroundings areas as well as from the local Fisheries officer, the fish breeding place in the Jamuna river is detected. This breeding place is situated within **½ km** upstream to **½ km** downstream of the project site.

According to the opinion of the local people in and around the project area, migrating birds come into the Jamuna River every winter. Their place of wandering is situated between **1 km** upstream and **2 km** downstream from the project site.

5.5 Rare and Endangered Species

According to Dhaka DOE, rare or endangered species are not stipulated in the laws and regulations of Bangladesh. Some of the terrestrial animals listed in the IUCN red data were observed around the protected site of the power plant, but the plants or aqueous animals and plants listed in this data have not been observed.

Though this river is enriched with different species of fresh water fishes, but **11 nos.** of important species have been detected in the Jamuna River by the Sirajganj Upazila Fisheries Department. The list of the rare and endangered species is given in **Table-5.5.1**.

Table-5.5.1: Rare and Endangered Fish Species in Jamuna River

Sl No.	Local/ Common Name	Scientific Name	Local Status
1	Aeor /cat fish	*Mystus aor*	Endangered
2	Bhagna bata	*Liza subviridis*	Endangerd
3	Pangus	*Pangasius pungasius*	Crtically endangered
4	Chapila	*Gudusia chapra*	
5	Kukurjib/ Long tongue	*Cynoglossus lingua*	Endangered
6	Datina	*Pomadasys hasa*	Endangered
7	Kazoli	*Ailichthys punctata*	Crtically endangered
8	Anguilla	*Anguilla begalensis*	Vulnerable
9	Plotosus/Estuarine cat	*Plotosus cnius*	Vulnerable
10	Selnda	*Silonia silondia*	Endangered
11	Shapla pata	*Himantura uarnak*	Endangered

Source: Sirajganj Upazila Fisheries Department

CHAPTER 6: EXISTING ENVIRONMENT: SOCIO-ECONOMIC

6.1 Introduction

The project is located in a rural area of Sirajganj Sadar Thana in the south western part of the district of Sirajganj. Most of the people living in the area are engaged in agriculture. Most of them are people of lower middle class.

The socio-economic information/data have been collected from secondary sources. Sources of secondary data are different official records and published reports of Bangladesh Bureau of Statistics (BBS), Population Census Reports and also reports of other organizations.

On the basis of present socio-economic status of people in and around the project area, the impact of project implementation on the socio-economic situation can be determined. Decision or measures can then be taken for the implementation of the project with sustainable friendly environment.

6.2 Land Use and Value

Land use pattern of Sirajganj Sadar upazila for the year 2011 is given in **Table 6.2.1.**

Table 6.2(1) : Sirajgonj Sadar Upazilla Land use pattern

Sl. No.	Type of Land Use by hectors	2011
1.	Cultivated Land	23194
2.	Current Fallow area	772
3.	Single Cropped area	3127
4.	Double Cropped area	13200
5.	Triple Cropped area	7550
Total cropped area		47843

Source: Sirajgonj Sadar Upazilla Agriculture office.

The classification of land types of Sirajganj district in 2008 is given in Table-6.2(2).

Table-6.2(2): Classification of Land Types (Hactor) of Sirajganj District / 2008

Highland	Medium high land	Medium low land	Low land	Very Low land	Total	Miscellaneous land	Grand Total
37368 (15%)	71582 (30%)	43900 (18%)	32715 (13%)	2060 (1%)	187625 (77%)	56941 (23%)	244566 (100%)

Note: 1. Forest area of Sirajganj district is not included in Land type classification.

2. Miscellaneous land means: settlement, ponds, water bodies, River, Channel, Brick Fields etc.

Source: BBS 2011 and Soil resource development institute.

As a whole, the land value is increasing all over the country. Although the project land lies within the BPDB area, at present the land value adjacent to and around the project area is about **Tk. 8,000.00** per decimal according to the opinion of local people.

6.3 Utilization of River Water

The Jamuna River is flowing on the eastern side of the project area. This river is playing vital and important role in the lives of the people of the project area and its surrounding areas also. The people of the area use this river water for household purpose. Transportation by Country boat, engine boat, launches are kinds of communication system in the area. Fishing activities are going on in the river by fishermen in the area.

6.4 Utilization of Underground Water

The groundwater is used around the project area from shallow level and deep aquifer also. The shallow level ground water is used for household purpose by using hand tube wells. The shallow pumps are used for irrigation purpose in the area. But shallow level ground water **is arsenic contaminated** at increasing rate. Use of shallow level ground water is, therefore, hazardous for both household and irrigation purposes. Further study of the present deep aquifer has been carried out for its quality (arsenic free) and its total volume or quantity before its utilization for the project.

6.5 Toilet facilities of Sirajganj Sadar Upazilla.

Toilet facilities of Sirajganj Sadar upazila as of Census 2011 is given in **Table-6.5.**

Table-6.5: Toilet facilities of Sirajganj Sadar upazila as of Census 2011

Number of households	Type of Structure (%)				Toilet Facility (%)			
	Pucca	Semi-Pucca	Kutcha	Jhupri	Sanitary (water-sealed)	Sanitary (non water-sealed)	Non-sanitary	None
124,852	4.1	14.0	80.9	1.0	25.8	36.5	32.9	4.9

Source: BBS census-2011.

6.6 Landscape

The project area is a plain land. The slope of the ground directs from west to east. There is no undulation or there is no basin like depression in the project area. The area has been sand filled by dredging the river near the site.

6.7 Demographic Characteristics

Total Population of Sirajgonj Sadar Upazilla is 5,55,155 out of which male 2,79,113 and female 2,76,042. Muslims are 95,16%, Hindus 4.80% and others 0.04%. The key features of the population and demographic profile of Sirajganj Sadar Upazilla area has been presented in **Table 6.7(1).**

Table 6.7 (1): Household and population of Sirajganj Sadar Upazila, 2011

Locality		All Areas	Urban	Rural
Geographic Unit	Number of			
	Upazilla	1	0	0
	Unions/Wards	25	15	10
	Mauzas	269	52	217
	Villages	299	0	299
Population Census 2011				
	Number of Households	1,25,485	35,556	88,043
	Population	5,55,155	1,58,913	3,87,955
	Male	2,79,113	86456	1,98,977
	Female	2,76,042	72457	1,88,978

Source : BBS-2011 Population Census. .

Projected households and population of Sirajganj Sadar Upazila in 2021 taking into consideration of annual growth rate from 2001 to 2011 are given in **Table 6.7(2).**

Table 6.7(2): Projected household and population of Sirajganj Sadar Upazilla, 2021,

Items	2001	2011	Yearly Rate of Increase	Estimated Figures in 2021
Household	99.769	1,25,485	**2.31**	1,57,679
Male	2,53,050	2,79,113	**1.00**	3,08,314
Female	2,31,120	2,76,042	**1.79**	3,29,630

6.8 Education & literacy rate:

Table 6.8 shows rate of school attendance in Sirajganj Sadar Upazila as per 2011 census. Rate of school attendance is higher for those older than 6 years of age. The overall literacy rate of Sirajganj Sadar upazila is **56%.**

Table 6.8: Rate of school attendance in Sirajganj Sadar Upazila under aged 3-29.

Age group	Attending School		Not Attending School	
	Male	Female	Male	Female
Aged 3-5 years	2198	2158	19172	18332
Aged 6-10 years	29776	28118	9307	7786
Aged 11-14 years	18961	19417	5490	3154
Aged 15-19 years	12212	9680	12253	13449
Aged 20-24 years	5090	2603	17821	27233
Aged 25-29 years	1038	375	23073	26846

Source: BBS census-2011.

The following institutions are located in Sirajganj sadar upazila:

Educational Institutions:

1. Government college - 3 Nos.
2. Non-Government college - 12 Nos.
3. Government High School - 4 Nos.
4. Non-Government High School - 53 Nos.
5. Junior high school - 7 Nos.
6. Non-government School and college - 3 Nos.
7. Madrasa - 26 Nos.
8. Government Technical institute - 1 No.
9. Non-Government Technical institute - 4 Nos.
10. Law college - 1 No.
11. Homeopath college - 1 No.
12. Medical assistant training school - 1 No.
13. Youth training centre - 1 No.
14. Vocational training institute - 1 No.
15. Nursing institute - 1 No.
16. Primary teacher's training center - 1 No.

17. B.Ed training centre	-	1 No.
18. Government primary school	-	237 Nos.,
19. Non-government primary school	-	3 Nos.
20. Noted educational institutions:	-	4 Nos.

a. Islamia College (1887),
b. Gyandayini High School (1884),
c. BL High School (1869),
d. Sirajgonj Government University College (1940).

Source: Sirajganj upazila Education Officer (TEO)

Religious Institutions:

1. Mosque	-	754 Nos.
2. Temple	-	68 Nos.
3. Tomb	-	4 Nos.

Most noted religious institutes are Sirajgonj Jame Mosque, Yogol Khishore Mandir and Kalibari Mandir.

6.9 Main occupations

The main occupations of the people of Sirajganj Sadar upazila are as follows:

j)	Agriculture	-	25.17%
k)	Agricultural labourer	-	15.76%
l)	Wage labourer	-	4.37%
m)	Commerce	-	16.09%
n)	Service	-	12.55%
o)	Weaving	-	6.10%
p)	Transport	-	3.53%
q)	Industrial labourer	-	4.12%
r)	Others	-	12.31%.

Source: Sirajganj Upazila Agriculture Office

6.10 Industry

In Sirajganj sadar upazila, the available industries are as follows:

a)	Jute mill	-	2 Nos.
b)	Spinning and cotton mill	-	1 No.
c)	Textile mill	-	2 Nos.
d)	Cement factory	-	1 No.,
e)	Flour mill	-	14 Nos.
f)	Sawmill	-	62 Nos.
g)	Semi Auto Rice Mill	-	23 Nos.
h)	Oil Mills	-	23 Nos.
i)	Press Mills	-	19 Nos.
j)	Cottage industries		
	- Weaving	-	17360 Nos.
	- Food and food processing	-	1068 Nos.
	- Bamboo and cane work	-	35 Nos.

- Jute and jute good	-	80 Nos.
- Goldsmith	-	90 Nos.
- Handicraft	-	33 Nos.
- Blacksmith	-	127 Nos.
- Potteries	-	40 Nos.
- Wood work	-	600 Nos.
- Mat and pati making	-	22. Nos.

Source: Sirajganj Sadar Upazila Statistical Office

6.11 Agriculture

The proposed project site falls within the Lower Brahmaputra-Jamuna Floodplain area of National Classification. Aggricultural products have become the prime economic activity in the area. The farmers are cultivating HYV Boro and HYVT, Aman, vegetables, chilly, eggplant, beans, cauliflower, cabbage, radish, carrots etc. Banana and sugar cane are also cultivated. HYVT Aman is cultivated in Kharif season and HYV Boro in Rabi season.

Main crops are Paddy, jute, wheat, mustard seed, sugarcane, onion, garlic, potato, sweet potato, chilli and ground nut etc. and Main fruits are Mango, jackfruit, black berry, papaya, guava, coconut, palm, date, olive, bel, tetul and banana etc.

6.12 Fisheries

In and around the project area there are culture fisheries and open water fisheries in the adjacent Jamuna River. There are no ponds within the project site. There is, therefore, no opportunity of fish culture within the project area.

According to Sirajganj Sadar Upazila Fisheries Department, open season for commercial fishing in Jamuna River is from September to July. The mainly fishing area in the River is around **2km up and down the streams** of project site. The main fishing areas in the Upazila are canals, ponds and so on.

According to the interview done with the fishermen around the construction site , fish catch reaches the peak in October to November. Fishing tools used are Drag net, Gill net, Trap, long lines etc. for Pangas, Air, Kalibaush, Ritha, Bata, Khorsola, Shole, Bacha, Bele, Bashpata, Pabda etc..

6.13 Public Health

There is Sirajganj Zila Sadar Hostptal located at Sirajganj town to provide public health services in the area. Apart from this Zila Sadar Hospital, there are several health centers in Sirajganj Sadar Upazila. The other health facilities available in Sirajganj Sadar upazila are as follows:

(xiii)	Private hospital	-	13 Nos.
(xiv)	Heart disease clinic	-	1 No.
(xv)	Palli (rural) treatment centre	-	1 No.
(xvi)	Satellite clinic	-	8 Nos.
(xvii)	Family welfare centre	-	9 Nos.
(xviii)	Mother and child welfare centre	-	1 No.
(xix)	Child hospital	-	1 No.
(xx)	Eye hospital	-	1 No.
(xxi)	Diabetic clinic	-	1 No.
(xxii)	Private clinic	-	6 Nos.
(xxiii)	Sandhani donor club	-	1 No.
(xxiv)	Diagonistic Centre	-	17 Nos.

Source: EAL Study Team

Different NGOs like BRAC, Proshika, NGO Forum, Manabmukti, TMSS etc. are conducting awareness raising programs on different health services as well as hygienic promotion activities through their sanitation programs. Department of Public Health Engineering (DPHE) is providing sanitary latrines, ring slab toilets through sanitation health program from their Upazila office. They are providing arsenic free water supply to the people of the area.

6.14 Transport

Road transport, railway communication and river transport are available in the area. On the northern side of the project area Dhaka – Sirajganj - Bogra national highway, on the eastern side river communication through Jamuna River and on the western side through Saydabad railway station easy communication with the site is established. Since the Jamuna River is adjacent to the project area, the river communication is an additional advantage. In Sirajganj Sadar Upazila, there are 125 km pucca road, 345 km mud road, 15 nautical mile waterways, and 23 km railways.As a result, road, railway and river communication and consequently, transportation system with the project area is well established.

6.15 Heritage

Sirajganj Sadar has one cultural heritage under Antiquities Act .XIV (1968)） *Archaeological heritage and relics* Elliot Bridge or *Lohar Poll* (iron bridge) built in 1893.

Jamuna Bridge is another important heritage of the District. If evidence of any other ancient heritage or any archeological symbol is found during execution of the project, actions will be taken in accordance with relevant GOB acts and rules.

6.16 Socio-economic Survey around the Project Site

6.16.1 Introduction:

Electrical power is very essential for improvement of socio-economic condition of people in Bangladesh through industrialization and creating more employment opportunities. But at present there is huge shortage of electrical power. In order to overcome this power crisis in Bangladesh, it is necessary to install new power plants immediately. In this regard, socio-economic survey is to be conducted before constructing any new power plant. For this, a social survey has been conducted in the proposed area.

6.16.2 Methodology

Survey has been conducted in the adjoining areas of the proposed site for new power plant in two ways – i. Quantitative approach and ii. Qualitative approach. For quantitative approach, standard questionnaire (socio economic and environmental issues) has been used for interviewing randomly selected respondents in the proposed area. Questionnaire for Socio-economic and environmental issues is enclosed under **Annex-6.16.2**. On the other hand, for qualitative approach, focus group discussion guidelines and in-depth interview instrument have been followed.

For Quantitative approach, 150 respondents have been randomly selected from the adjacent villages, Panchasona and Bara Shimul of Siadabad union under Sirajgonj Sadar upazila.

For Qualitative approach, two Focus Group Discussions – one for Community leader group and another for Local general people (Villagers) group were conducted in the proposed area. Apart from FGDs, in-depth interview was conducted with local administrative authorities and sirajgonj sadar upazilla public representative.

Survey report has been prepared compiling all data / information collected from the above approaches.

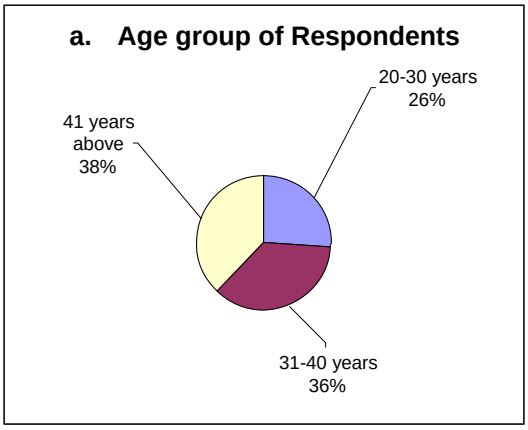
There are in total of 43 villages under the Saydabad Union of Sirajgonj upazilla, Under this village, there are in total of 10485 households, and within these households, the total population is 47610, the average household size is 4.54. Two villages namely Boroshimul and Ponchoshona, which are under the union of Saydabad, are the closest near the power plant site the total number of households of these two villages are 781 and the total population is 3741 (BBS 2011 census)

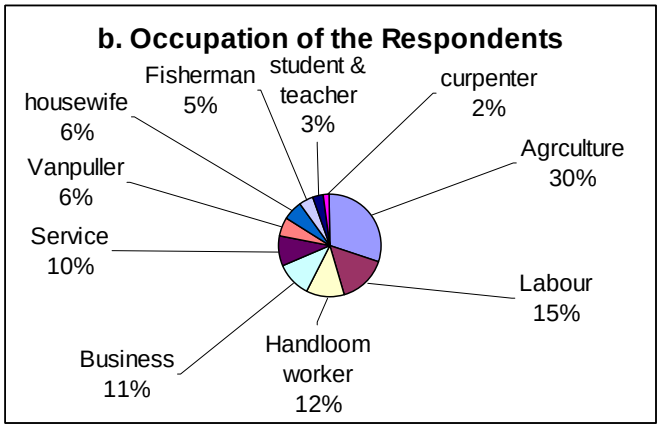
According to the objective of the study the closest villages near the power plant area (about 500 meters or less) are classified to be in the direct impact zone and the villages that are further away from the 500 meter radius from the power plant site are classifed as general impact zone. As a result, the villages of Boroshimul and Ponchoshona are classified to be on the direct impact zone from this zone 75 households are picked randomly for interview, And lastly, another 75 households were chosen randomly from the village of the general impact zone (Purno Bashon and south Saydabad) and data has been collected through an interview from the household heads of the respective households

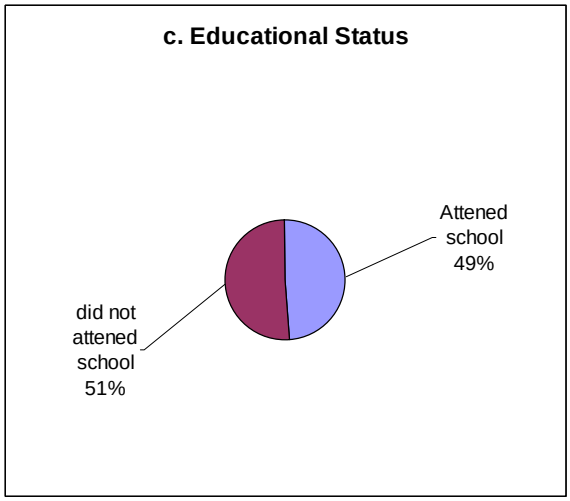
6.16.3 Findings of Quantitative Approach:

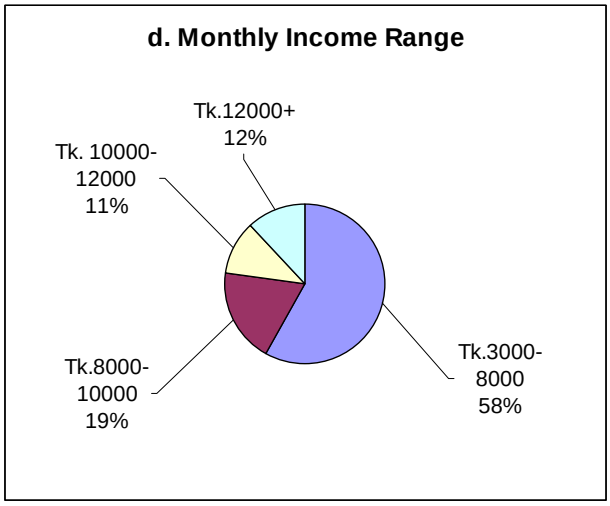
6.16.3.1 Respondents' background:

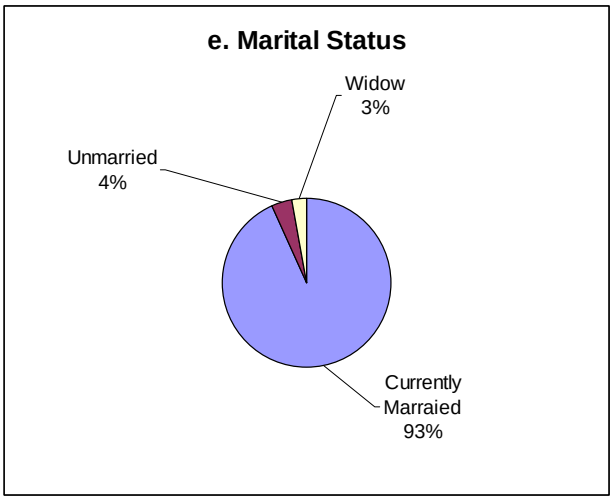
General interview was conducted with 150 respondents of Panchasona and Bara Simul and Ponorbashan Villages of Saydabad Union. The background of the respondents are given below:











f. Family Size of the Respondents

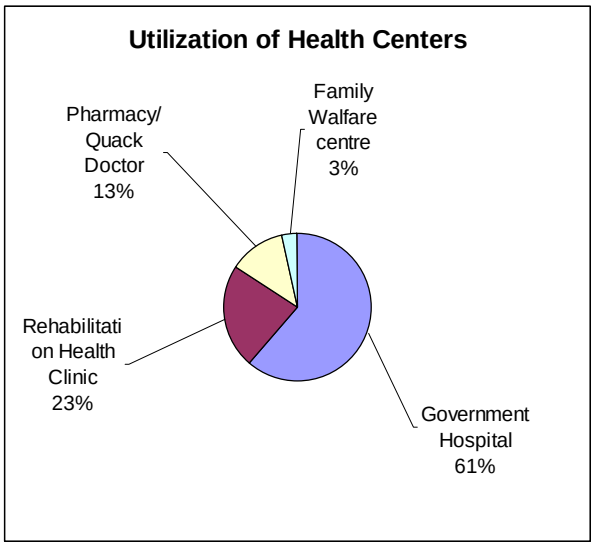
No .of Respondents	Total Family member	No. of Member Sex		< 5 Year Child		Average Family Size	Remarks
		Male	Female	Male	Female		
150	735 (100%)	389 (53%)	346 (47%)	36	26	4.9	

g. Respondent's Migrating In.

No. of Respondents	Own Birth Place	Migration in	Reason for Migrating in	No. of Respondents
150 (100%)	Nil	100 (100%)	* Due to erosion of river	122 (81%)
			* Due to Near by agriculture owned land	13 (9%)
			Due to Service (Job)	15 (10%)

6.16.3.2 Health Care:

Among the total 150 respondents, the maximum number of respondents goes to Govt. Hospital for their medical treatment, and the number of respondents going there are 89. The rest of the respondents go to different places to seek medical attention, namely, 52 respondents goes to Pharmacy or Quack Doctor, 09 respondents goes to Private clinic or to some Graduate M.B.B.S Doctor. There are 55 such respondents who go to Rehabilitation health centre to get medical attention and the rest of the four family members go to the family welfare centre for maternal and child health treatment average per house hold treatment cost per month 330 taka.



6.16.3.3 Homestead:

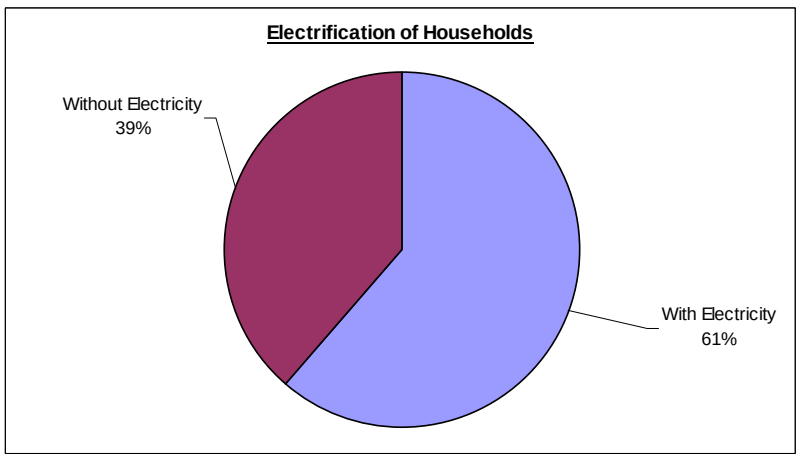
In most of the houses, the roof is made of Tin. The walls are made of either Tin or Concrete or Thatch/hay. The floors of the houses are made of either concrete or clay.

6.16.3.4 Source of Drinking Water

Total 150 (100%) respondents said they use and drink the tube well water and also said that there is no arsenic in the tub well water and it is completely pure. This water is used by the respondents in various purposes like, bathing, cooking, cleaning etc. But, they use only tube well water as their only source of drinking water.

6.16.3.5 Electrification of Houses:

Among the 150 respondents, there are 109 (72%) respondents that have electricity in their households and 41(28%) of respondents do not have electricity in their households.



6.16.3.6 Fuel used for household works:

The major fuels for household works are as follows:

a. Wood
b. Natural Grabge
c. Manure
d. LP/Liquid Gas

e. Electric Heater

f. Kerosene

6.16.3.7 Household Assets:

The list of assets owned by the respondents is given in **Table-6.16.3.**

Table-6.16.3 Households Assets of the Respondents

SL. No.	Household Assets	No. of Respondents
01	Radio	12
02	TV	66
03	By Cycle	30
04	Sewing machine	10
05	Al Mira	32
06	Bed	153
07	Chair/Bench	119
08	Watch	35
09	Mobile	98
10	Refrigerator	03
11	Rickshaw/Van	15
12	Land Phone	Nil
13	Motor Cycle	Nil

CHAPTER 7: POTENTIAL ENVIRONMENTAL IMPACTS AND MITIGATORY MEASURES

7.1 Selection of Assessment Items

The Sirajganj 225MW Combined Cycle Power Plant (2nd Unit-Dual Fuel) is planned to be installed beside the existing 150MW Peaking Power Plant upgraded to 225MW CCPP in Sirajganj Sadar Thana under Sirajganj District. For this project, the land of the proposed site has been already acquired where there is no need for relocation of the inhabitants.

A cooling system has been selected where ground water will be used.

In association with construction of the proposed 25MW CCPP (2nd Unit), gas pipeline was taken off from the Gas Transmission line along Bangabandhu setu.

A 230kV switching station of PGCB is located beside the proposed power plant and requirement of Transmission line to connect the power plant with the grid system is minimal.

Since waterborne traffic is used for the transportation of heavy objects, piers will be built in the riverside storage site, and an access road will be built to connect between the pier of the unloading yard and construction site.

Impact assessment was implemented by picking up the factors affecting the environment at the time of construction and operation for all the related facilities.

For the impact assessment, reference has been made of the guidelines of Bangladesh and international organizations:

- EIA Guideline for Industries (DoE, 1997)
- ADB Environmental Assessment Guideline 2003
- JICA Guideline for Environmental and Social Considerations (JICA, 2004)
- JBIC Guideline for Confirmation of Environmental and Social Consideration (JBIC, 2004)*. &
- . Pollution Prevention and Abatement Handbook (WB,1999)

The ODA department of JBIC has been integrated with JICA since 2008. The guideline used here is the previous one before integration.

To implement impact assessment, the impacts anticipated from various projected activities were picked up, and measures for avoiding or alleviating such impacts were studied. The impacts assumed to be particularly serious were estimated on a quantitative basis whereby impact assessment was performed.

Whenever required, further measures for mitigating the impact were studied. Consideration was also given to the comments and views on the Sirajganj CCPP (2nd Unit) presented by the inhabitants in the survey on the surrounding community and environment and at the stakeholders' meeting.

Table 7.1.(1) shows the overview of the selected assessment items during construction period and **Table 7.1.(2)** shows the overview of the selected assessment items during operation period.

Table 7.1.(1) Overview of the selected assessment items (Construction period)

	No.	Assessment Item	Overall Rating	Construction Phase			
				Temporary impact by undertaking construction	Power Plant		
					Land formation of Earth work	Operating of construction machinery	Carrying construction materials in and out
Environmental contamination	1	Air pollution	B			B	B
	2	Water pollution	B		B	B	
	3	Solid waste	B	B			
	4	Noise/Vibration	A		B	A	B
	5	Odor	B	B			
Natural environment	6	Climate					
	7	Hydrology					
	8	Flood					
	9	Underground water	B	B			
	10	Ground subsidence	B	B			
	11	Soil erosion	B		B		
	\2	Sanctuary					
	13	Terrestrial ecosystem	B		B		
	14	River ecosystem	B		B		
	15	Precious species	B		B		
Social environment	16	Involuntary resident resettlement					
	17	Employment /Livelihood	B	B	B		
	19	Local economy	B	B	B		
	20	Land utilization	B		B		
	22	Social infrastructure/service facillities	B	B	B		
	23	River traffic	B				B
	24	Land traffic	B		B		B
	25	Sanitation	B	B			
	31	Risks for infectious diseases such as (HIV/AIDS)	B	B			
	26	Local custom					
	27	Burden on vulnerable groups (women, children, aged, impoverished, minorities, indegenous people and such)	B	B	B		
	28	Uneven distribution of benefit and loss(damage)	B	B	B		
	30	Utilization/Right of water, including underground water	B	B		B	
	32	Cultural heritage					
	33	Landscape	B	B			
Other	34	Accident	B	B	B	B	B
	35	Global warming					

A: Serious impact is expected.
B: Some impact is expected.
No mark: No impact

Table 7.1.(2) Overview of the selected assessment items (Operation period)

	No.	Assessment Items	Overall Rating	Operation Phase					
				Power Plant					
				Operation of Facilities				Carrying materials/stuff in and out	Solid waste
				Intake of cooling water	Gas emissions	Waste water	Others		
Environmental contamination	1	Air pollution	A		A				
	2	Water pollution	B			B			
	3	Solid waste	B						B
	4	Noise/Vibration	A				A	B	
	5	Odor	B						B
Natural environment	6	Climate							
	7	Hydrology							
	8	Flood							
	9	Underground water	A	A		B			
	10	Ground subsidence	B	B					
	11	Soil erosion							
	12	Sanctuary							
	13	Terrestrial ecosystem							
	14	River ecosystem	B			B			
	15	Precious species	B			B			
Social environment	16	Involuntary resident resettlement							
	17	Employment /Livelihood	B				B		
	19	Local economy	B				B		
	20	Land utilization							
	22	Social infrastructure/service facilities	B				B		
	23	River traffic	B						
	24	Land traffic	B					B	
	25	Sanitation	B				B		
	31	Risks for infectious diseases such as (HIV/AIDS :	B				B		
	26	Local custom							
	27	Burden on vulnerable groups (women, children, aged, impoverished, minorities, indigenous people and such)	B				B		
	28	Uneven distribution of benefit and loss (damage)	B				B		
	30	Utilization/Right of water, including underground water	A	A					
	32	Cultural heritage							
	33	Landscape	B				B		
Others	34	Accident	B				B	B	
	35	Global warming	B		B				

A: Serious impact is expected.
B: Some impact is expected.
No mark: No impact

7.2 Impact assessment and measures for avoiding or mitigating the Impact

Impact assessment has been made by studying the measures for avoiding or mitigating the impact with respect to various forms of environmental items. The measures for avoiding or mitigating the impact are shown in the Environment Management Plan (EMP) in **Chapter-8.**

7.2.1 Construction phase

Some of the items where the need for impact assessment by construction work is assumed are separately described below:

7.2.1.1 Environmental pollution

1) Air pollution

IMPACTS:

With the progress of construction work, SOx, NOx, smoke and soot will be generated from the construction machinery and transportation vehicles and earth, sand and dust particles will be scattered. This may cause air pollution.

MITIGATION MEASURES:

Periodic inspection and maintenance control will be conducted to reduce exhaust discharged from construction machines and vehicles. To minimize scattering of earth, sand and dust particles, protective covers will be provided, and washing of the vehicles and cleaning of the surrounding roads will be performed on a periodic basis, whereby impact of air pollution will be reduced.

2) Water pollution

IMPACTS:

Drainage caused by rainfall, effluent resulting from washing the equipment, sewage and sanitary wastewater will be generated during the work. Waste will also be produced from washing of aggregate and sand.

If these are inadequately handled, river water and underground water will be contaminated.

Contamination will occur during the civil construction work. This may cause river pollution.

MITIGATION MEASURES:

To prevent earth and sand from flowing out due to rainfall, a fence against earth and sand deposition will be installed around the site where excavation is performed. To drain the sewage, a settling tank will be installed on a temporary basis, whereby the supernatant will be removed.

Regarding effluent resulting from washing the equipment, a tank will be installed on a temporary basis, because chemicals may be used at the time of washing the equipment. Then the waste water will be discharged after having been adequately handled.

The waste generated with the progress of the construction work will be adequately handled according to the procedures shown in the following item.

In the civil construction work and washing of aggregate and sand, adequate fencing will be constructed around aggregate and sand storages and around construction site, so as to prevent flow of waste into the river along with water.

To avoid contamination by sewage, adequate sanitary tanks will be constructed and sewage will be thoroughly treated before the resulting water is discharged into the river.

These measures will minimize the impact of contamination of river water and underground water.

3) Solid Waste

IMPACTS:

Solid Waste resulting from the construction work includes metal chips, waste plastic, wood shavings, waste glass and waste oil. Further, the household solid waste discarded from the camping ground of the workers includes cans, bottles and food remnants. If such waste is inadequately handled, underground water and river water will be contaminated, and sanitation problems will arise.

MITIGATION MEASURES:

Basically, a waste management program including the plan for reduction in the amount of waste, reuse and recycling of waste will be worked out regarding Metal chips, waste plastic, wood shavings, waste glass and waste oil. Measures taken include adequate classification of waste and adequate disposal at the disposal site for each type of waste.

To reduce the amount of solid waste discarded by the workers during the construction work, efforts will be made to employ the local workers wherever possible, so that the amount of household solid waste will be minimized.

The aforementioned measures will be taken to ensure that water pollution or sanitary problems resulting from waste do not arise.

4) Noise and vibration

IMPACTS:

With the progress of construction work, noise will be generated from the construction machinery and transportation vehicles. Sufficient consideration must

be given to minimize the noise impact.

MITIGATION MEASURES:

In the actual construction work, the scheduled management will be performed to ensure leveling of the sound level of construction work wherever possible, and the state-of-the-art low-noise equipment will be introduced. Thus, efforts will be made to minimize the noise impact.

Material and equipment transportation vehicles will be placed under the scheduled management to ensure that the sound level of the construction work will be leveled. Measures for reducing generation of noise such as requirements for installation of mufflers and speed reduction in the residential area will be taken wherever possible, whereby vehicle noise impact will be minimized.

5) Odor

IMPACTS:

The amount of household solid waste will increase due to inflow of a great number of workers. If such waste is inadequately handled, odor may be produced by putrefaction.

MITIGATION MEASURES:

Before starting the construction work, the workers will be instructed to classify and collect garbage. Garbage will be disposed on a periodic basis to ensure that odor is not produced by putrefaction. These measures will be taken to minimize generation of odor.

7.2.1.2 Natural environment

1) Underground water

IMPACTS:

The surrounding wells may be affected by reduction of underground water level resulting from underground water intake during the construction work.

MITIGATION MEASURES:

Substantial amount of water will be required for construction work. It is estimated that groundwater can be taken without any substantial decrease of the water level even in the period of high water intake during summer.

For this reason, it is presumed that no significant decline of groundwater level at surrounding wells will occur due to water intake used for construction. Monitoring of groundwater levels of the wells for residential and office use will be conducted for confirmation. Please refer to the study report on ground water modeling given under **Annex-3.3.**

2) Ground subsidence

IMPACTS:

If there is a considerable reduction of underground water level resulting from underground water intake during the construction work, ground subsidence may occur.

MITIGATION MEASURES:

As described above, there will be no substantial reduction in the underground water level of the surrounding wells as a result of underground water intake during the construction work. This indicates that there will be no ground subsidence as a result of underground water intake.

3) Soil erosion

IMPACTS:

With the progress of excavation work, earth and sand together with muddy water may flow into the surrounding area at the time of heavy rainfall.

The unloading yard will be built on the side of the river, and earth and sand may flow out at the time of rainfall.

MITIGATION MEASURES:

Measures will be taken to avoid outflow of the earth and sand where a fence will be installed against subsidence of earth and sand.

As a mitigation measure, the actual civil construction will be implemented during dry seasons.

4) Terrestrial ecosystem

IMPACTS:

With the progress of excavation work, the habitat of the plants and animals may disappear.

The power plant site and its surrounding areas have already been converted into the agricultural land and are used for artificial purposes. There is no natural forest in these areas.

The area to be modified by installation of gas pipelines and Jetty is small, and there will be not much impact on plants and animals.

With the progress of excavation work, the habitat of the plants and animals may disappear.

MITIGATION MEASURES:

The plants are restricted to fruit trees and ornamental plants.

5) River ecosystem

IMPACTS:

With the progress of construction work, river water pollution will occur due to inadequate handling of waste water and may have an adverse effect on many forms of life in the river.

Contamination will occur due to civil construction work. This may have an adverse effect on many forms of life in the river.

MITIGATION MEASURES:

The measures indicated in the description of "Water pollution" will be taken against the river water pollution resulting from drainage during the construction work and installation of equipment, whereby the impact on the river plants and animals will be minimized.

6) Precious species

IMPACTS:

With the progress of excavation work, the habitat of the plants and animals will not be affected. However, the life of the precious species, if any, may be endangered.

Around the Power Plant site, there are **four** species falling under the category of the light concern species (LC) of the IUCN red list. They are a **jungle cat, fox, pigeon and kite**. They are all characterized by a high degree of mobility. The concerned area is not their major living place for building nests, for example. Accordingly, they will not be much affected by the construction work.

With construction work, water pollution will occur due to inadequate handling of waste water and may have an adverse effect on precious species of plants and animals in the river.

MITIGATION MEASURES:

The Jamuna River is inhabited by fishes as precious species of Sirajganj district. The impact of river water pollution will be minimized by the measures indicated with reference to "Water pollution".

7.2.1.3 Social environment

1) Employment and livelihood, land utilization, burden on vulnerable groups, uneven distribution of benefit and loss

IMPACTS:

The construction work requires a great number of workers. There are a high percentage of day workers around the site. They want to be hired on a steady basis as regular employees.

The Power Plant site is the landed property of the BPDB.

When the Jamuna River will be used to transport heavy items, activities relating to fishery may be interfered.

There will be a need for land expropriation to acquire the required land for installation of Gas pipeline and Transmission line.

MITIGATION MEASURES:

Before starting the construction work, priority will be given to employment of the local residents.

It is assumed that the inhabitants around the site have deficiency in technical level required for the construction work. Measures are required to be taken so that those prospective indigenous workers can acquire relevant skills for construction through preliminary education and training program in cooperation with local municipalities from an early stage of construction, so that local people are given priority for employment opportunity.

In addition, the guideline for employment will be developed so as to assure fair opportunity as a mitigation measure. The aforementioned priority employment policy will be implemented to ensure that their livelihood will not be affected by the reduced income, if any.

Regarding operating plan, the schedule will be explained to local fishermen at an early stage in order not to cause any effect to their fishery activities.

For the transmission line and gas pipeline installation work, compensation for land expropriation will be given to the people according to the laws and regulations of Bangladesh. At the same time, the construction work will be performed during the off-season period wherever possible, so that there will be suspension of farming.

Further, the scope and processes of the construction work will be explained so that relocation of the work site can be achieved quickly.

2) Local economy

IMPACTS:

The potential increase in income of inhabitants and local companies owing to this project may be contributed to local economic revitalization.

MITIGATION MEASURES:

As described with reference to "Employment and livelihood", before starting the construction work, priority will be given to employment of the local residents.

Cleaning and catering services as well as local materials supply will be provided by the local companies.

In addition, compensation for land acquisition will be conducted complying with relevant national laws, in parallel with the mitigation measures so that income levels of local people and fishermen will not be declined.

Moreover, it is important to corporate for the fostering of new local industries through consultation with local municipality.

3) Infrastructure and service facilities

IMPACTS:

Local workers will be hired wherever possible; as such, construction of new infrastructure facilities will not be necessary.

An increase in the number of vehicles for construction work may affect the access of the inhabitants to the infrastructure and service facilities of the community.

The local inhabitants desire additional medical facilities to be built.

MITIGATION MEASURES:

Regarding material installation and staff mobilization vehicles due to the construction work, measures will be taken as is shown in '5) Land traffic' described below.

Efforts will be made to ensure that the existing medical facilities for the workers can be improved and expanded and also can be used by construction workers as well.

4) River traffic

IMPACTS:

Large-sized heavy equipment will be transported for maintenance and management by ship. Transportation will be carried out in the rainy season when a sufficient water depth is ensured.

MITIGATION MEASURES:

In the rainy season, the river width will increase and there will be little impact on the river traffic of the local inhabitants.

5) Land traffic

IMPACTS:

Workers' commutation and traffic of vehicles for carrying the periodic inspection materials may affect land traffic in the surrounding area.

MITIGATION MEASURES:

Measures such as use of buses, inspection of the traffic rules, introduction of the traffic signs and markings and education on safe driving will be taken to alleviate the impact.

6) Sanitation

IMPACTS:

About 150 Engineers/ Workers will be engaged in the construction of the power plant. There may be a shortage of sanitary facilities such as toilet facilities.

MITIGATION MEASURES:

These measures include the installation of the septic tank treatment system conforming to the number of employees and an education and training course on sanitation management.

7) Risk of infectious disease

IMPACTS:

Workers and Engineers coming from the outside area may carry infectious disease, which may spread among other workers.

MITIGATION MEASURES:

The following measures will be taken against infectious diseases:

- Installation of medical facilities and periodic medical checkup
- Education and training for sanitation management of the workers
- Protection of construction workers against HIV/AID, dengue fever, malaria and hepatitis A,

8) Utilization and Right of water (including groundwater)

IMPACTS:

There is a possibility to have a negative effect to fishery activities in the river due to water pollution caused by inappropriate waste water disposal generated by construction activities.

Furthermore, turbidity generated by the construction also may cause an adverse effect to the fishery activities in the river.

Regarding the effect of water use at surrounding wells due to groundwater level decrease, although it is presumed that no significant decline of the water level will occur, as is shown in '1) Underground water of b) Natural environment'.

MITIGATION MEASURES:

These possible causes of water pollution (waste water disposal and the civil construction) will be reduced through the mitigation measures indicated in the section of 'Water Pollution '.

Monitoring of the water levels at residential wells will be conducted for confirmation.

9) Landscape

IMPACTS:

Fences will be installed around the site on a temporary basis during the period of construction work.

The construction work period is limited, and impact on landscape will be small.

MITIGATION MEASURES:
Not required.

10) Accident

IMPACTS:

Inadequate construction work may cause accidents. The percentage of traffic accident may rise by an increase in the number of vehicles movement.

MITIGATION MEASURES:

During the construction work, a safety management program setup regulation will be worked out, and various forms of safety measures will be implemented based on this regulation. To ensure traffic safety, various forms of measures will be taken, as exemplified by inspection of traffic rules, installation of traffic signs and markings, education on safe driving, reduction of the vehicle speed in the school-commuting roads and residential areas, and avoidance of driving during the school commuting time zone.

7.2.2 Operation period

7.2.2.1 Environmental pollution

1) Air pollution

IMPACTS:

Natural gas will be used as the fuel for operation. Light oil (HSD) will also be used as alternative fuel on the temporary basis. The exhaust gas due to combustion of gas/HSD from a gas turbine passing through HRSG during the operation may lead to air pollution by SOx or NOx.

The amount of exhaust gas from a power plant into the atmosphere is greater than that in other industries. During the operation, there is estimated to be impact on air quality by exhaust from the gas turbine.

DoE standard of ambient air quality is given in the following **Table.-7.2.2(1)**

Table.-7.2.2(1) DoE Standard of Ambient Air Quality

Air Pollutant	Standard	Averaging Time
1	2	3
Carbon Mono-oxide	10mg/cu- m(9ppm) (Ka)	8 hours
	40mg/cu-m(35ppm) (Ka)	1 hour
Lead	0.5µg/cu-m	annual
Nitrogen Oxide	100µg/cu-m (0.053ppm)	Annual
Suspended Particulate Matter (SPM)	200µg/cu-m	8 hours
Particulate Matter 10 (PM_{10})	50µg/cu-m(Kha)	Annual
	150µg/cu-m(Ga)	24 hours
Particulate Matter 2.5 ($PM_{2.5}$)	15µg/cu-m	Annual
	65µg/cu-m	24 hours
Ozone	235µg/cu-m(0.12ppm)(Gha)	1 hour
	157µg/cu-m(0.08ppm)	8 hours
Sulfur Dioxide	80µg/cu-m(0.03ppm)	Annual
	365µg/cu-m(0.14ppm) (Ka)	24 hours

Abbreviation:

ppm: Parts Per Million

Notes: * In this schedule Air Quality Standards means Ambient Air Quality Standards

(Ka) Not to be exceeded more that once per year

(Kha) Annual Average value will be less than or equal to 50 microgram/cubic meter

(Ga) Average value of 24 hours will be less or equal to 150 microgram/cubic meter for one day each year.

(Gha) Maximum average value for every one hour each year will be equal or less than 0.12 ppm.

The current air quality in the project area is below the limit of the environmental standards of Bangladesh. Appropriate measures must be taken to ensure that the standards will be met in future as well.

The exhaust NOx concentration will be kept below 40 ppm and below the emission standard. This value is sufficiently below the guideline of the World Bank. NOx emission concentration is given in **Table-7.2.2(2).**

Table 7.2.2(2) NOx emission concentration

Item	New installation (natural gas)	Emission standard of Bangladesh	IFC/World Bank guideline (PPAH)
NOx emission concentration	< 40 ppm	40 ppm	165 mg/m^3 (80 ppm)

MITIGATION MEASURES:

- Sulfur content may cause air pollution if HSD fuel is used. But Sulfur content in the natural gas is very negligible. So, special attention must be given to reduce sulfur content if HSD fuel is used. Apart from this measures, stack of adequate height is to be installed to discharge the exhaust gas in the atmosphere to reduce the air pollution. From NREL study, the SO_2 emission rate for combined cycle power plant is **324kg/GWh**. Using this base data, for 225MW CCPP, the SO_2 emission rate will be **73kg/hr.** Using stack height formula, $H=14Q^{0.3}$ (where, H= Stack height in m and Q = SO2 emission rate in kg/hr), the approximate height of the stack is about **60m.**
- Basically, complete combustion of the fuel occurs in the gas turbine. Almost no CO or SPM is produced.
- A low-NOx burner/ water injection is used to minimize generation of the nitrogen oxides.

In order to mitigate the air pollution, based on the above calculation of stack height, it is suggested to install a high stack having a height of about **60 meters** to minimize the impact of the major building within the aforementioned site.. Further, to minimize the chance of the building affecting diffusion, arrangement is so configured that high buildings will not be located to the leeward in the north and south as the main wind direction.

2) Water pollution

IMPACTS:

Ground water will be used in the cooling system and therefore, thermal discharge will be produced. In addition, plant effluent and domestic wastewater will be generated, and waste will also be produced. If they are inadequately handled, river water and underground water will be contaminated.

To dispose of the waste water produced by operation of the power plant, waste water treatment facilities capable of precipitation by condensation, neutralization and oil separation and household waste water treatment facilities will be installed. Further, leakage of light oil as alternative fuel can be assumed.

MITIGATION MEASURES:

To dispose of the waste water produced by operation of the power plant, waste water treatment facilities capable of precipitation by condensation, neutralization and oil separation and sanitary waste water treatment facilities will be installed. When the aforementioned measures are taken, the waste water level will not exceed the waste water reference level of Bangladesh.

The bottom surface of the tank in the existing power plant is lined with concrete. The newly installed tank will be provided with measures to protect underground water against contamination by oil.

In order to minimize the effect of discharge of hot water in the river, water will be carried away as far as possible from the source, either through canal or pipe line and water will be discharged over a wide concrete surface near the river bank. These combined actions will cool the hot discharge water. However, the temperature of discharge waste water should not exceed **3^0C** compared to the temperature of intake water.

3) Solid Waste & Sludge Management

IMPACTS:

The industrial waste produced during the operation includes the waste oil and sludge from the wastewater treatment equipment. Further, the household solid waste such as cans, bottles and food remnants discarded by employees is also generated.

If such waste is inadequately handled, river water and underground water will be contaminated, and sanitation problems will arise.

MITIGATION MEASURES:

For the waste produced in the process of operation of the power plant, the waste management program including the reduction, reuse and recycling of the waste will be worked out. To put it more specifically, the measures to be taken includes systematic solid waste collection at the worksite, prohibition of dumping contaminated substances, appropriate classification, and disposal at the disposal site determined for each class of waste.

The existing Industrial Wastewater pool had been already constructed near demineralizing plant in the simple cycle project, which is set to store and treat wastewater from power plant and demineralizing plant. The industrial wastewater shall be transferred into this pool for further treatment.

Boiler blowdown shall be sent to a blowdown pit, cooled by mixing with service water and collected in a common wastewater sump.

Sludge wastewater from sludge tanks should be transferred to concentrator and

centrifugal dehydrator. The treated water should be recycled to aeration tank, and the sludge will be transferred by truck for selling out.

4) Noise and vibration

IMPACTS:

The noise generation source during the operation includes workers' commutation, traffic of vehicles for carrying the periodic inspection materials and operation of the power generation facilities.

Noise problem has been taken up by the inhabitants of the surrounding area. Noise of the power generation facilities is produced even during the nighttime, so sufficient consideration must be given to the impact of noise and vibration.

MITIGATION MEASURES:

In the field of more detailed designing for future, efforts must be made to achieve the estimated noise level resulting from the operation of the power generation facility, for example, by introduction of the state-of-the-art low-noise equipment.

5) Odor

IMPACTS:

Facilities or equipment that produce odor are not included in the power generation facilities.

The household solid waste of the employees will be produced. If such waste is inadequately handled, odor may be produced by putrefaction.

MITIGATION MEASURES:

Garbage will be subjected to separate collection, and garbage will be disposed of on a periodic basis to make sure that odor by putrefaction will not be produced.

7.2.2.2 Natural environment

1) Under Groundwater

IMPACTS:

Since no additional underground water will be lifted, there will be no additional impact.

MITIGATION MEASURES:

Since no additional impact is expected, no mitigation measure is necessary.

2) Ground subsidence

IMPACTS:

If there is a considerable reduction of underground water level resulting from underground water intake, ground subsidence may occur.

MITIGATION MEASURES:

It is estimated that there will be no substantial reduction in the underground water level in the surrounding area by the underground water intake.

3) Terrestrial ecosystem

IMPACTS:

The power plant site and its surrounding areas have already been converted into the agricultural land and are used for artificial purposes. There is no natural forest in these areas.

The area to be used in the power plant is comparatively small and will have little impact on plants and animals.

Further, after the gas pipeline has been laid, the site will be backfilled, and the transmission line except for the scaffolding will be put back to the current state. There will be almost no impact on the terrestrial ecosystem.

MITIGATION MEASURES:

The buffer zone will be planted with fruit trees.

4) River ecosystem

IMPACTS:

Water pollution will occur due to inadequate handling of waste water and may have an adverse effect on many forms of life in the river.

MITIGATION MEASURES:

As discussed with reference to "Water pollution", measures will be taken to prevent water pollution in the river so that the impact on the plants and animals living in the river will be minimized.

5) Precious species

IMPACTS:

For the precious land species having been verified around the project site, the industrial and agricultural area is not their major living place for building nests. Accordingly, impact on these species will be very small.

Water pollution will occur due to inadequate handling of waste water and may have an adverse effect on precious species of plants and animals in the river.

MITIGATION MEASURES:

The buffer zone will be planted with trees.

The Jamuna River is inhabited by fishes as precious species of this Sirajganj district. The impact of river water pollution will be minimized by the measures indicated with reference to "Water pollution".

7.2.2.3 Social environment

1) Employment and livelihood, Land utilization, Burden on vulnerable groups, Uneven distribution of benefit and loss

IMPACTS:

There are a high percentage of day workers around the Sirajganj project site. They want to be hired not only during the period of construction work but also during the operation of the power plant.

The site is the landed property of the BPDB.

When large-sized heavy equipment will be transported for maintenance and management by ship, activities of fishery may be interfered.

Materials may be unloaded at the time of maintenance and management.

MITIGATION MEASURES:

It is assumed that the inhabitants around the site are very deficient in high technical level applied to the operation work.

Measures are taken that local people are prioritized at employment opportunity in simple work like cleaning.

In addition to this, prospective indigenous workers can acquire relevant high skills for operation through preliminary education and training program in cooperation with local municipalities from an early stage , so that hiring of as many people as possible is conducted within local area.

Moreover, the guideline for employment will be developed so as to assure fair opportunity as a mitigation measure.

After the gas pipeline has been laid, the site will be backfilled, and the transmission line except for stubs will be put back to the current state. There will be no impact on the livelihood of the farmers.

Regarding operating plan, the schedule will be explained to local fishermen at an early stage in order not to cause any effect to their fishery activities.

2) Local economy

IMPACTS:

The potential increase in income of inhabitants and local companies owing to this project may be contributed to local economic revitalization.

MITIGATION MEASURES:

As described with reference to "Employment and livelihood", even in the operational phase, local inhabitants will be prioritized at employment as many as possible.

Cleaning and catering services as well as supply of materials will be provided by the local companies.

In addition, compensation for land acquisition (for gas and transmission lines) will be conducted complying with relevant national laws, in parallel with the mitigation measures so that income levels of local farmers, fishermen will not be declined.

Moreover, it is important to corporate for the fostering of new local industries through consultation with local municipality.

3) Infrastructure and service facilities

IMPACTS:

Workers' commutation and traffic of vehicles for carrying the periodic inspection materials may affect land traffic in the surrounding area.

The local inhabitants desire new and increased medical facilities to be built so that the current medical care system will be improved.

MITIGATION MEASURES:

Regarding commuting vehicles, measures will be taken as is shown in '5) Land traffic' described below.

The existing medical facilities will be expanded and improved, so that the construction workers can also be benefited.

4) River traffic

IMPACTS:

Large-sized heavy equipment will be transported for construction as well as maintenance by ship. Transportation will be carried out in the rainy season when a sufficient water depth is ensured.

MITIGATION MEASURES:

In the rainy season, the river width will increase and there will be little impact on the river traffic of the local inhabitants.

5) Land traffic

IMPACTS:

Workers' commutation and traffic of vehicles for carrying the periodic inspection materials may affect land traffic in the surrounding area.

MITIGATION MEASURES:

Measures such as use of buses, inspection of the traffic rules, introduction of the traffic signs and markings and education on safe driving will be taken to alleviate the impact.

6) Sanitation

IMPACTS:

About 150 employees will be engaged in the operation of the power plant. There may be a shortage of sanitary facilities such as toilet facilities.

MITIGATION MEASURES:

These measures include the installation of the septic tank treatment system conforming to the number of employees and an education and training course on sanitation management.

7) Risk of infectious disease

IMPACTS:

Workers coming from the outside area may carry infectious diseases.

These workers coming from the outside area will receive health checkup before being employed.

MITIGATION MEASURES:

Further, the following measures will be taken:

- Installation of medical facilities and periodic health checkup
- Education and training of workers on sanitation management.

8) Utilization and Right of water (including groundwater)

IMPACTS:

Since no additional underground water is planned to be used, surrounding wells may not be adversely affected.

As discussed with reference to "Underground water", water for domestic and office use can be supplied sufficiently without the underground water level being substantially reduced.

MITIGATION MEASURES:

No additional mitigation measure is envisaged.

9) Landscape

IMPACTS:

The building of the power plant is higher than the surrounding structures, and this may affect the landscape.

The power generation facility contains a smokestack having a height of 45 meters, a turbine building having a height of 35 meters.

MITIGATION MEASURES:

The area of the Sirajganj project site is limited and there will be little impact on landscape.

10) Accident

IMPACTS:

Possible accidents may include leakage of light oil as a standby fuel or breakage of the gas pipeline in terms of equipment. Further, various forms of operation or maneuvering errors may occur during the operation.

Possible accident may be breakage of the transmission line due to cyclone and others.

MITIGATION MEASURES:

The following measures are taken against possible accidents:

- Creating and implementing a sanitation and safety education program
- Installation of emergency measure facilities and quick introduction of a transport system into the medical facilities
- Working out a management program for gas leakage prevention and setting up the leakage preventive equipment as part of the leakage risk management program
- Installation of fire prevention equipment and facilities at proper positions inside the power plant.
- Installation of fixed type fire prevention equipment, fire hydrant, fire extinguisher, escape hatch, fire alarm, fire prevention zoning facilities and emergency exit.
- Working out safety regulations.

11) Global warming

IMPACTS:

CO2 as a warming substance will be discharged from the power plant.

About **241,776 tons** of CO2 as a warming substance is estimated to be discharged from the power plant every year.

MITIGATION MEASURES:

The present project uses a power generation system characterized by high efficiency and a reduced amount of CO2 produced per unit of electricity produced. If the plant is assumed as simple cycle, the amount of CO2 emissions from 225MW Natural Gas power plant would be **362,664 Tons per year** whereas for combined cylce power plant, CO2 emissions would be **241,776 Tons/year**. In other words, about **120,888 Tons/year.** CO2 emissions will be reduced.

CHAPTER 8: ENVIRONMENTAL MANAGEMENT PLAN (EMP) AND MONITORING PLAN

8.1 Scope of EMP

The main objective of the Environmental Management Plan (EMP) and Environmental Monitoring Plan is to ensure implementation of the mitigation measures planned to reduce the environmental impact by the implementation of the power plant project, and to verify and record the environmental impact.

The EMP and Monitoring Plan are worked out based on the following:

- To reduce the environmental impact to the permissible level by the mitigation measures during the period of construction and operation, so that a hazardous impact will not occur.
- To configure a responsible organization for the implementation of the mitigation measures.
- To implement the EMP and Monitoring Plan adequately during the period of construction and operation.

The permissible level mentioned above is determined based on the national standard of Bangladesh listed below

(1) Air Quality

a) Ambient Environment

Table 8.1.1 shows the atmospheric environmental standard. In Bangladesh, although strategic area including industrial area and school and hospital are designated, the classification of other lands, either "commercial" or "residential", is determined by DoE in charge according to the situation. The project site is classified as "residential area" by Bogra DoE.

Table 8.1.1 : Ambient Air Quality Standard

Air Pollutant	Standard	Averaging Time
1	2	3
Carbon Mono-oxide	10mg/cu- m(9ppm) (Ka)	8 hours
	40mg/cu-m(35ppm) (Ka)	1 hour
Lead	0.5µg/cu-m	annual
Nitrogen Oxide	100µg/cu-m (0.053ppm)	Annual
Suspended Particulate Matter (SPM)	200µg/cu-m	8 hours
Particulate Matter 10 (PM_{10})	50µg/cu-m(Kha)	Annual
	150µg/cu-m(Ga)	24 hours
Particulate Matter 2.5 ($PM_{2.5}$)	15µg/cu-m	Annual
	65µg/cu-m	24 hours
Ozone	235µg/cu-m(0.12ppm)(Gha)	1 hour
	157µg/cu-m(0.08ppm)	8 hours

Air Pollutant	Standard	Averaging Time
Sulfur Dioxide	80µg/cu-m(0.03ppm)	Annual
	365µg/cu-m(0.14ppm) (Ka)	24 hours

Abbreviation:

ppm: Parts Per Million

Notes: * In this schedule Air Quality Standards means Ambient Air Quality Standards
(Ka) Not to be exceeded more that once per year
(Kha) Annual Average value will be less than or equal to 50 microgram/cubic meter
(Ga) Average value of 24 hours will be less or equal to 150 microgram/cubic meter for one day each year.
(Gha) Maximum average value for every one hour each year will be equal or less than 0.12 ppm.

b) Gas emissions

The emission standard regarding the operation of the power plant is shown in **Table 8.1.2**. Natural gas is used for fuel in the power plant and SOx and particulate matter are not emitted: NOx is the only concern. The emission standard of NOx for Sirajganj CCPP is **40ppm**.

Diesel oil will be used in case gas is not available, and the regulation value for dust emission is 150 mg/Nm3. Regarding SOx, regulation for emission amount applies as well as concentration. The regulation applies only to coal-fired power plant.

Table 8.1.2 : Gas Emission Standard for Industrial Facilities

No.	Parameter	Unit	Standard Limit
1.	Particulates a) Electric Power Station of 200 Megawatts and above	mg/Nm^3	150
	b) Electric Power Station less than 200 Megawatts	mg/Nm^3	350
2.	Chlorine	mg/Nm^3	150
3.	Hydrochloric Acid gas & mist	mg/Nm^3	350
4.	Total Fluoride (F)	mg/Nm^3	25
5.	Sulfuric Acid mist	mg/Nm^3	50
6.	Lead particle	mg/Nm^3	10
7.	Mercury particle	mg/Nm^3	0.2
8.	Sulfur Dioxide		
	a) Sulfuric Acid manufacture (DCDA process)	kg/ton	4
	b) Sulfuric Acid manufacture (SCSA process) Minimum Stack height for Sulfuric Acid emission	kg/ton	10
	Lowest height of stack for dispersion of sulfuric acid a) Coal Fired Electric Power Station	m	
	i) 500 Megawatts & above	m	275
	ii) 200-500 Megawatts	m	220
	iii) Below 200 Megawatts	m	14 (Q)$^{0.3}$
	b) Boiler	m	
	i) For Steam up to 15 tons/hour	m	11
	For steam above 15 tons/hour	m	14 (Q)$^{0.3}$
9.	Nitrogen Oxides		
	a) Nitric Acid manufacture	kg/ton	3
	b) Gas Fired Electric Power Station		
	i) 500 Megawatts & above	ppm	50
	ii) 200-500 Megawatts	ppm	40
	iii) Less than 200 Megawatts	ppm	30
	c) Metal Treatment Furnace	ppm	200

No.	Parameter	Unit	Standard Limit
10.	Soot & Dust Particles		
	a) Air Ventilated Furnace	mg/Nm^3	500
	b) Brick-field		1000
	c) Cooking Furnace		500
	d) Limestone Furnace		250

Note:Q=SO_2 emission in kg/hour

2) Water quality

a) Ambient Water Quality

The classification of water area is determined by the DoE in charge, as in the case of air quality. Jamuna River flowing near the project site is classified as "water used for pisciculture" by Bogra DOE. For other parameters, the water quality standard for drinking water applies.

Table 8.1.3 : Ambient Water Quality Standard (Inland Surface Water)

Sl. No.	Best Practice based classification	pH	BOD mg/1	Dissolved Oxygen (DO), mg/l	Total Coliform Bacteria quantity/ml
a)	Potable Water Source supply after bacteria freeing only	6.5-8.5	2 or less	6 or above	50 or less
b)	Water used for recreation purpose	6.5-8.5	3 or less	5 or above	200 or less
c)	Potable Water Source Supply after conventional processing	6.5-8.5	3 or less	6 or above	5000 or less
d)	Water used for pisciculture	6.5-8.5	6 or less	5 or above	5000 or less
e)	Industrial use water including chilling & other processes	6.5-8.5	10 or less	5 or above	
f)	Water used for irrigation	6.5-8.5	10 or less	5 or above	1000 or less

Note :1) Maximum amount of ammonia presence in water are 1.2 mg/l (as nitrogen molecule) which is used for pisciculture.

2) For water used in irrigation, Electrical Conductivity-2250 micro mho/cm (at 25^oC). Sodium less than 26 mg/l* Boron less than 2 mg/l*

Table 8.1.4 : Environmental Water Quality Standard (Drinking Water)

Sl. No.	Parameter	Unit	Standard limit
1.	Aluminum	mg/l	0.2
2.	Ammonia (NH3)	"	0.5
3.	Arsenic	"	0.05
4.	Barium	"	0.01
5.	Benzene	"	0.01
6.	BOD : 5 20^OC	"	0.2
7.	Boron	"	1.0
8.	Cadmium	"	0.005
9.	Calcium	"	75
10	Chloride	"	150-600 **
11	Chlorinated Alkanes	"	

Sl. No.	Parameter	Unit	Standard limit
	Carbon tetrachloride		0.01
	1.1 Dichloroethylene	”	0.001
	1.2 Dichloroethylene	”	0.03
	Tetrachloroethylene	”	0.03
	Trichloroethylene	”	0.09
12.	Chlorinated phenols	“	
	Pentachlorophenol		0.03
	2.4.6 Trichlorophenol	”	0.03
13.	Chlorine (residual)	”	0.2
14.	Chloroform	”	0.09
15.	Chromium (hexavalent)	”	
16.	Chromium (total)	”	
17.	COD	”	
18.	Coliform (fecal)	n/100 ml	0
19.	Coliform (total)	”	0
20.	Color	Huyghens unit	15
21.	Copper	mg/l	1
22.	Cyanide	”	0.1
23.	Detergents	”	0.2
24.	DO	“	6
25.	Fluoride	”	1
26	Alkalinity (as CaCo3)	”	200-500
27.	Iron	”	0.3
28.	Nitrogen (Total)	”	1
29	Lead	”	0.05
30.	Magnesium	”	30-35
31.	Manganese	”	0.1
32.	Mercury	”	0.001
33.	Nickel	”	0.1
34.	Nitrate	”	10
35.	Nitrite	”	Less than 1
36.	Odor	”	Odorless
37.	Oil & Grease	“	0.01
38.	pH	”	6.5-8.5
39.	Phenolic compounds	”	0.002
40.	Phosphate	”	6
41.	Phosphorus	”	0
42.	Potassium	”	12
43.	Radioactive Materials total alpha radiation	Bq/l	0.01

Sl. No.	Parameter	Unit	Standard limit
44.	Radioactive Materials total beta radiation	”	0.1
45.	Selenium	mg/l	0.01
46.	Silver	”	0.02
47.	Sodium	“	200
48.	Suspended solid particles	mg/l	10
49.	Sulfide	”	0
50.	Sulfate	”	400
51.	Total soluble matter	”	1000
52.	Temperature	0C	20-30
53.	Tin	mg/l	2
54.	Turbidity	J.T.U	10
55.	Zinc	mg/l	5

Note : ** In coastal Aera 1000

b) Waste water

Table 8.1.5 shows waste water discharge standard. As waste water treated within the power plant is discharged into the Jamuna River, the standard value for “Inland Surface Water” applies.

Table 8.1.5 : Water Discharge Standard.

Sl. No.	Parameter	Unit	Inland Surface Water	Public Sewer at secondary treatment plant	Irrigated Land
1.	Ammoniacal Nitrogen (N molecule)	mg/l	50	75	75
2.	Ammonia (free ammonia)	mg/l	5	5	15
3.	Arsenic (As)	mg/l	0.2	0.05	0.2
4.	BOD5 200C	mg/l	50	250	100
5.	Boron	mg/l	2	2	2
6.	Cadmium (Cd)	mg/l	0.05	0.5	0.5
7.	Chloride	mg/l	600	600	600
8.	Chromium (total Cr)	mg/l	0.5	1.0	1.0
9.	COD	mg/l	200	400	400
10.	Chromium (hexavalent Cr)	mg/l	0.1	1.0	1.0
11.	Copper (Cu)	mg/l	0.5	3.0	3.0
12.	Dissolved Oxygen (DO)	mg/l	4.5-8	4.5-8	4.5-8
13.	Electrical Conductivity	micro mho/cm	1200	1200	1200
14.	Total Dissolved Solids (TDS)	mg/l	2,100	2,100	2,100
15.	Fluoride (F)	mg/l	7	15	10
16.	Sulfide (S)	mg/l	1	2	2

Sl. No.	Parameter	Unit	Inland Surface Water	Public Sewer at secondary treatment plant	Irrigated Land
17.	Iron (Fe)	mg/l	2	2	2
18.	Total Kjeldahl Nitrogen (N)	mg/l	100	100	100
19.	Lead (Pb)	mg/l	0.1	1.0	0.1
20.	Manganese (Mn)	mg/l	5	5	5
21.	Mercury (Hg)	mg/l	0.01	0.01	0.01
22.	Nickel (Ni)	mg/l	1.0	2.0	1.0
23.	Nitrate (N molecule)	mg/l	10.00	Undetermined	10.0
24.	Oil & grease	mg/l	10	20	10
25.	Phenol compounds(C6H5OH)	mg/l	1.0	5	1
26.	Dissolved Phosphorus (P)	mg/l	8	8	10
27.	Radioactive Materials.	As determined			
28.	pH		6-9	6-9	
29.	Selenium	mg/l	0.05	0.05	0.05
30.	Zn (Zn)	mg/l	5.0	10.0	10.0
31.	Total Dissolved solid	mg/l	2,100	2,100	2,100
32.	Temperature	Centigrade			
	Summer		40	40	40
	Winter		45	45	45
33.	Total Suspended Solid (TSS)	mg/1	150	500	200
34.	Cyanide (CN)	mg/1	0.1	2.0	0.2

Note : 1) These standards shall be applicable to industrial units or projects other than those given under Quality Standards for Classified Industries (Schedule 12).

2) These quality standards must be ensured at the moment of going into trial production for industrial units and at the moment of going into operation for other projects.

3) The value must not exceed the quality standard during spot check at any time ; if required, the quality standards may be more strict to meet the environment terms in certain areas.

4) Inland Surface Water shall mean drain, pond, tank, water body or water hole, canal, river, spring and estuary.

5) Public sewer shall mean sewer connected with fully combined processing plant including primary and secondary treatment.

6) Irrigated land shall mean appropriately irrigated plantation area of specified crops based on quantity and quality of waste water.

7) Inland Surface Quality Standards (Schedule 13) shall be applicable for any discharge taking place in public sewer or land not defined in Notes 5

3) Noise level

The applicable category of zone and noise standard for noise level are determined by the DoE in charge. The Bogra DOE determined the noise standard in the surrounding area of the power plant as follows: along the vehicle road, 75dBA in daytime and 70dBA in nighttime; in the residential area, 55dBA in daytime and 45 dBA in nighttime (**Table 8.1.6**).

Table 8.1.6 : Noise Standard

Sl. No.	Zone Class	Limits in dBA	
		Day	Night
a)	Silent Zone	50	40
b)	Residential Zone	55	45
c)	Mixed Zone (this area is used combinedly as residential, commercial and industrial purposes)	60	50
d)	Commercial Zone	70	60
e)	Industrial Zone	75	70

Note: 1) The day time is considered from 6 a.m. to 9 p.m. The night time is considered from 9 p.m. to 6 a.m

2) From 9 at night to 6 morning is considered night time.

3) Area within 100 meters of hospital or educational institution or government designated / to be designated / specific institution / establishment are considered Silent Zones. Use of motor vehicle horn or other signals and loudspeaker are forbidden in Silent Zone.

8.2 Work Plans and Schedules

8.2.1 Construction Phase

Before starting the construction work, the Project Director (PD) of NWPGCL is required to give sufficient consideration to the details of the construction work, and to make sure that the required EMP and Monitoring Plans are thoroughly understood by the contractor.

Thus, the Project Director (PD) of NWPGCL is required to form the required organization.

Especially, there is an active inflow of the workers and many construction-related vehicles during the construction. The details of the construction work, schedule and mitigation measures should be sufficiently explained to the communities in the surrounding area. The countermeasures should be altered as appropriate, based on the correct understanding of the views of the residents.

The following are the major environmental impacts during the construction work.

- Inflow of workers and an increase in the number of construction-related vehicles
- Generation of construction wastes
- Generation of dust particles, and gas emission from vehicles and machinery
- Generation of noise from vehicles and machinery
- Occurrence of muddy water in the excavation area

Employing workers from local areas during the construction phase will have a favorable impact on the local economy. Sufficient consideration must be given to the local employment, including implementation of the preliminary education and training program of the workers.

Table 8.2.1 gives the basic information of the EMP during the construction phase, and **Section 8.4** describes the Environmental Monitoring Plan.

The EMP and monitoring plan should be worked out by sufficient discussions between NWPGCL and the contractor. To confirm the implemented plan and to study further measures, a report schedule should be worked out in such a way that the contractor will report the current situation of implementation in the form of a written statement. This report should be submitted to the Bogra DoE for further discussion.

Table 8.2.1 : Major Environmental Impacts and Mitigation Measures at Construction Phase

Factor	Potential impact	Planned environmental mitigation measures	Responsible person
Inflow of workers	▪ Generation of sewage and refuse	▪ Installation of sewage treatment facilities ▪ Can and bottle refuse is classified and are supplied to a third party for reuse ▪ Disposal at a predetermined disposal site.	Contractor (NWPGCL)
	▪ Outbreak of diseases	▪ Installation of sewage treatment facilities ▪ Installation of medical facilities and implementation of periodic health checkups ▪ Education and training on health management of the workers ▪ Prevention of epidemics among workers (HIV/AID, dengue fever, malaria, hepatitis A) ▪ Elimination of potential breeding site for harmful insects, provision of preventive medicine as necessary	
	▪ Safety, accident prevention, land traffic	▪ Use of Bus for worker ▪ Avoidance of the time when students travel between school and home ▪ Reduction of vehicle speed in resident areas and close to schools ▪ Observation of traffic regulations, installation of traffic signs, and education on driving safety ▪ Implementation of safety program(traffic sign, speed limit, lighting of track, load restriction, checkup of auto parts (brake, klaxon)	
	▪ Employment, income, livelihood, vulnerable groups, uneven distribution of benefit	▪ Priority of employment for local residents, development of employment standard ▪ Utilization of local service (cleaning, catering, materials) ▪ Implementation of the preliminary education and training programs with local authority	
	▪ infrastructure	▪ Installation of medical facilities	
Installation	▪ Safety, accident prevention, land	▪ Avoidance of the school commuting time	Contractor (NWPGCL)

Factor	Potential impact	Planned environmental mitigation measures	Responsible person
of construction equipment	traffic	▪ Reduction of vehicle speed in resident areas and close to schools ▪ Observation of traffic regulations, installation of traffic signs, and education on driving safety ▪ Implementation of safety program(traffic sign, speed limit, lighting of track, load restriction, checkup of auto parts (brake, klaxon)	
	▪ Noise	▪ No traffic at night	
	▪ Gas emission, flying sand and dust particles from vehicles	▪ Periodic inspection and maintenance management ▪ Periodic check of the concentration of vehicle emissions based on laws and regulations ▪ Stop the engine when idling ▪ Use of a cover to protect against dust, and periodic washing of vehicles ▪ Periodic cleaning of the surrounding roads ▪ Monitoring of resident areas	
	▪ River traffic	▪ BIWTA will be consulted to determine appropriate safety and/or scheduling standards to be followed.	
Excavating work and operation of construction equipment	▪ Emission gas from machinery/sand and dust dispersion ▪ Noise	▪ Periodic watering of sediment disposition site and such ▪ Monitoring in residential area ▪ Operation in daytime only in principle ▪ Use of low-noise machinery (silencer, muffler) ▪ Construction of temporary fence around Project site ▪ Restriction of worker's prolonged exposure to noise ▪ Use of Personal Protective Equipment (PPE)	Contractor (NWPGCL)
	▪ Construction debris	▪ Waste management program consisting of reduction, reuse, and recycling of materials. ▪ Prohibition on dumping of any contaminating material ▪ Appropriate segregation of waste and disposal into designated disposal site	Contractor (NWPGCL)
	▪ Soil runoff, turbid water, waste water	▪ Installation of temporary settling tanks and sediment fencing	

Factor	Potential impact	Planned environmental mitigation measures	Responsible person
	from equipment cleaning ▪ Leakage of harmful substances ▪ Loss of habitat of flora and fauna ▪ Income, livelihood, vulnerable group	▪ Water used for equipment cleaning is collected in the temporary tank and treated before discharge ▪ Monitoring at the water outlet ▪ Mitigation measures to prevent leakage, installation of cleaning facility ▪ Installation of green buffer ▪ The agricultural products growing on the site is compensated according to the Bangladesh regulation. ▪ Explanation of the construction extent and procedure in the early stage. ▪ Preferentially employ local people predicting decrease in income.	
	▪ Safety, accident prevention, land traffic, infrastructure	▪ Develop a safety management plan and rules ▪ Swift transport to medical facility ▪ Observation of traffic regulations, installation of traffic signs, and education on driving safety ▪ Reduction of vehicle speed in resident areas and close to schools ▪ Installation of bypass for farm road and waterway within the site	
Water intake	▪ Lowering of groundwater level ▪ Ground subsidence	▪ Monitoring of underground water level in the surrounding wells ▪ Dig deeper wells as necessary ▪ Monitoring of underground water level in the surrounding wells	Contractor (NWPGCL)
Jetty construction	Sediment outflow, turbid water	▪ Construction of jetty will adopt vertical piles type to minimize the dredging area ▪ Dredging activities will occur during dry season when water levels and flow are the lowest. ▪ Adoption of dredging method that minimizes environmental effect ▪ Use of the floating siltation curtains where appropriate. ▪ Dredged materials will be landed and dried on-site. ▪ Installation of sediment fencing	Contractor (NWPGCL

Factor	Potential impact	Planned environmental mitigation measures	Responsible person
	• River traffic • income, Livelihood	▪ Conduct dredging activity during dry season with less traffic ▪ Minimization of jetty construction area ▪ Explanation of the construction extent and procedure in the early stage.	

8.2.2 Operation Phase

During the operation phase, the NWPGCL is responsible to form a required organization for environmental management. This organization is responsible for receiving the complaints from the residents of the surrounding area during the operation phase and to take appropriate measures, so that the complaints of the residents will be correctly understood and necessary measures will be taken.

The basic idea is to establish a relationship with the local communities. It is important to sufficiently explain the environmental management procedures taken at the power plant. It is also important to invite the residents and school children to observe the power plant.

The following describes the major environmental impacts during the operation phase.

- Generation of gas emissions and waste water
- Generation of noise from operating machinery
- Generation of solid waste from operation

The operation workers are required to have specialized knowledge. It will be difficult to hire workers from the local area. However, employing local workers will have a favorable impact on the local economy. For the comparatively easy work, sufficient consideration must be given to local employment, including implementation of the preliminary education and training programs for workers.

Table 8.2.2 gives the basic information on the EMP during the operation phase, and Chapter 9.4 describes the environmental monitoring plan.

NWPGCL should prepare a report on the implementation of the EMP and monitoring plan and should submit it to the Bogra DoE and related organizations for further discussion.

Table 8.2.2 : Major Environmental Impacts and Mitigation Measures at Operation Phase

Factor	Potential impact	Planned environmental mitigation measures	Responsible person
Power generation	▪ Generation of gas emissions	▪ Adoption of a high stack ▪ Installation of a continuous monitoring system for gas emissions ▪ Adoption of pre-mixing method and a low-NOx combustor ▪ Monitoring of atmospheric air ▪ Periodic maintenance and management	NWPGCL
	▪ Generation of cooling and waste water	▪ Construction of open channel for a distance for cooling the hot water ▪ Installation of a wastewater treatment system capable of coagulation sedimentation, neutralization, and oil separation ▪ Monitoring of waste water ▪ Monitoring of the river or local water ▪ Blow-off water from cooling tower is cooled by dilution	
	▪ Generation of noise and vibration	▪ Planting trees around the power plant ▪ Adoption of low-noise type machinery and installation of soundproofing covers ▪ Installation of low-vibration type machinery and the use of rigid foundations ▪ Periodic maintenance and management ▪ Monitoring around the border of the site and residential area ▪ Distribution of ear protectors to employees	
Water intake	▪ Lowering of Groundwater level ▪ Ground subsidence	▪ Monitoring the underground water level in the surrounding wells ▪ Did wells of appropriate deepness as necessary	NWPGCL
Generation of waste	▪ Generation of sludge from the wastewater treatment system ▪ Generation of waste	▪ Waste management program consisting of reduction, reuse, and recycling of materials. ▪ Systematic collection and protected-storage on-site ▪ Prohibition on dumping of any contaminating material	NWPGCL

Factor	Potential impact	Planned environmental mitigation measures	Responsible person
	oil ▪ Generation of domestic waste	▪ Waste away from the site and their appropriate disposal in a designated municipal dumping site.	
Presence of power plant, inflow of workers	▪ Loss of habitat of flora and fauna ▪ Employment, livelihood, vulnerable people, uneven distribution	▪ Provision of vegetated buffer ▪ Preferential employment of local people ▪ Utilization of local service (cleaning, catering) and materials ▪ Implementation of the preliminary education and training programs with local authority	NWPGCL
	▪ Land traffic	▪ Use of Bas for worker ▪ Observation of traffic regulations, installation of traffic signs, and education on driving safety ▪ Speed limit in residential- and school area	
	▪ Social foundation ▪ Diseases	▪ Provision of emergency medical facility ▪ Medical facility and periodical health checkup ▪ Education and training on health management of the workers	
	▪ Accident and safety management	▪ Tank storage areas will be equipped with oil spill bank and countermeasure for underground oil seepage and designed as physical containment area. ▪ Implement gas leakage prevention procedures and have available on-site all preventive equipment and materials as part of the process of developing emergency plan. ▪ Fire protection equipment and facilities shall be made available at suitable locations in power plant including fixed fire protection system, fire hydrants, portable fire fighting equipment, fire vents, alarm system, fire compartments and fire exit signs. Preparation of safety standard.	
Presence of jetty	▪ River traffic, land use, livelihood	▪ Develop an appropriate maintenance and management schedule	NWPGCL

8.3 Environmental Implementation and Training

During operation phase, NWPGCL is responsible for the system organization of environmental management of the power plant and its implementation. The **Assistant Manager (Environment)** based at NWPGCL's Head Office should take charge of the management of the system to ensure environmental management and monitoring described hereinafter.

The **Assistant Manager (Environment)** should be responsible for reporting the planning and implementation of environmental management plan and environmental monitoring plan to the manager of the power plant through all the phases of the project, and the director should take the final responsibility.

The **Assistant Manager (Environment)** provides preliminary training on environmental management to the staffs prior to the beginning of the operation. The **Assistant Manager (Environment)** should also provide appropriate updated training all through the operation phase.

The **Assistant Manager (Environment)** is also responsible for reporting about the negotiation with local residents and issues of environmental management and monitoring and training to Bogra DoE and relevant organization.

8.4 Environmental Monitoring Plan

8.4.1 Monitoring Parameters

a) Construction Phase

Table 8.4.1 shows the monitoring condition during the construction phase.

- Air quality monitoring: SPM, SO_2, and NO_2 are used as parameters for the measurement. Air quality will be monitored in the residential areas in principle. If there are any places susceptible to impact such as schools, select those places as the target of the measurement.
- Waste water monitoring: TSS will be used as a parameter for the measurement. Waste water will be monitored at the outlet from the settling tank.
- Noise monitoring: Noise level will be used as the parameter for the measurement. Noise will be monitored in the residential areas in principle. If there are any place susceptible to impact such as schools, those places will be selected as the target of the measurement.
- Underground water monitoring: The underground water level , Water temperature, and precious metals As etc is used as the parameter for the measurement. Underground water will be monitored in the tube wells used for drinking water which are used in the surrounding residential areas.

b) Operation Phase

Table 8.4.2 shows the monitoring condition during the operation phase.

- Gas emission monitoring: SPM, SO2, and NO2 will be used as parameters for the measurement. Gas emissions will be monitored in the flue.
- Air quality monitoring: SPM, SO2, and NO2 will be used as parameters for the measurement. Air quality will be monitored in the residential areas in principle. If there are any place susceptible to impact such as schools, select those place as the target of measurement.
- Waste water monitoring: Water temperature, DO, SS, oil, BOD, and precious metals will be used as parameters for the measurement. Waste water will be monitored at the outlet where the waste water is discharged from treatment plant.
- Water quality monitoring: Water temperature, DO, SS, oil, BOD, and precious metals are used as parameters for the measurement. Water quality will be monitored at river or local.

- Noise monitoring: Noise level will be used as the parameter for the measurement. Noise will be monitored on the boundary of the site and in the residential areas in principle. If there is any place susceptible to impact such as schools, select those places as the target of the measurement.
- Underground water monitoring: The underground water level, Water temperature, and precious metals As , etc will be used as the parameter for the measurement. Underground water will be monitored in the tube wells used for drinking water which are used in the surrounding residential areas.

8.4.2 Monitoring Schedule

Tables 8.4.1 and **8.4.2** show the monitoring schedule during the construction and operation phases.

Table 8.4.1 : Monitoring Schedule during the Construction Phase

Item	Parameter	Place	Frequency
Air quality	SPM, SO_2, NO_2	Residential areas and schools	Monitor SPM every two weeks, and SO_2 and NO_2 every two months.
Water quality	TSS	Drain outlet	Every month
Noise	Noise level	Residential areas and schools	Every week when the amount of construction work is maximized
Underground water	Underground water level Water temperature, heavy metals(As, etc)	Residential area	Twice/year (dry season and rainy season)

Table 8.4.2 : Monitoring Schedule during the Operation Phase

Item	Parameter	Place	Frequency
Gas emission	SPM, SO_2, NO_2	Flue	Monitor SO_2 and NO_2 on a continuous basis (by a continuous monitoring system), and SPM every month.
Air quality	SPM、SO_2, NO_2	Residential areas and schools	Monitor SO_2 and NO_2 every month, and SPM every two months.
Waste water	Water temperature, DO, SS, oil, BOD, and heavy metals	Drain outlet	Every two months
Water quality	Water temperature, DO, SS, oil, BOD, and precious metals	River	Twice a year (dry and rainy seasons)
Noise	Noise level	On the border of the site and in the residential areas	Twice a year
Underground water	Underground water level Water temperature, heavy metals (As, etc.)	Residential area	Twice/year (dry season and rainy season)

8.5 Occupational Health and Safety

8.5.1 General Requirements

In Bangladesh the main law related to occupational health and safety is Labor Law 2006. The law has provisions on occupational hygiene, occupational diseases, industrial accidents, protection of women and young persons in dangerous occupation.

8.5.2 Workplace Environmental Quality

The proposed power plant project has several phases - the construction of infrastructure and installation and commissioning of plant equipment, operation of the plant etc.

The construction phase includes site preparation and plant construction, access road construction etc. The health hazards associated with these activities are mainly due to dust and noise pollution. Excessive noise contributes to loss of hearing and triggers physiological and psychological body changes. Dust pollution can cause eye and respiratory irritation and in some cases allergic reactions. The inhalation of exhaust gases from vehicles and machinery are also harmful for health. Stress can be caused by working in shifts, high work load, poor living condition of workers etc.

Remedial measures

To minimize the hazards arising from the activities at different phases of plant construction and operation, the following measures should be taken:

Employees should be informed of the potential health impacts they are facing. The employer should inform his employees of these potential hazards, arrange proper medical examination prior to and during employment, as well as tests and analyses necessary for the detection of diseases. Works with volatile toxic chemicals should be undertaken in a well ventilated place. Laborers handling offensive toxic chemicals should be provided with and forced to use protective clothing. Workers exposed to an excessive amount of noise should be provided with protective gear and be relieved frequently from their post. Workers exposed to large amounts of dust should be provided with adequate protective gear. Frequent spraying of water should be undertaken to minimize dust pollution. Persons undertaking construction and installation works should have access to amenities for their welfare and personal hygiene needs such as sanitary toilets, potable drinking water, washing facilities, shelter sheds etc. Proper disposal of waste and sludge should be arranged. Health education and information on hygiene should be provided to the workers. Regular checks on food quality should be arranged within the work site

(a) Safety

Safety implies the reduction of risk of accidents at the work site. Accident prevention is more valuable than any mitigatory or compensatory measures. This may be achieved through strict rules and procedures for the execution of specific tasks, enforcement of the rules, discipline amongst workers, maintenance of machineries used and by providing all necessary gear or equipment that may enhance the safety of the workers.

The following guidelines should be followed to maintain the safety of the workers:

- Workers have to be informed about the possible damage or hazards related to their respective jobs.
- If pedestrian, traffic or plant movements at or near the site are affected by construction works, the person with control of the construction project must ensure that these movements are safely managed so as to eliminate or otherwise to control any associated health and safety risks.
- Must ensure sufficient lighting in the area where a person performs construction work or may be required to pass through, including access ways and emergency exit or passage without risk to health and safety.
- Construction site needs to provide safe access to and egress from all places where they may be required to work or pass through.
- This includes the provision of emergency access and egress route that must be free from obstructions.
- Adequate perimeter fencing should be installed on the site before construction work commences and that should be maintained during the construction work and signs should be placed which is clearly visible from outside the site including emergency telephone numbers.
- Must ensure that electrical installations materials, equipment and apparatus are designed,

installed, used, maintained and tested to eliminate the risk of electrical shock, burns, fire or explosion.

- Construction site should be kept orderly and tidy. Access ways should be kept clear of materials and debris and maintained in a non-slippery condition. Materials should be stored in an orderly manner so that it does not pose any risk to the health or safety of any person.
- Arrangements of first aid facility should me made accessible when construction work is being undertaken.

8.5.3 Work in Confined Spaces

In the operational phase of the plant, the work will mainly be limited in confined spaces.

In this phase, noise pollution may pose risk to health. It has been observed that the measured noise level near the generators and turbines ranged from 90 dBA to 110 dBA.

This level of noise limits the continuous exposure to the workers from 2 to 4 hrs beyond which hearing impairment may be caused. If the installation of generators and turbines are within a confined space and monitored through glass windows, it will not pose any serious threat. However precautions should be undertaken during routine inspections and maintenance works. Supervisors, inspectors and related personnel should wear noise protectors like ear plugs or ear muffs. Wearer should be given a choice between ear muffs and plugs as muffs are easy to use but may be a nuisance in a confined work space and be uncomfortable in hot environment. Whereas ear plugs don't get in the way in confined spaces but may provide little protection if not used carefully.

As the employees will work in confined spaces, the air pollution may not pose a health risk. However, the ambient temperature may be high due to plant operation and measures should be taken to keep temperature within a comfortable limit. Where damage to plant presents an electrical hazard, the plant should be disconnected from the electricity supply main and should not be used until the damaged part is repaired or replaced.

8.5.4 Hazardous Material Handling and Storage

During construction of the plant, commercially available chemicals (paints, thinners etc) will be used and stored in the construction area. Hence small amount of unused or spent chemicals (used paints, motor oils) will be generated. Hazardous wastes likely to be generated during routine project operations include oily water, spent catalyst, lubricants and cleaning solvents.

Operation and maintenance of the plant also generates some hazardous wastes. These include waste oil, boiler bottom ash, spent solvents, batteries, fluorescent light tubes, lubricating oils etc. The project will also involve the construction and operation of gas pipe line and handling of large amount of natural gas. Natural gas poses some risk of both fire and explosion.

Used lead acid batteries contain lead, sulfuric acid and several kinds of plastics which are hazardous to human health. Therefore the following set of storage guidelines should be adopted:

- the storage place must be sheltered from rain and other water sources and if possible , away from heat sources
- the storage place must have a ground cover
- the storage place must have an exhaust ventilation system in order to avoid gas accumulation
- the storage place must have a restricted access and be identified as a hazardous material storing place
- any other lead materials which may eventually arise, such as plumbing, should be conveniently packaged and stored in accordance with its characteristics

It is recommended that where dangerous goods are stored and handled, that premises should be provided with fire protection and fire fighting equipment. These equipments should be

installed, tested and maintained in accordance with the manufacturer's guidelines. The employer must ensure that a procedure for dealing with emergencies is in place, implemented, maintained and communicated to persons on the premises who may be affected by or respond to an emergency.

Ignition sources in hazardous areas should be eliminated. The facility staff should be trained and equipped with personal protective gear such as rubber gloves, boots, hard hats, apron or splash suit and a face shield with safety glasses or goggles.

8.5.6 Training

Training is an integral part of a preventive strategy. The target groups requiring training should be managers, supervisors, and technicians and related staff who may be exposed to risk at work.

Employee representatives should represent the views of workers to management about occupational health and safety and report to workers about management policy. Persons likely to be exposed to risks should be provided with information and instruction in safety procedures associated with the plant at the work place.

Relevant health and safety information should be provided to persons involved in installation and commissioning, use and testing of the plant.

Information on emergency procedures relating to the plant should be displayed in a manner that can be readily observed by persons who may be affected by the operation of the plant.

Training should be provided to use fire fighting equipment when necessary.

Facility staff needs to be trained in the safety procedures that are to be implemented during unloading, transfer and storage of hazardous materials.

8.5.7 Record Keeping and Reporting

Record keeping and reporting is one of the requirements of any QA/QC system and essentially of a good management tool. Properly maintained records of construction, installation, training, equipment maintenance, operation, fault detection and remedy can help in reducing risks of accidents, legal costs and thereby overall cost of operation of a plant. Records also help in identifying causes of any accident and elimination of the same accident in future. Records may be maintained for the proposed plant as follows.

Construction phase

A person with control of a construction project or control of construction work should retain records for a reasonable period after the completion of the construction project of the occupational health and safety induction training and any other training given to persons directly engaged or trained by them to undertake construction work on the project.

Operation phase

During operation of the plant, arrangements should be made to keep records on any relevant tests, maintenance, inspection, commissioning and alteration of the plant, and make those records available to any employee or relevant health and safety representative.

All other records, including assessment reports not indicating a need for monitoring and/or health surveillance and records of induction and training, shall be maintained for at least five years in a suitable form.

CHAPTER 9: RISK ASSESSMENT AND MANAGEMENT

9.1 Introduction

The problem of protecting human health and the environment may best be defined as the management of risk. The failure to manage risk effectively and to establish priorities rationally translates ultimately into a failure to protect health, safety, and the environment. Through the use of risk assessment, concerned authorities can estimate the relative level of risks posed by different substances, products and activities and can establish priorities in determining whether, and how, to regulate.

Risk assessment is the technical process for estimating the level of risks posed by operational processes or products, i.e. the probability that a given harm will occur as a result of the processes or products. Risk assessment is applied to a substance, proceeds in four major steps:

Hazard identification: determining what kinds of adverse health effects a substance, product or activity can cause

- Dose - response assessment: predicting the degree of adverse effects at a given exposure level
- Exposure assessment: estimating the amount of exposure, and
- Risk characterization: combining the foregoing into a numerical range of predicted deaths or injuries associated with actual exposure event

Risk management options are then evaluated in a proposed solution to provide reduction of risk to the exposed population. Specific actions that are identified and selected may include consideration of engineering constraints as well as regulatory, social, political and economic issues related to the exposure. Quantitative assessment of risks associated with hazard identification, dose-response assessment, exposure estimation and risk characterization were beyond the scope of the present study. However, this study takes a qualitative approach to identify common hazards within the power plant and recommends measures for managing these risks with accidents and external threats.

9.2 Power Plant Risks Assessment

The process of electricity generation from oil or gas is by no means risk free because of high temperature and pressure conditions within the plants, rotating machineries and high voltages involved. Apart from risks associated with emissions, noise generation, solid waste, hazardous waste and wastewater disposal as a result of construction and operation, the oil/gas fired power plants put human beings and the environment inside and outside of the plant to a certain degree of risk of accident and sometime loss of life. It is therefore essential that a risk management plan should be devised in order to both reduce risk of accident and to take the correct action during accidents. Important risks of accidents in thermal power plants leading to disasters or emergency situations may occur during following events:

- Risks during emergency: Fire, Explosion, Oil/acid spillage, Toxic chemical spillage, Electrocution
- Risks due to natural disasters: Flood, Cyclone, Earthquake, Storm, Lightning,
- Risks due to external threats: Sabotage, War situation, Water/food poisoning

In power plants, accidents can occur at two different levels. First, these may occur due to fires, explosions, oil or chemical spillage and spontaneous ignition of inflammable materials. In such events, operators working inside the plant and at various strategic hazard locations will be affected.

Second, risks are also associated with external threats of sabotage. Failure of automatic control/warning systems, failure of fuel oil storage tanks and chemical release from acid and alkali stores and handling also pose great degree of associated risks.

9.3 Managing the Risks

As mentioned earlier, in order to reduce the risks associated with accidents, internal and external threats, and natural disasters, a risk management program is essential. Risk management planning can be done during design and planning stage of the plant as well as during plant operation. While risk management is mainly preventive in nature during the plant operation stage, the design and planning stage of the plant can incorporate changes in basic engineering to include safety design for all processes, safety margins for equipment, and plant layout. The following steps among others are important in managing the risks mentioned.

- Gas storage is to be designed with adequate precautions in respect of fire hazard control.
- Storage of hazardous substances such as acids and alkalis should be sited in protected areas.
- With respect to plant operation, safe operating procedures should be laid down and followed to ensure safety, optimum operation and economy.
- A fire fighting group with adequate manpower and facilities such as water tank of sufficient capacity, C02 tank, foam tank, portable fire extinguishers should be provided and facilities located at strategic locations e.g. generator area, high voltage panel, control rooms, and fuel tank area.
- Regular checks on safe operating practices should be performed.

In order to achieve the objective of minimizing risks at the Sirajganj PPP, the unit will be trained to act in a very short time in a pre- determined sequence to deal effectively and efficiently with any disaster, emergency or major accident to keep the loss of life, human injury, material, plant machineries, and impacts on the environment to the minimum.

9.4 Emergency Response Plan

Emergency response plans are developed to address a range of plausible risk scenarios and emphasize the tasks required to respond to a physical event. The emergency response plan (ERP) for the proposed power plant has been developed listing various actions to be performed in a very short period of time in a pre-determined sequence if it is to deal effectively and efficiently with any emergency, major accident or natural disaster.

The primary objective of the plan is to keep the loss of life, material, machinery/equipment damage, and impacts on the environment to minimum.

9.4.1 Emergency Response Cell

It is highly recommended that an Emergency Response Cell (ERC) adequately equipped with highly trained manpower and appropriate gears is established within the power plant in order to effectively implement the emergency response plan. The main functions of the emergency response cell should include the following.

- Identification of various types of emergencies
- Identification of groups, communities, and areas those are vulnerable to different kinds of emergencies
- Preparing service teams for various operations within the organization through extensive training
- Establishment of early detection system for emergencies
- Developing reliable, instant information and communication system
- Mobilizing all units in the plant within a very short time to address any emergency

9.4.2 Emergency Preparedness

The ERC headed by a trained Manager should establish an Emergency Control Room with links to all plant control rooms and all other services.

The team will be responsible for preparing and executing a specific emergency response plan for the power plant . The team should meet at regular intervals to update the plan, based on plant emergency data and changes in support agencies.

The team should undertake some trial runs, e.g. fire drill, in order to be fully prepared and to improve upon the communication links, response time, availability and workability of emergency gears and other critical factors.

Upon receiving information about an accident, the ERC team will assemble in the Emergency Control Room within the shortest possible time and formulate emergency control procedure.

9.4.3 Fire Fighting Services

The Fire Officer will be the commanding officer of the fire fighting services. The FO will head a fire fighting team of trained officers and workers. Adequate fire fighting equipment e.g. fire extinguishers of different types appropriate for different strategic locations must be planned according to requirements of existing and future plants.

Depending on the scale of emergency, the fire fighting team will work in close association with security and maintenance personnel of plant. Additional assistance may also be sought from outside fire stations when required.

Preparedness is extremely important for efficient and effective fire fighting services at the time of emergency. This can be better achieved by organizing fire drills at regular intervals, e.g. once every two weeks during dry summer, months and once every two months during wet months involving all team members, all other service groups, all staff of the power plant, and utilizing all fire fighting gears.

9.4.4 Emergency Medical Services

The Chief Medical Officer will be responsible for providing medical services within the power plant at the time of any emergency. The services should also be rendered to people living in the close vicinity of the plant and affected by any accident within the plant.

The Medical room of the Sirajganj PPP must be equipped with adequate medical personnel and equipment for providing emergency services in addition to normal Medicare services to population of the plant.

A team of well trained Medical Officers specializing in burn injury, orthopedics, electrocution, chemical toxicity or poisoning, and shock treatment must be available at the power plant Medical room. The number of officers may be determined considering the total number of staff and their family members in the plant. Special attention must be given to child injury treatment.

The following services must be on alert at all times in the plant.

First aid services for attending patients on the spot. The Medical room should provide training on first aid services to some designated staffs of important areas of operation, e.g. boiler area, turbine hall, transformer area, electrical rooms, and chemical storage facilities, for immediate attention to the injured.

Ambulance services should be available for transport of casualties from spot to Medical room of the plant, and from Medical room to outside hospital, as necessary. Facilities for transportation of fatalities to appropriate hospital or to relatives or to the police following prescribed procedure should be available.

All potential areas for emergency1 accidents in the plant must have an information chart including contact phone numbers of relevant services.

9.4.5 Rescue Services

Without going for additional manpower, the rescue team can be formed with potential staffs of the Power Plant, e.g. from medical services, security services and fire fighting services, for conducting rescue operations following an emergency. A senior member can be designated Rescue Officer who will be responsible for formulating rescue plan and guiding the team.

9.4.6 Security Services

Sirajganj CCPP will have a strong independent security team headed by the Chief Security Officer and will be responsible for the overall security of the plant , its equipment, machineries, buildings, utilities. The security office shall maintain liaison with other emergency services at the time of emergency and during normal hours.

9.4.7 Public Relations Services

The Public Relations Officer (PRO) of the Power Plant will be responsible for communicating emergency related information to concerned officials within the power plant. The PRO however, will consult the Emergency Manager before communication with outside agencies.

The PRO will be responsible for warning people in and around the plant against potential fire hazards, or possible chemical contamination of water.

The PRO will keep close contact with outside local community and provide direction, and participate along with management team in the welfare services for the affected communities.

9.5 Concluding Remarks

Apart from the services mentioned above, the Environmental Management Unit and the Emergency Response Cell must ensure that all staffs working within the Power Plant are oriented, through orientation programs, about the dos and don'ts during emergencies as well as overall environmental aspects and issues related to power plant operations.

It is however, to be emphasized that the emergency response plan (ERP) outlined above is to be used as guide only and that the Environmental Management Unit and the Emergency Response Cell shall develop their own environmental management system (EMS) following ISO 14001 and the emergency response plan (ERP) respectively in consultation with and involving the Sirajganj CCPP (2nd Unit) and the NWPGCL Management.

CHAPTER 10: PUBLIC CONSULTATIONS

10.1 Introduction

Public consultation forms an important part of the EIA study. The main objective of the consultation process is to apprise the local inhabitants about the proposed project and to seek their opinions regarding the possible impacts of the project. It was recognized that their opinions would be more useful as they are accustomed to construction and operation of a number of power plant units in the locality in last few years.

Public involvement is a fundamental principle of any environmental assessment study. The inclusion of the views of the affected and interested public helps to ensure that the decision making process is equitable and fair and leads to more informed choice and better environmental outcomes. The findings from the public consultations carried out as a part of the EIA study were utilized in the development of the EMP (presented in Chapter 8), especially in identifying the significant impacts of the proposed project and developing the corresponding mitigation measures.

10.2 Approach and Methods

Within the framework of the present study, public consultation process has been initiated with an explicit objective to ensure people's participation. More specifically this was aimed at improving the study, taking into account opinions from the people of the study area.

The consultation sessions included Focused Group Discussions (FGD). one FGD was organized only with villagers adjacent to the project site and another with community leaders around the project site.

Formal and informal meetings in terms of FGD with different groups and interviews with Key Informants (KIs) of the area were held with the primary objective to understand the people's perceptions regarding relevant issues. Discussion mainly centered on problems of the area relevant to the proposed project and suggested solutions.

Apart from Focus Group Discussion, In-depth interviews were conducted with the different officials of Sirajganj Sadar upazila to grasp their views and opinions.

The study also took into consideration the findings of questionnaire survey carried out as part of the EIAs conducted for other power plants, (positive and negative impacts), the socio-economic and political situation and peoples' perception about the project.

Consultation was undertaken at early stages of the EIA study so that potentially affected groups/people could provide meaningful input to the EIA. The dialogue, both formal and informal, was continued throughout the period. All consultations and meetings were documented including responses to the questionnaire.

10.3 Public Consultations

10.3.1 General:

Survey has been conducted in the adjoining areas of the proposed site for new power plant in two ways – i. Quantitative approach and ii. Qualitative approach. For quantitative approach, standard questionnaire (socio economic and environmental issues) has been used for interviewing randomly selected respondents in the proposed area. On the other hand, for qualitative approach, focus group discussion guidelines have been followed.

For Quantitative approach, 150 respondents have been randomly selected from the adjacent villages, Char Panchasona, Char Bara Simul, Punarbashan and North Saydabad of Saydabad union under Sirajgonj Sadar upazila.

For Qualitative approach, two Focus Group Discussions – one for adjacent villagers and another for community leaders were conducted in the proposed area. Apart from FGDs, in-depth interview was conducted with local administrative authorities and public representative. .

10.3.2 General Interview:

For Quantitative approach, 150 respondents have been randomly selected from the

adjacent villages, Char Panchasona, Char Bara Simul, Punarbashan and North Saydabad of Saydabad union under Sirajgonj Sadar upazila. The Comments of the Respondents are as follows:

- Crops get affected due to air pollution (no fruits are produced)
- Noise/vibration from the existing power plant makes sleeping problem at night
- Exhaust gas emissions from the existing power plant causes respiratory diseases
- It will be better if the new power plant is established..
- The wastes have to be managed properly so that there are no negative impacts on the water or to the environmental.
- The authority must make sure that the local people get a good supply of electricity.
- As the rate of electricity generation will increase, the rate of load shedding will decrease.

10.3.3 Focus Group Discussion:

FGD-1 (Villagers)

- Venue: Md. Moyan Mondol Shops Front Side
- Village: Moholla:. Boro Shimol Pansha Sona
- Time: 3:00pm
- Date: 19-09-2013

Profile of Participant:

S.L No.	Name of the participant	Age	Occupation	No. of Family Size	Education	Monthly income	Marital status	Member of Association	Taken loan	Remarks
01	Md. Sondur Hossain	23	Driver	06	X	8000	Unmarried	No	60000/-	
02	Asaduzaman	65	Agriculture	06	H.S.C	8000	Married	No	No	
03	Sakil	17	Student	04	X	13000	Unmarried	No	No	
04	Abu Sayed	50	Agriculture	06	No	10000	Married	No	No	
05	Saruzzam Mollaha	65	Service	05	S.S.C	15000	Married	No	No	
06	Ariful Islam	20	Weaver	07	X	16000	Unmarried	No	No	
07	Belal Ahmed	30	Agriculture	07	No	7000	Married	No	No	
08	Nayem Islam	22	Service	09	S.S.C	12000	Unmarried	No	No	

Outcome of FGD-1:

All of the above respondents were local citizens from the Boroshimul and Ponchoshona village, Union- Syedabadh, Upazilla- ShirajganjShadar, JIlla- Shirajganj. They all live near the power plant site.

There were in total 8 respondents. Among them, 3 were farmers, 2 of them were service holders, 1 of them was a driver, 1 embroidery worker and 1 student.Among the 8 respondents, 2 of them passed their SSC, HSC by 1, standard 10 by 3 and the rest of the two were illiterate.

The average monthly income of the respondents was 9662 taka. People of this area improvise their skills and depending on the condition and the opportunities, they somehow keep themselves employed and income money in the process. The average age group of the respondents is 37 years. Through the meeting it is known that some of the respondents live in this area from birth. On the other hand, some live here for about 8-20 years. And some of them used to live somewhere else before moving on to this area. The reason behind their rehabilitation is because their lands were broken by the flow of water from the Jamuna River. People of this area are more health-conscious now. For any sort of medical treatment, people often take help from the Shirajganj Sadar Hospital and private hospitals. For minor health oriented problems, people take aid from the local-small pharmacies.

From the meeting, it is known that an NGO named Manobmukti took the initiative and made hygienic latrines at a very low cost for the local people. As a result, health hazards like diarrhea, stomach oriented problems and formation of stomach worms have become less severe over time. All of the respondents use and consume arsenic free water. The depth of water in this area is near 40'-70'.

The respondents addressed that there is a severe case of noise pollution from the 150 MW power plant. This is the reason why people cannot sleep properly at night. This also causes seismic movements of the lands. Emitted smog from the power plant mixes with the air and causes air pollution as well. They complained that they cannot directly use the generated electricity from this power plant. They also added that if their area gets sufficient supply of electricity then there will be a rapid economic growth in their area. Their embroidery sector is not getting sufficient electricity from the Polli Biddut, so they think that if this sector gets sufficient supply of electricity, then it will flourish and will bring about a rapid and positive economic change to their area.

In recent times, the number of trees and plants in this area is beyond the level of satisfaction, because the people of this area are very interested in planting trees and keeping it "green." Currently, the number of trees are more compared to what was found nearly 15-20 years back, and the reason behind this is because there were less number of people living in this area at that moment. As the number of population increased, the number of trees also increased over the years. Mango, Jaam, Jackfruit, Papaya, Mahogany, Eucalyptus and Guava are found in huge quantities at the moment.

But, some trees have decreased in this area, like the Taal Gaach. The use of mammals like Buffalo and Horses does not exist over here at the moment .Siting of birds like vulture, owl and eagle are rare these days. In case of fishes, the numbers of kaunia and pabda fish have decreased.

At the end of the meeting the respondents added that they don't want any negative

environmental impacts in their area. They want the authority to keep a close eye on the fact that there is no possible air or water pollution from the power plant site. However, they are really looking forward to the establishment of this power plant, because there still is a major lacking of electricity in this country.

Photograph taken during conduction of FGD-1 is given below:

Focus Group Discussion with Villagers

FGD-2 (Community Leaders):

- Venue: Ponorbashan Ground
- Village: Moholla:. Char Soyadabad
- Time: 6.00 PM
- Date: 17-09-2013.

Profile of Participant:

S.L No.	Name of the participant	Age	Occupation	No. of Family Size	Education	Monthly income	Marital status	Member of Association	Taken lone	Remarks
01	Badsha	26	Businessman	09	II	4000	Married	No	No	
02	Abdul Aziz Mondol	65	UP Member	05	X	16000	Married	No	No	
03	Md. Karim	45	Business	08	No	10000	Married	No	No	
04	Md. Ashan Ali Shekh	50	Madrasha Teacher	09	No	10000	Married	No	Yes 100000/-	
05	Abdul Aziz Bepari	40	Fish Business	05	III	8000	Married	No	Yes 70000/-	
06	Siddik Mondol	70	Agriculture	05	No	12000	Married	No	Yes 60,000	
07	Md. Yousuf Ali	37	Business (Contactor)	05	S.S.C	15000	Married	No	No	
08	Md. Abdul Manan	48	Service	05	V	12000	Married	No	Yes 150000	

Outcome of FGD-2:

The male participants were local civilians of Purnobashon and North Syedabadh. This area is under the Syedabadh union, Upazilla- Shirajganj, Shadar and Jila- Shirajganj.

The numbers of participants in the FGD were 8. All of them were married and only 5 of them could read and write. The remaining 3 could not read or write. Among the 8 respondents, 4 of them were businessmen, 2 of them were service holders, 1 of them was related to farming and the remaining one was a member of the local UP.

The average monthly income of the respondents was 10815 taka and each of them was affiliated with some sort of occupation.Related to works like business or farming and so on. Their average age is 47. Before living on this village they used to live on various other villages.Now they arepermanently living on this village due to the warring of the lands near the Jamuna River.

The participants normally consult the doctors of the Shirajganj Shadar Hospital or to the local doctors of their village regarding their health issues.

All of the participants drink hygienic drinking water. They also informed that there is no trace of arsenic in their village. Currently, the depth of their tube-well is around 40'-80' layers. It is hard to get water during the dry seasons. The following participants also added that each and every member of their family uses hygienic latrines. These hygienic latrines were provided by the Manob Mukti Committee. The also said that after using these hygienic latrines, the rate of health hazards have decreased over the years.

The respondents said that there is a supply of rural-electricity in their area. If a new power plant is established in their area, then this will create more employment opportunities for the people of this area. Both the merits and demerits behind establishing this power plant came in to the subject of the meeting. They said that no trees or plants are growing under the transmission line of the Grid Company. The amounts of cultivated crops have also declined. People have often complained of being a victim of electric shocks while traveling down the transmission line on a rainy day with an umbrella in hand. They also added that current passes through their television antennas.

In recent times, people are seeding more plants and trees in their area. As a result, the amounts of trees and plants have increased in the area. This is the reason why fruits like-mango, jaam, jackfruit, coconut, guava, papaya etc are easily found. Before establishing this power plant, the area used to be a low-land. While building the Jamuna Bridge, this area was covered with sand in order to increase the elevation of the land.

The participants also added that on recent times, the reported sightings of bird like- vulture, eagle, falcon, babui, owl etc have decreased dramatically. In case of mammals, the use of horses and buffaloes by the people has decreased over the years. As for fishes, many people of this area are related to fishing and according to them, the number of fishes (like-Kaunia, Pabda, River-Pangash) have decreased in the Jamuna River.

In the end, all of the participants agreed to the terms of establishing this power plant in their area but also advised to keep a close eye on the possible environmental impacts that are likely to take place after this power plant is established.

Photograph taken during conduction of FGD-2 is given below:

Focus Group Discussion with Community Leaders

10.3.4 In-depth Interview

a) Interview with Local Administrative Authority

Upazilla Nirbahi Officer (UNO)/ Fisheries officers/ Agriculture Officer/ Education Officer (TEO)/ Forest Officer

All the officers of Sirajgonj Sadar Upazilla have come into an agreement to generate an additional 75 MW with the initial 150 MW power station in Saydabadh. They also added that a total of 225 MW electricity will further enhance our national power grid supply which will be beneficial for us. The reason behind this energy supply is “to stay in accordance with the technically updated world”. “Nothing is possible to achieve without electricity in this digital era, “All the resources of our country rely on electricity”. “It is very important to establish new power plants in order to improve the current situation of the people in our country”. Everyone agreed in terms for the establishment the power plant.

And lastly they also reassured that there are no presence of any environmental hazards; emitted from the 150 MW power plant.

Some photographs taken during in-depth interview with administrative officials of Sirajganj Sadar upazila are given below:

In-depth interview with UNO

In-depth interview with Education Officer

In-depth interview with Agriculture Officer

In-depth interview with Fisheries Officer

In-depth interview with Forest Officer

b) Interview with Public Representatives

Upazilla Chairman, Union Parishad Chairman, Union Parishad Members and NGO Representative

Sirajgonj Sadar upazilla chairman, chairman of Union parishad, member of Union parishad, is the peoples representative and an NGO representative. All of them are residents of the local area. According to them if an additional 75 MW electricity is added with the 150 MW power plant project, then this will increase the national grid power supply and this grid electricity can be supplied to any region of the country if required. As a result, the entire nation will be benefited. This will improve our current issue regarding load shedding. This electricity can also be used in various small, medium and large industries. As a result our economic condition will improve. This area is rich in the art of embroidery. So, if this electricity can be utilized for further enhancement in the field of embroidery. then more people can be employed. If 75 MW electricity is produced, then this will create more opportunities for the people to get employed. But this is true that till now, the plants, animals and aquatic mammals of this area are free from any environmental hazards. Any sort of negative environmental impact is yet to take place in this area. They also added that,

in this technologically modern era, it is quite impossible to develop our economic condition without electricity. In order to maintain the on going development process, electricity is very important so more power plants needs to be established. We also have to keep in mind that this project does not affect the environment by any means. They also added that the waste should not pollute the water as well.

Some photographs taken during in-depth interview with public representatives of Sirajganj Sadar upazila are given below:

In-depth interview with Upazila Chairman

In-depth interview with Saydabad UP Chairman

In-depth interview with Saydabad UP Member

In-depth interview with Saydabad UP Female Member

In-depth interview with Saydabad UP Member

In-depth interview with MMS (NGO) Representative

CHAPTER 11: CONCLUSIONS AND RECOMMENDATIONS

11.1 Conclusions

In this study, the effects of the project activities on physico-chemical, ecological and socio-economic (i.e., human interest related) parameters during both construction and operation phases have been assessed. The impacts have been identified, predicted and evaluated, and mitigation measures suggested for both construction and operation phases of the proposed power plant. The important physico-chemical environmental parameters that are likely to be affected by the project activities include air and noise pollution.

The study suggests that most of the adverse impacts on the physico-chemical environment are of low to moderate in nature and therefore, could be offset or minimized if the mitigation measures are adequately implemented. Since the project site is located in a developed area that does not appear to be very sensitive ecologically, the impact of project activities on most ecological parameters (e.g., wet lands, homestead vegetation, forest cover, bushes and trees, wild life, species diversity) are mostly insignificant.

Some adverse impact during the operation phase of the plant will come from NO2 and SO_2 emission from the power plant. However, the effect of increased NO2 and SO_2 in the ambient air due to emission from the proposed power plants will not be very significant.

Noise level has been identified as significant potential impact of the proposed power plant during both the construction and operation phases. The noise generated from construction activities during the construction phase might become a source of annoyance at the residential area close to the project site. However, since residential areas are located away from the site and the trees and boundary walls will have some damping effect, the noise level is expected to come down to tolerable levels within residential area

It is concluded from ground water modeling study that the natural aquifer condition in the study area would be suitable for supplying 30000 m^3/day of water continuously without any permanent lowering of groundwater table and environmental degradations. Jamuna River invariably fully recharges the aquifer in the wet season of each year preventing any adverse effect on the natural condition of the project area.

There is no need for land acquisition. Additionally, there is no settlement in this designated area. Therefore, no population will be displaced and no resettlement will be required for the construction of the power plant.

During operation phase, no significant negative impact is anticipated on socio-economic environmental parameters.

During public consultations carried out as a part of the EIA study, people welcomed the proposed power plant project at Sirajganj. However, they recommended installing a plant of good quality, which will be able to provide uninterrupted power during peak hours and will be able to keep anticipated air and noise pollution to a minimum level.

11.2 Recommendations

The environmental assessment carried out for the proposed Sirajganj CCPP(2nd Unit) suggests low to moderate scale of adverse impacts, which can be reduced to acceptable level through recommended mitigation measures as mentioned in the EMP. It is therefore recommended that the proposed upgraded Combined Cycle Power Plant may be installed, provided the suggested mitigation measures are adequately implemented. It is also recommended that the environmental monitoring plan be effectively implemented in order to identify any changes in the predicted impacts and take appropriate measures to off-set any unexpected adverse effects.

Apart from risks associated with emissions, noise generation, solid waste, hazardous waste, cooling and wastewater disposal as a result of construction and operation activities, the power plant put human beings and the environment inside and outside of the plant to a certain degree of risk of accident and sometime loss of life. An emergency response plan (ERP) for the proposed power plant has been developed listing various actions to be performed in a very short period of time in a pre-determined sequence if it is to deal effectively and efficiently with any emergency, major accident or natural disaster

Annexure

Annex-1.1: DoE letter for Exemption of IEE Studies and Approval of the TOR for EIA Study

Government of the People's Republic of Bangladesh
Department of Environment
www.doe-bd.org
Head Office, Paribesh Bhaban
E-16 Agargaon, Dhaka-1207

PD, Sirajganj (2nd Unit) 24.09.13

Memo No: DoE/Clearance/5243/2013/ 337 Date: 17 09 / 2013

Subject: Exemption 0f IEE and Approval of Terms of Reference (ToR) for Environmental Impact Assessment (EIA) for implementation of 225 MW Combined Cycle Power plant project (2nd Unit-Dual Fuel) at Saydabad under Sirajganj District.

Ref: Your Application dated 15/07/2013..

With reference to your letter dated 15/07/2013 for the subject mentioned above, the Department of Environment hereby approves your application for exemption from IEE studies and gives approval of TOR for Environmental Impact Assessment (EIA) for the proposed 225 MW Combined Cycle Power plant project (2nd Unit-Dual Fuel) at Saydabad under Sirajganj District subject to fulfilling the following terms and conditions.

I. The project authority shall submit a comprehensive Environmental Impact Assessment (EIA) considering the overall activity of the said project in accordance with the TOR and time schedule submitted to the Department of Environment (DOE) and additional suggestions provided herein.

II. The EIA report should be prepared in accordance with following indicative outlines:

1. Executive summary.
2. Introduction: (Background, brief description, scope of study, methodology, limitation, EIA team, references).
3. Legislative, regulation and policy consideration (covering the potential legal, administrative, planning and policy framework within which the EIA will be prepared).

4a. Project activities:

- A list of the main project activities to be undertaken during site clearing, construction as well as operation
- Project Plan, Design, Standard, Specification, Quantification, etc.

4b. Project schedule: The phase and timing for development of the Project.

4c. Resources and utilities demand: Resources required to develop the project, such as soil and construction material and demand for utilities (water, electricity, sewerage, waste disposal and others), as well as infrastructure (road, drains, and others) to support the project.

4d. Map and survey information

Location map, Cadastral map showing land plots (project and adjacent area), Topographical map, Geological map showing geological units, fault zone, and other natural features.

5. Baseline Environmental Condition should include, inter alia, following: (Identification and Quantification of Physical Situation that has been proposed to be changed)

   - Physical Environment : Geology, Topology, Geomorphology, Land-use, Soils, Meteorology, and Hydrology
   - Biological Environment : Habitats, Aquatic life and fisheries, Terrestrial Habitats and Flora and Fauna
   - Environment Quality : Air, Water, Noise, Vibration, Soil and Sediment Quality
   - Relate baseline in both Quantitative and Qualitative term with the anticipated outcomes, achievement of goals, objectives and changes due to project interventions

6. Socio-economic environment should include, inter alia, following:

   - Population: Demographic profile and ethnic composition
   - Settlement and housing
   - Traffic and transport
   - Public utilities: water supply, sanitation and solid waste
   - Economy and employment: employment structure and cultural issues in employment
   - Fisheries: fishing activities, fishing communities, commercial important species, fishing resources, commercial factors.

7. Identification, Prediction and Evaluation of Potential Impacts (identification, prediction and assessment of positive and negative impacts likely to result from the proposed project).

   In identification and analysis of potential impacts'-the 'Analysis' part shall include the analysis of relevant spatial and non-spatial data. The outcome of the analysis shall be presented with the scenarios, maps, graphics etc. for the cases of anticipated impacts on baseline. Description of the impacts of the project on air, water, land, hydrology, vegetation-man maid or natural, wildlife, socio-economic aspect shall be incorporated in detail.

   Appropriate models shall be used for prediction of potential impacts of the project on surface water and ambient air quality using updated data. Model prediction shall be compared with national water and air quality standards and specific sensitivity data of the organisms known to be present in the project area (likely impacted area) for impact assessment.

8. Management Plan/Procedures:

   For each significant major impact, proposed mitigation measures will be set out for incorporation into project design or procedures, impacts, which are not mitigable, will be identified as residual impacts Both technical and financial plans shall be incorporated for proposed mitigation measures.

   An outline of the Environmental Management Plan shall be developed for the project.

   In Environmental Monitoring Plan, a detail technical and financial proposal shall be included for developing an in-house environmental monitoring system to be operated by the proponent's own resources (equipments and expertise).

9. Consultation with Stakeholders/Public Consultation (ensures that consultation with interested parties and the general public will take place and their views taken into account in the planning and execution of the project)

   Beneficial Impacts (summarize the benefits of the project to the Bangladesh nation, people and local community and the enhancement potentials)

10. Risk assessment, risk management, system of valuation of environmental and properties damage, damage compensation issues shall be addressed

11. Conclusion and Recommendations

Without obtaining approval of EIA report by the Department of Environment, the project authority shall not be able to start the physical activity of the project and also not be able to open L/C in favor of importable machineries.

IV. Without obtaining Environmental Clearance, the project authority shall not be able to start the operation of the project.

V. The project authority shall submit the EIA along with a filled-in application for Environmental Clearance in prescribed form, the no objection certificate (NOC) from the local authority, NOC from forest department (if it is required in case of cutting any forested plant, private or public) and NOC from other relevant agencies for operational activity etc. to the Rajshahi Divisional Office of DOE at Bogra with a copy to the Head Office of DOE in Dhaka.

17.09.2013

(Syed Nazmul Ahsan)
Deputy Director (Environmental Clearance)
&
Member Secretary
Environmental Clearance Committee
Phone # 8181778

Company Secretary
North-|West Power Generation Company Limited
Bidyut Bhaban (Level-14)
1, Abdul Gani Road, Dhaka-1000.

Copy Forwarded to :

1) The Secretary, Ministry of Environment and Forests, Bangladesh Secretariat, Dhaka.
2) Chairman, Bangladesh Power Development Board, Dhaka.
3) Director, Department of Environment, Rajshahi Divisional Office, Bogra.
4) Assistant Director, Office of the Director General, Department of Environment, Head Office, Dhaka.

Annex-3.3: Study Report on Ground Water Modeling in the Project Area of 225 MW CCPP (2nd Unit)

NORTH-WEST POWER GENERATION COMPANY LIMITED

NORTH-WEST POWER GENERATION COMPANY LTD., DHAKA
(AN ENTERPRISE OF BPDB)

Groundwater modelling of the proposed site of Sirajganj 225 MW combined cycle power plant project (2nd unit- dual fuel), Saydabad, Sirajganj and surrounding areas

FINAL REPORT

Submitted by:

ENGINEERS ASSOCIATES LIMITED

1/3, ASAD GATE ROAD, BLOCK– A

MOHAMMADPUR HOUSING ESTATE, DHAKA-1207

TEL.: 9111358, 8117246, FAX.: 880-2-8118512

E-MAIL: engineers.associates@gmail.com
WEB: www.ealbd.com

MAY 2014

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ACRONYMS AND ABBREVIATIONS

BADC	Bangladesh Agricultural Development Corporation
BBS	Bangladesh Bureau of Statistics
BM	Bench Mark
BMD	Bangladesh Meteorological Department
BTM	Bangladesh Transverse Mercator
BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
CEGIS	Centre for Geographical Information System
DEM	Digital Elevation Model
DPHE	Department of Public Health Engineering
DOE	Department of Environment
DSHTW	Deep Set Hand Tube Well
DTW	Deep Tube Well
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
GoB	Government of Bangladesh
GPS	Global Positioning System
GSB	Geological Survey Of Bangladesh
GWL	Ground Water Level
GWT	Ground Water Table
HTW	Hand Tube Well
JICA	Japan International Co-operative Agency
JL	Jurisdiction Limit
LGED	Local Government Engineering Department
MPO	Master Plan Organization
NCA	Net Cultivable Area
NWMP	National Water Management Plan
NWP	National Water Plan
PVC	Polyvinyl Chloride
PWD	Public Works Datum
STW	Shallow Tube Well
SW	Surface Water
SoB	Survey of Bangladesh
TOR	Terms of Reference
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Emergency Fund
WL	Water Level
WQ	Water Quality
WRP	Water Resources Planning

1.0 INTRODUCTION

1.1 Background and Objectives

The proposed 225MW Combined Cycle Power Plant (2nd Unit) will be located beside the existing Sirajganj 150MW Peaking Power Plant which is situated on the bank of the Jamuna river near Bangabandhu Bridge at Sirajganj. This is located at Barashimul Mouza of Saydabad Union of Sirajganj Sadar Thana under the District of Sirajganj. This is about 15 km south-east of Sirajganj town. The JMB (Bangabandhu Setu) is on the north of the site, Khas Barashimul village on the south, Jamuna river on the east and Saydabad is on the west side of the power plant site. The proposed site is about 130 km north-west of the capital city of Dhaka. This site lies between N $24^0$23'4" and N $24^0$23'16" and between E $89^0$44'33" and E $89^0$44'51".

In NWPGCL power station complex of Sirajganj, at present there is one 150MW peaking power plant upgraded to 225MW combined cycle power plant. The requirement of water in this power plant is about 600 m^3/hr. This water requirement is being met by withdrawing groundwater through 5 Deep Tube Wells. The abstraction rate of the above 5 DTWs is about 640 m^3/hr. NWPGCL is going to construct another 225MW Combined cycle power plant (2nd unit) in the same complex. This proposed power plant will also require water of about 600 m^3/hr. This water requirement is expected to be met by withdrawing ground water though 4 DTWs.

The power station will require in total about 1240 m^3/hour of water for cooling purposes. Because of the uncertainty in the use of river water it has been decided to evaluate groundwater resources of the project site and surrounding areas.

The prime objective of the study is to design, construct, calibrate and run a digital computer model which would realistically simulate the groundwater system prevailing at the project site and surrounding areas. The purpose of constructing a model is to assess the potentiality of the aquifer system of Sirajganj and surrounding areas to provide a continuous supply of 1240 m^3/hour of water for cooling purposes of the power plant.

In accordance with these requirements, using the results of groundwater investigations at the proposed site along with the existing groundwater database and the current understanding of the aquifer system, a model has been constructed to simulate all the principal hydrogeological processes that have been observed in the study area.

Many of these processes are complex and in order to effectively simulate them the model has, of necessity, had to incorporate relatively complex routines. Nevertheless the model has been designed to be easily understood and operated and, if necessary, to facilitate modifications in the future. After calibrating the model and sensitivity analyses, the model was used to predict the condition of groundwater after 20 years of pumping.

This document constitutes the Final Report which described the database and the concept of the model, set out the results of the calibration and testing of the model. This report concentrates upon the results of the model predictive runs and the recommendations.

1.2 Summary of Principal Data Sources

Extensive geological, geomorphological, meteorological and hydrological data are needed for preparing groundwater model. The quality of modelling results depends strongly on the availability and quality of various input data. Geological, meteorological and hydrogeological data of different kinds were collected from Bangladesh Water Development Board (BWDB), Department of Public Health Engineering (DPHE), Bangladesh Meteorological Department (BMD), Bangladesh Agricultural Development Corporation (BADC), Centre for Geographic Information System (CEGIS) and local government offices. Exploratory bore log data of the area were collected from BWDB.

Bore log data were collected from BADC, DPHE, IWM and BWDB. Four bore logs of the project site up to a depth of about 80m were collected from the office of the existing power plant. This provided a clear picture of the hydrostratigraphy at the project site. **Total 295 bore logs** of the study area have been collected from different organisations to delineate the hydrostratigraphy of the study area. Groundwater Circle of Bangladesh Water Development Board (BWDB) drilled **18 exploratory boreholes** in the study area the depth of which varies between 92 to 312m. Information of deep aquifer has been

revealed from the study of exploratory bore logs of about 312m depth in or around the study area. Other 277 bore logs were collected from Bangladesh Agricultural Development Corporation (BADC). The wells were drilled for irrigation purposes. The delineation of aquifer system at the project site also matched with the pre-existing data of the surrounding area obtained from different sources.

Rainfall and other climatic data were collected from BMD (Bangladesh Meteorological Department) and from Bangladesh Water Development Board (BWDB). River stage and discharge data were collected from BWDB.

Water level data were collected from BWDB and DPHE. Different GIS coverage's of the study area were collected from CEGIS.

Aquifer properties data were collected from BWDB (BWDB 1989 & BWDB 1994) and the report of the Institute of Water Modelling (IWM) (IWM 2009). Evapotranspiration and recharge data were collected from different published reports.

Groundwater abstraction data were estimated from the Minor Irrigation Survey Report 2012-2013 published by BADC.

In addition to these data different published reports and unpublished M.S. or Ph.D. theses of different Dhaka University and Jahangirnagar University were also consulted.

2.0 EXECUTIVE SUMMARY AND RECOMMENDATIONS

This report describes the results obtained from using a mathematical model to evaluate the potential of the groundwater resources to supply 1240 m^3/hour of water continuously for the cooling system of proposed power plant. Numerous runs of the model were made to test the sensitivity of the various model parameters. By using the available hydrogeological data it has been possible to simulate historic groundwater fluctuations of the study area for the calibration period of 2010 to 2013 and to predict the future groundwater condition 20 years after the initiation of pumping.

This study concentrated on the overall evaluation of groundwater resources and hydrogeological characteristics of the proposed site and surrounding areas as a prior requirement for developing a realistic groundwater model. Physiographically, the study area falls within Brahmaputra-Jamuna Flood Plain. The surface geology of the study area comprises unconsolidated alluvial sand and alluvial silt of Recent age. The Jamuna River flows through the study area carrying huge volume of water per year to the Bay of Bengal. The study area enjoys a subtropical monsoonal climate.

Analysis of bore logs of the project site and surrounding areas indicates that the study area is underlain by an extensive aquifer system which in some parts is covered by up to 41m thick clay and silt aquitard. The Jamuna River cuts this layer and this layer is absent at the bottom of the Jamuna and in some areas adjacent to the river Jamuna. The thickness of the aquifer is more than 200m throughout the whole area. The bottom of the aquifer has not been encountered in any of the borehole of the study area. In general the entire sequence down to some 120m below ground level becomes coarser with depth. The aquifer is subdivided into the Composite aquifer and the Main aquifer following UNDP (1982) three-layer model. The Composite aquifer is the uppermost aquifer, composed mainly of very fine to fine sand and its thickness in the study area varies from 0 to 58m. The Main aquifer underlies the Composite aquifer. It is composed mainly of medium grained sands with some coarse sands and gravels. The thickness of this layer is more than 75m in most part of the study area. The transmissivity of aquifer near project area is about 2500 m^2/d (IWM 2009).

The analysis of groundwater level data showed that the minimum elevation of water level in the study area varies from 5 to 10.5 m and the maximum elevation varies from 10 to 18m. In dry season, groundwater moves towards the river. In wet season, surface water

moves from the river towards the aquifer. Fluctuation of water table is higher in narrow zone adjacent to the river Jamuna. The trend of groundwater level in the study area remained regular and steady over the last 10 years.

A conceptual model was developed taking into consideration of the hydrostratigraphy of the study area. Model area was chosen carefully so that the stresses to the system provided by the pumping wells at the project site do not reach the boundary. A three layer transient groundwater flow model was set up with time steps of a month using MODFLOW. Layer 1 comprises low permeability clays and silts. Layer 2 comprises moderately permeable very fine sand to fine sand. Layer 3 comprises medium to coarse sand and gravel. Different hydrogeological parameters were assigned for each of the modelled layer. River, recharge and evapotranspiration boundaries along with municipal and irrigation pumping wells were incorporated to the model. The model was then calibrated by matching the observed head at different parts of the modelled area with the calculated head and the sensitivity analysis was conducted.

After calibration 10 pumping wells with a discharge of 1240 m^3/hour were introduced in the model at the project site. Two model scenarios were considered. In the first scenario the pumping wells were arranged in line over a distance of 1 km. In the second scenario the pumping wells were arranged in cluster over a distance of 400m.

For both the scenarios the model was run for twenty years maintaining projected future increase in groundwater abstraction. The modelled minimum elevation of groundwater table occurs in the month of May. The River Jamuna is influent in the dry season. Due to lowering of the head, water from the river bed passes into the aquifer in areas adjacent to the pumping wells. The modelled maximum elevation of groundwater table occurs in the month of September. The pumping wells in the proposed power plant will get plenty of water supplies from the river and water level in the pumping well will rise substantially. It has been found that the Jamuna River lying in the eastern side of the project site acts as a recharge boundary for the aquifer system in both dry and wet season.

For the first scenario about 3 km^2 area surrounding the pumping wells of the proposed power plant water level may decline by 0.5 to 1 m from the existing water level. As the cone of depression is elongated in the direction of the river, the river water from a large area will infiltrate into the aquifer due to enhanced vertical head gradient.

For the second scenario about 3 km^2 area surrounding the pumping wells of the proposed power plant water level may decline by 0.5 to 1.5 m from the existing water level. The cone of depression is circular and covers a shorter part of the river. The infiltration of river water from a small area will infiltrate into the aquifer.

The modelling study confirms that the water abstracted from wells in the project site mostly come from the river in both dry and wet seasons. Over the past 50 years the Jamuna river flow at Bahadurabad (SW-46) in the wet period varied between 30000 and 50000 m^3/s and in the dry period 3000 and 12000 m^3/s (Rajib et. al. 2011). The average discharge of the river is about 20,000 m^3/s (Bristow, 2009; Gupta, 2008; Schumm and Winkley, 1994). It could be assumed that the minimum and maximum discharge of Jamuna River varies between 3000 m^3/s and 50000 m^3/s near Bangabandhu Jamuna Bridge. To satisfy the need of water of the power plant for a day, a fraction of a second to maximum 10 second's discharge of the Jamuna River is quite sufficient.

Taking into consideration of the model predictions it has been recommended from this study that a number of pumping wells of cumulative discharge of 1240 m^3/hour can be set up in a one kilometre or longer line parallel to the river Jamuna, so that the catchment of the pumping wells spread mostly on the river.

It is concluded from this study that the natural aquifer condition in the study area would be suitable for supplying 30000 m^3/day of water continuously without any permanent lowering of groundwater table and environmental degradations. Jamuna River invariably fully recharges the aquifer in the wet season of each year preventing any adverse effect on the natural condition of the project area.

The MODFLOW results generated through this modeling effort reflect only assumed conditions based on site data, collected data or literature values. It is also assumed that the rainfall, river water level and other climatic factors would not change in the next 20 years. However, recent studies indicate that the rainfall in Bangladesh and surrounding areas in increasing due to climate change (UK Met Office 2011) which would obviously contribute to enhance recharge to the aquifer in the projected period.

3.0 THE PHYSICAL BASIS OF THE MODEL

3.1 Introduction

The groundwater model developed during the study was based upon the current level of information and understanding of the hydro-meteorological, hydrological and hydro-geological patterns which prevail in the study area. The model's physical basis has therefore been dictated by the extent of the available database and the major known physical features and processes which control the groundwater response to both seasonal recharge and widespread aquifer withdrawals.

3.2 Description of the study area

3.2.1 Location and Extent

The location of the study area is shown in Figure 1. The study area is situated between 24º 5′ and 24º 50′ north latitude and between 89º 20′ and 90º 10′ east longitude. Sirajganj and Tangail districts and part of Bogra, Pabna and Jamalpur districts constitute the study area. The two districts are separated by the river Jamuna. The two districts were taken into consideration for developing detailed regional model. The catchment of the proposed well field located on the bank of the river Jamuna is extended to both side of the river Jamuna. The area is well communicated with the other part of the country by railway, road and river.

3.2.2 Climatic Condition

The study area experiences a tropical monsoon climate with three relatively distinct seasons being recognized:

Monsoon Season: Usually extends from June to October with high humidity, high rainfall and maximum temperatures in excess of 30°C.

Cool Season: Usually extends; from November to February and is characterised by low rainfall and maximum temperatures below 27°C.

Hot season: Usually extends from March to May with temperatures in excess of 31°C and north-westerly cyclonic storms giving intense scattered rainfall.

Annual average temperature of the study area is 25 °C (77 °F).

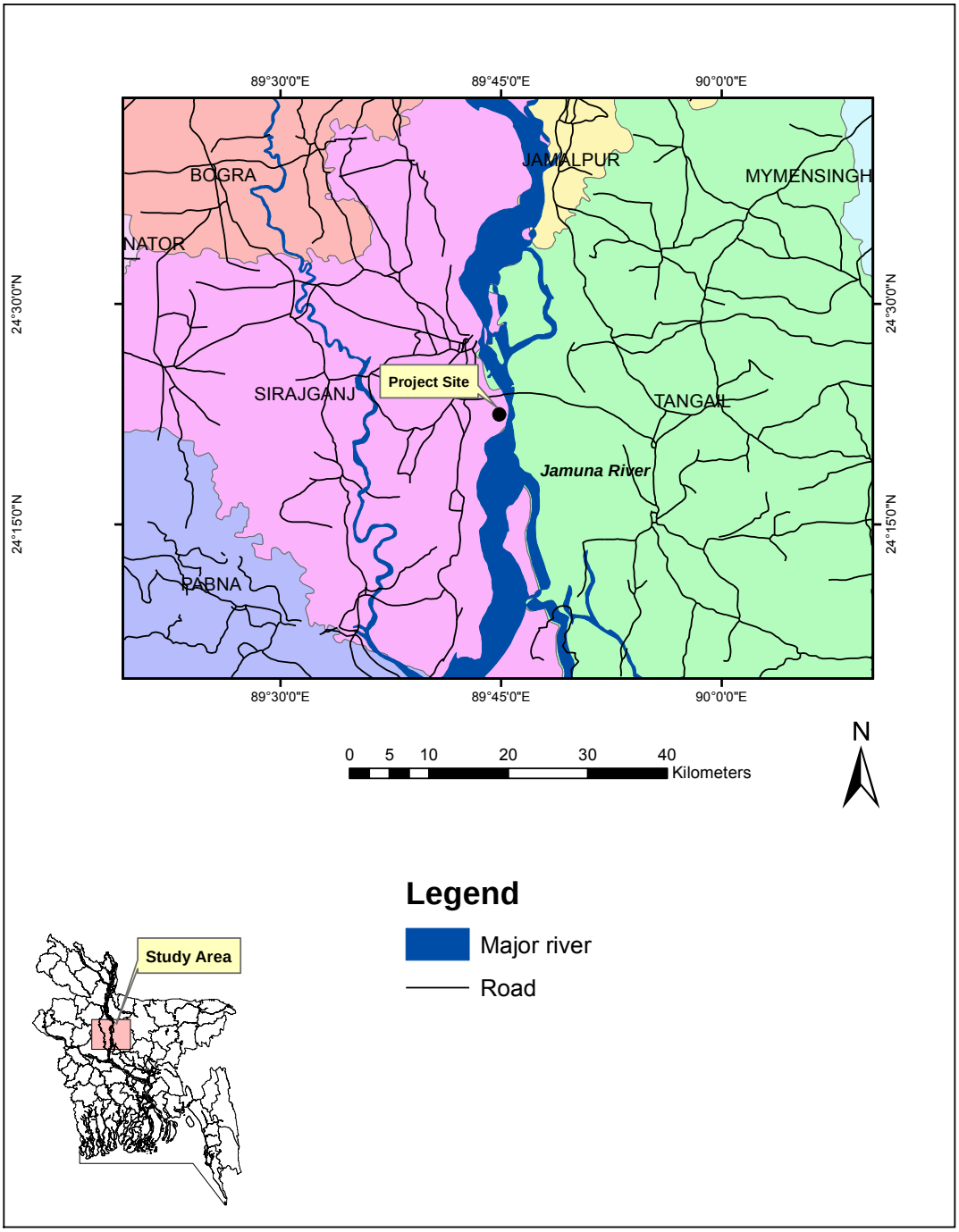

Figure 1. Location map of the study area

During the monsoon (June to September), wind direction from the southwest brings moisture laden air from the Bay of Bengal. The annual distribution pattern emphasises the high summer rainfall when approximately 95% of the total annual rainfall occurs between April and October. Table 1 gives monthly rainfall data of Bogra (Sherpur) collected from Bangladesh Meteorological Department (BMD). The maximum annual rainfall of 2157mm occurred in the year 2004 and the maximum monthly rainfall of 732mm occurred in the month of June 2007. Figure 2 gives the monthly rainfall of Bogra (Sherpur). Annual rainfall averages about 1630 millimetres.

Bangladesh is projected to experience increases in precipitation. Increases of up to 20% could occur in the north of the country with more general increases of 5-10% in average annual precipitation by 2100 from 1960-1990 baseline climate (UK Met Office 2011).

Table 1 Rainfall data of Bogra (Sherpur), 2003-2012

Station : Bogra Monthly & Yearly Total Rainfall (mm)

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Year Total
2003	4	53	72	113	214	364	219	220	156	264	0	13	1692
2004	0	0	45	90	137	638	529	261	206	251	0	0	**2157**
2005	5	9	58	72	138	130	471	328	356	523	0	1	2091
2006	0	0	12	143	193	184	192	138	174	69	1	0	1106
2007	0	18	25	28	92	**732**	320	256	302	131	15	0	1919
2008	27	0	22	20	213	393	474	374	109	159	0	0	1791
2009	0	3	3	49	205	128	194	570	169	89	0	0	1410
2010	0	0	0	29	185	286	92	225	244	190	2	20	1274
2011	1	0	7	145	194	193	175	606	389	0	11	0	1721
2012	19	0	0	74	94	147	186	164	345	74	36	1	1140

Source: Bangladesh Meteorological Department, Dhaka

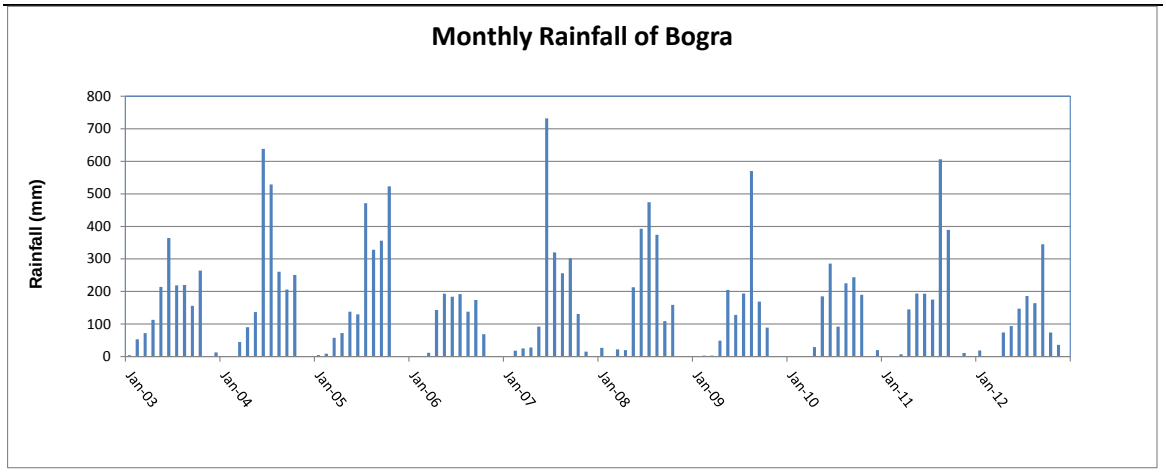

Figure 2. Monthly rainfall of Bogra (Sherpur) Upazila

3.2.3 Topography and Drainage

The study area comprises gently undulating flood plains of Jamuna, Padma, Karatoa, Bangali, Teesta and Brahmaputra rivers and part of Pleistocene Barind and Madhupur tract. The dominant topographic elements are mid channel bars, ridges, inter-ridge depressions and basins, active streambeds and abandoned channels. The ridges are usually linear and comprise level to very gently undulating or sloping young and old levees that form the point bar of meandering rivers.

Major physiographic unit of the study area include active Brahmaputra floodplain, Karatoya Bangali floodplain, young Brahmaputra Jamuna floodplain and part of Barind and Madhupur tract (Figure 3).

The ground surface elevations range from about 30 metres above mean sea level in the Pleistocene Madhupur Tract to about 3 to 6 metres along the Jamuna river floodplain (Figure 4). In the Barind area ground elevation ranges from 14 to 19m. Elevation is low in the floodplain areas of Jamuna and other rivers. The elevation between ridges and basins differs by between 2 and 3 metres.

The surface drainage within the study area is provided by many rivers all of which are either major or minor tributaries of the River Jamuna (Figure 3).

In each monsoon season surface flooding occurs across some part of the study area, particularly in the area adjacent to the rivers. Figure 5 shows the flood depth map of the study area. Excepting Pleistocene Barind and Madhupur Tract most of the area is

frequently flooded in each year. Flooding depths are high in areas adjacent to river valleys.

The general drainage direction traverses the study area from north to south. Numerous small rivers and some excavated channels in the study area assist drainage, most of which ultimately connect to the main rivers. As river embankments and drainage systems are improved the extent and depth of flooding will decrease.

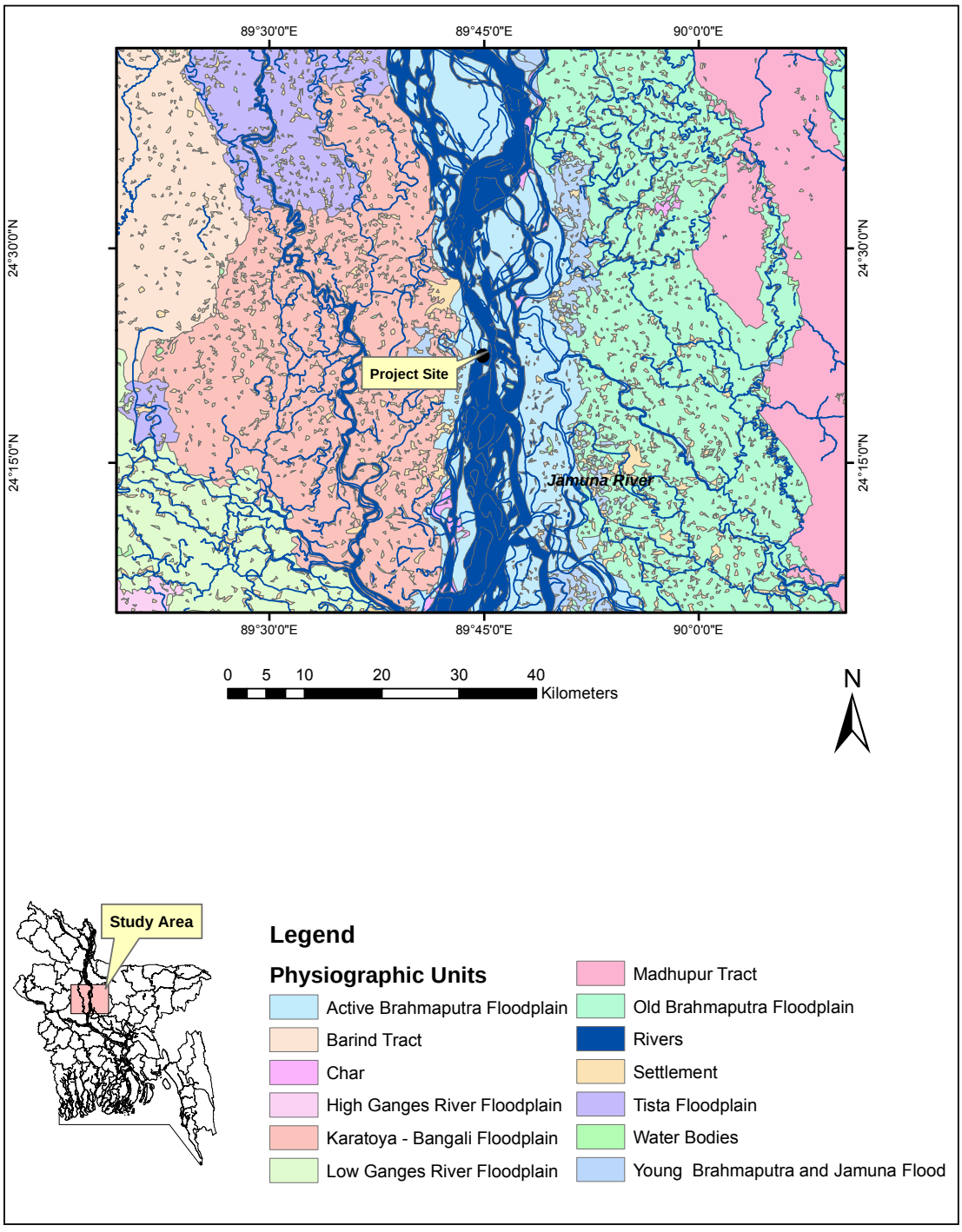

Figure 3. Physiographic map of the study area

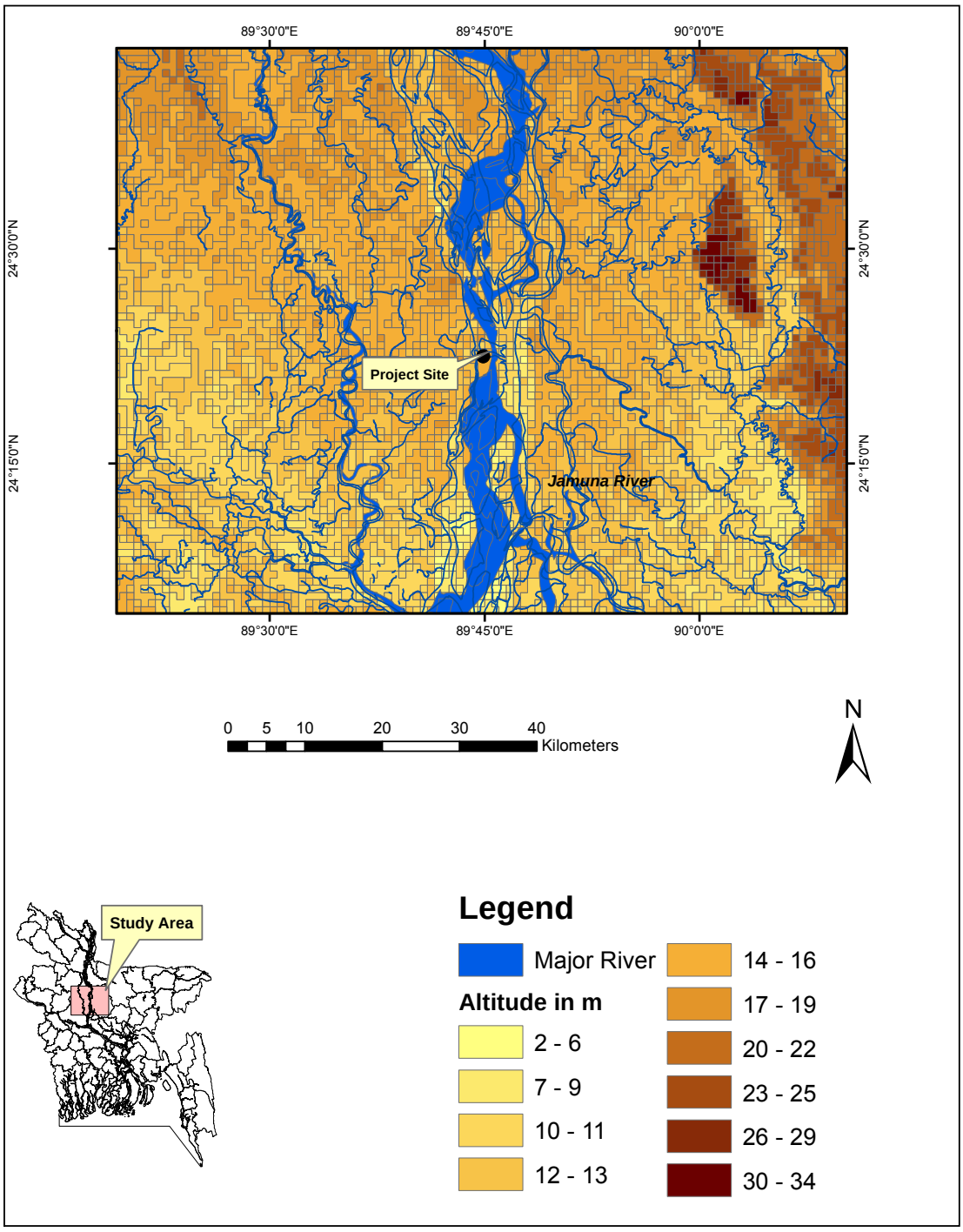

Figure 4. Ground elevation map of the study area

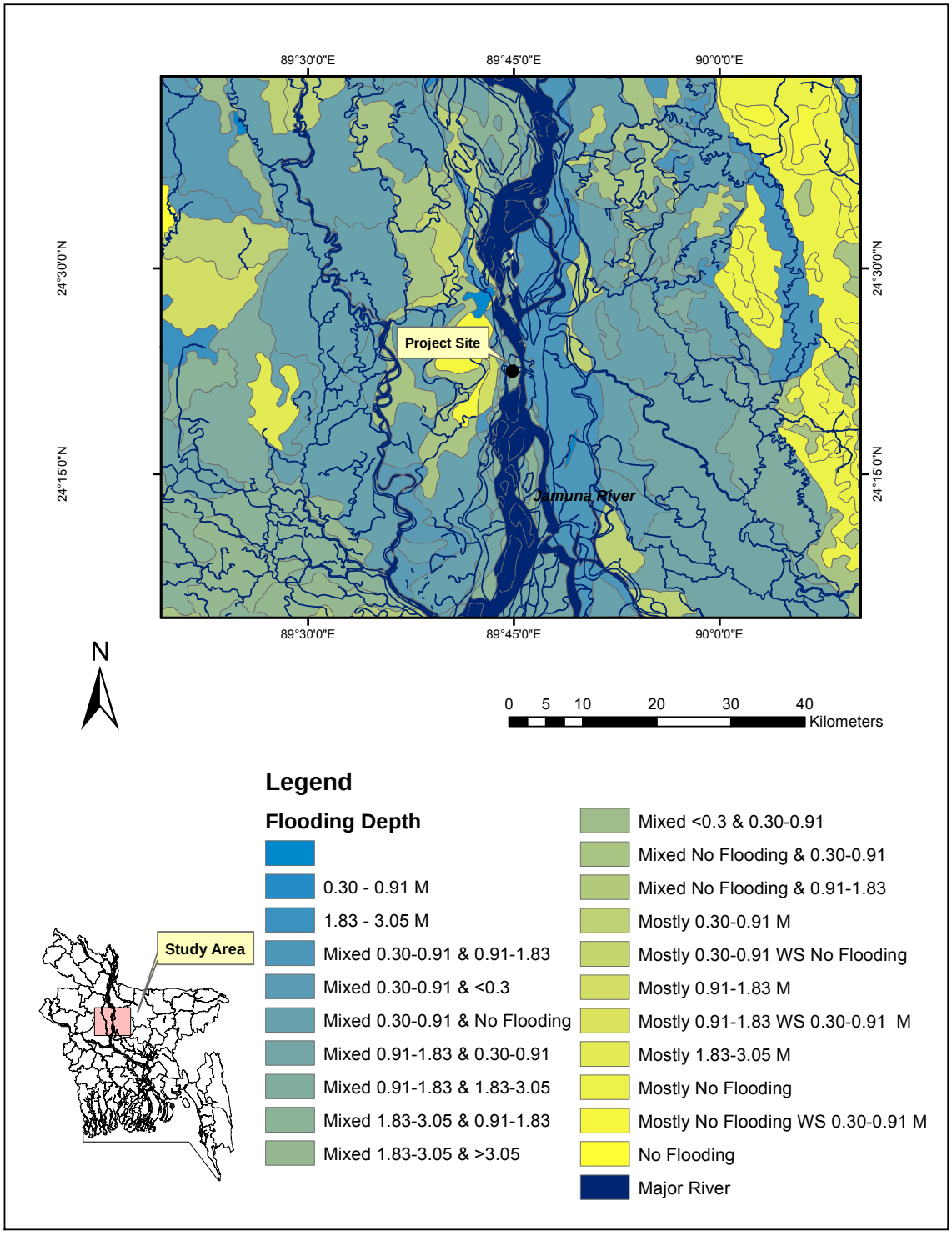

Figure 5. Flood Depth map of the study area

3.2.4 Soils and Geology

The soils within the study area constitute Jamuna, Teesta, Karatoa and other river's alluvial sediments of Recent geological age. Most areas have broad floodplain ridges and almost level basins. Figure 6 gives the soil map of the study area. Soil type include clay, loam, silty clay loam, fine sandy loam to sandy loam.

The Project area has irregular patterns of grey stratified sands and silts. There is overall pattern of olive brown, rapidly permeable, loamy soils on the floodplain ridges, and grey or dark grey, slowly permeable, heavy silt loam or silty clay loam soils on the lower land and parent materials rich in weatherable minerals.

Karatoya-Bangali Floodplain apparently comprises a mixture of the Teesta and Brahmaputra sediments. Most areas have smooth, broad, floodplain ridges and almost level basins. The soils are grey silt loams and silty clay loams on ridges and grey or dark grey clays in basins. Five General Soil Types occur in the region of which, Noncalcareous Grey Floodplain and Noncalcareous Dark Grey Floodplain soils predominate. They are moderately acidic throughout. Organic matter content is low in ridge soils and moderate in basins.

Active Brahmaputra-Jamuna Floodplain region comprises the belt of unstable alluvial land along the Brahmaputra-Jamuna rivers where land is constantly being formed and eroded by shifting river channels. It has an irregular relief of broad and narrow ridges and depressions. The area is occupied by sandy and silty alluvium, rich in weatherable minerals with slightly alkaline in reaction. Six General Soil Types occupy the area of which, only Non Calcareous Alluvium predominates. Organic matter status is low and fertility status is low to medium. Nitrogen is limiting whereas the K, S and Zn status is low to medium.

Surface geology of the project site includes alluvial sand. Most of the area is covered by alluvial sand, silt and clay (Figure 7). Madhupur and Barind Clay residuum are exposed on the Madhupur and the Braind tract. Marsh clay and peat layer is found in some low lying areas of Pabna and Tangail districts.

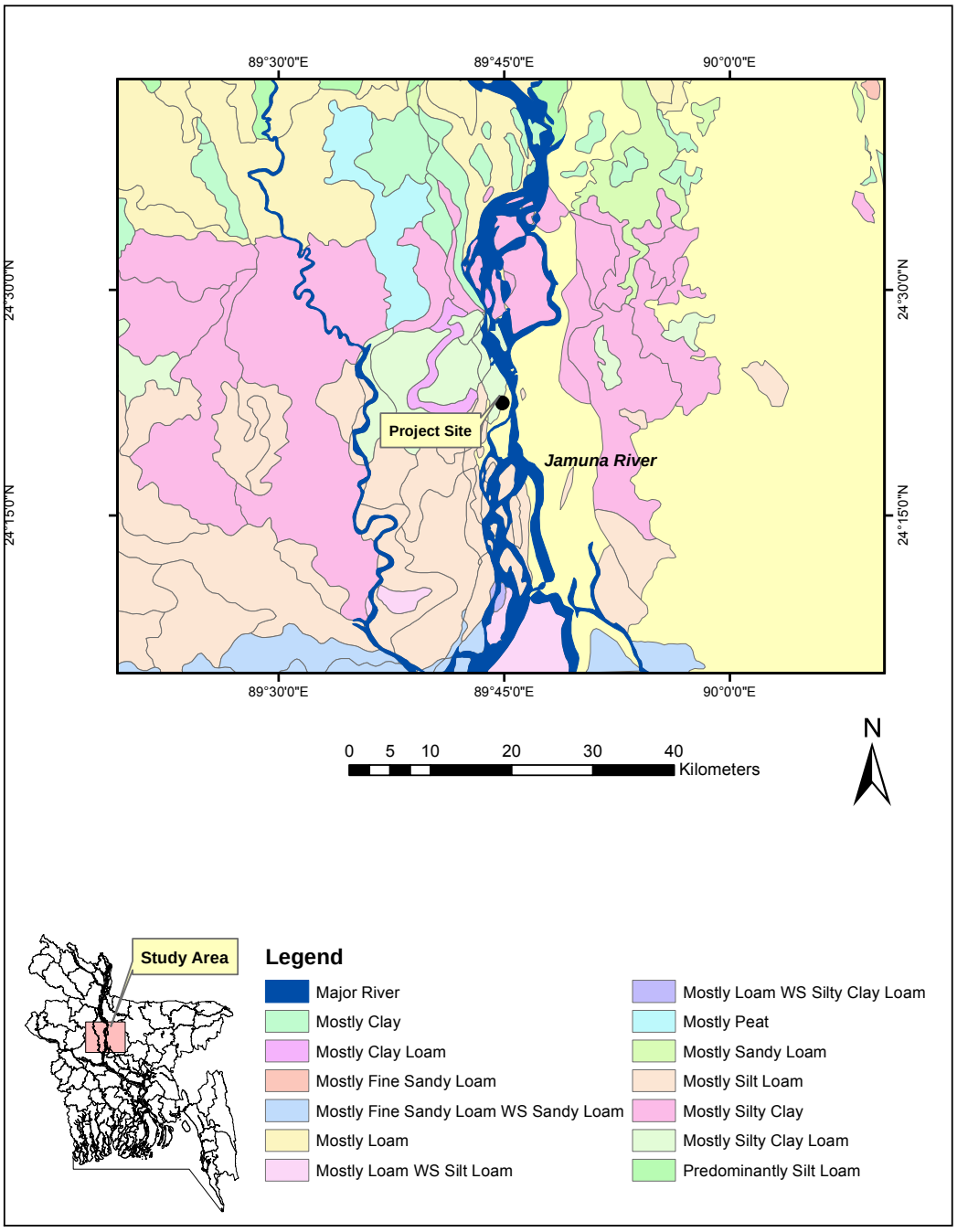

Figure 6. Soil map of the study area

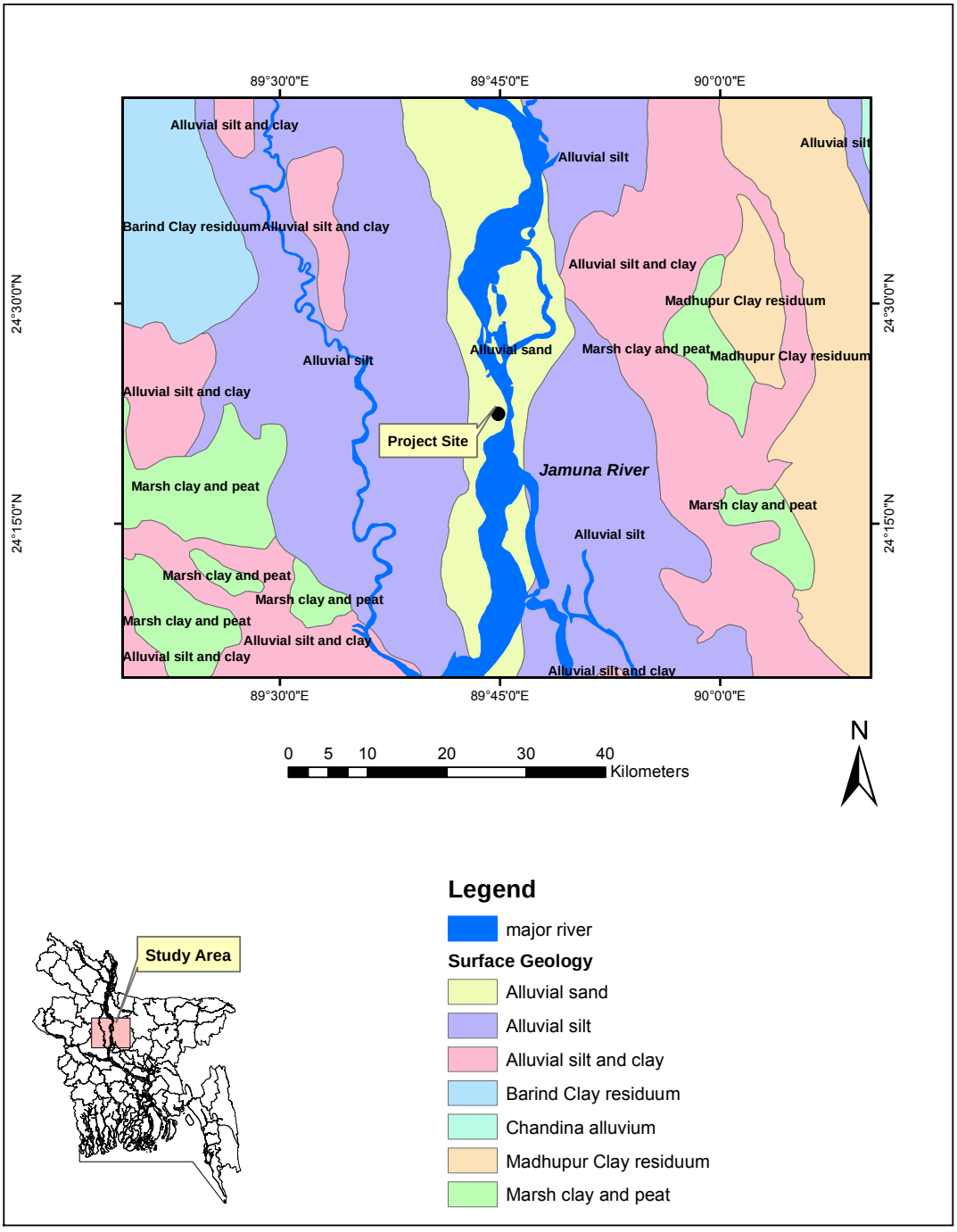

Figure 7. Surface Geology map of the study area

3.2.5 River Systems and Hydrology

A unique river network drains the study area. The main river is the Jamuna which passes through the middle part of the study area. The river Jamuna, originates on the northern slope of the Himalayas in China, where it is called Yalung Zangbo. It flows eastwards for about 1130 km, then turns southwards and enters Arunachal Pradesh (India) at its northern-most point and flows for about 480 km. Then it turns westwards and flows through Arunachal Pradesh, Assam and Meghalaya for another 650 km and then enters Bangladesh. Then the river curves to the south and continues on this course for about 240 km until its confluence with the Ganges River. The total length of the river from its source to the sea is about 2 840 km.

It enters Bangladesh through the northern boundary and covers a basin-area of approximately 13330 sq km within the country premises. It is one of the world's great rivers, ranking in the top three in terms of both sediment and water discharge. The high water and sediment discharges are generated by the monsoon-dominated floods and the tectonic setting.

The discharge of the Jamuna River mostly comes from the snowmelt in China on the other side of the Himalayas before it enters Arunachal Pradesh. In Arunachal Pradesh, Assam and Meghalaya of India and Dinajpur and Mymenshingh districts of Bangladesh rainfall is quite heavy and this contributes substantially to the river flow. The maximum velocity ranges from 3-4 m/sec with a depth of 21-22 m. The average discharge of the river is about 20,000 m^3/s with average annual silt load of 1,370 tons/sq km. During the rains it is about 8.0–12.9 km from bank to bank. Even during the dry season when the waters subside, the breadth is hardly less than 3.2–4.8km. The average slope of the Jamuna is about 1:11,400; however, the local gradient differs quite considerably from the average picture (Bristow, 2009; Gupta, 2008; Schumm and Winkley, 1994).

The Jamuna is a braided stream characterised by a network of interlacing channels with numerous sandbars enclosed in between them. During low flows the river becomes a multiple channel stream with sand bars in between and the channels shift back and forth between the main stream banks, which are 6 to 12 km apart. The sandbars, known in the Bengali as chars do not, however, occupy a permanent position. The river deposits them in one year very often to destroy and redeposit them in the next rainy season.

Seasonal Variability of River Stage: Dry and Wet Period: During monsoon heavy rainfall in the Bengal basin and surrounding areas initiates high flow of water through the Jamuna River. The elevation of water measured at SW49 (Sirajganj) in the wet season can be as high as 13.5 metres above PWD datum (Figure 8). The maximum elevation of water level generally occurs in the months of August or September in most of the years. During dry season (April or May) water level in the Jamuna River can be as low as 6.7 metres above PWD datum in most of the years. The Jamuna is a very wide river.

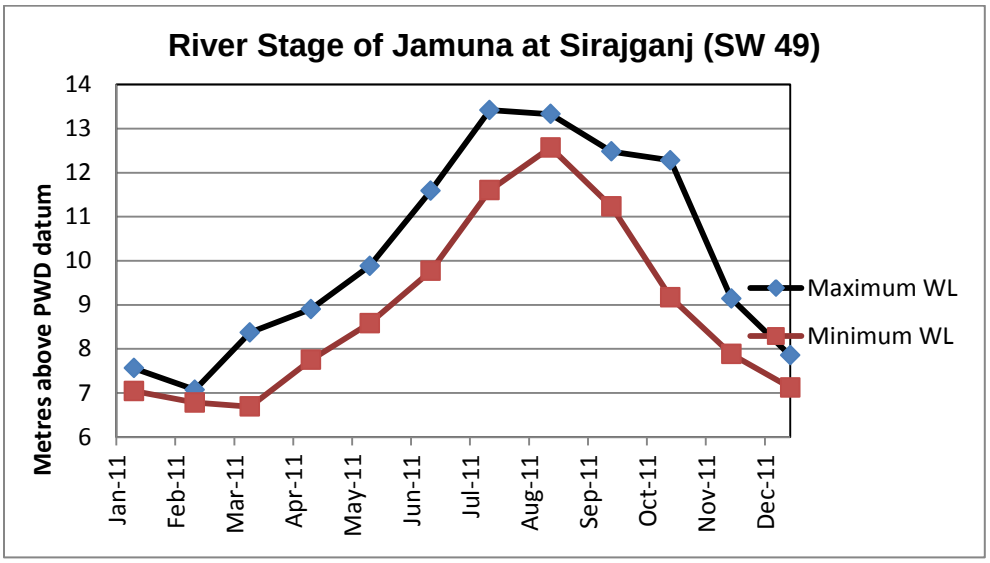

Figure 8. Monthly maximum and minimum Water level of Jamuna at Sirajganj (SW- 49)

Seasonal Variability of River Discharge: Dry and Wet Period: The historical flow pattern in individual years has been shown in Figure 9 below for a range of period starting from 1956 to 2006, which aids to explore the dry and wet period for this river in terms of high and low discharge within a year at the particular station. Wet period in terms of high flow for the river Jamuna appears to be between June and October, as there is a visible peak in this period. The dry period, in contrast, appears between January to April in terms of very low flow.

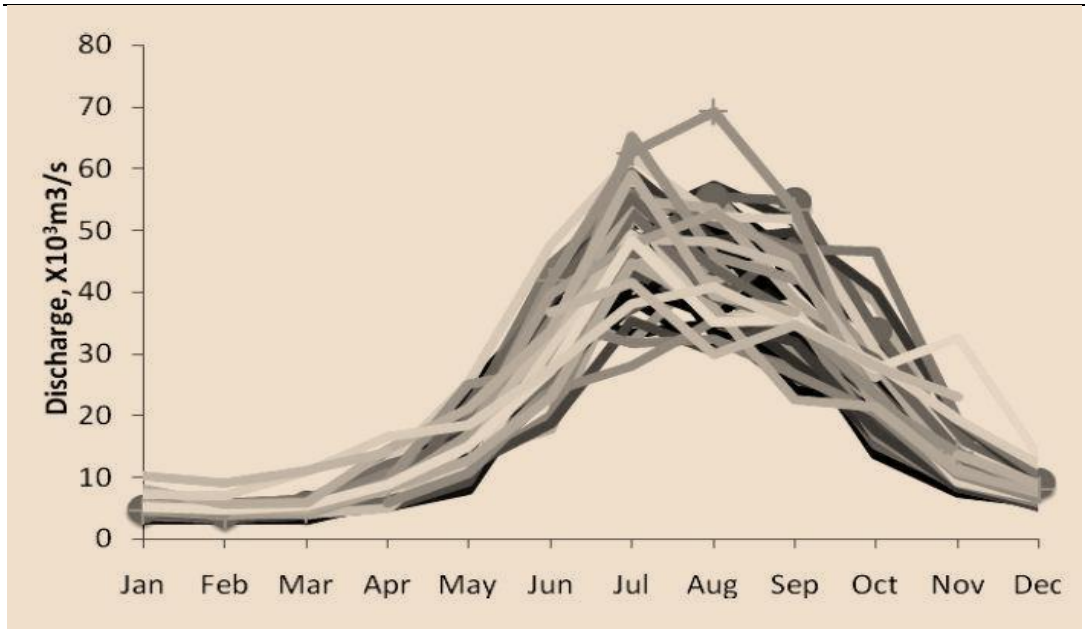

Figure 9. Monthly distribution of flow from 1956-2006 (SW46.9L) (source: Rajib et. al. 2011)

The monthly maximum discharge of water through the river Jamuna varies between about 30000 to 70000 m^3/s (Figure 9). The maximum discharge in the river takes place in the wet season (August or September). The minimum discharge of water generally occurs in March and April and it varies from less than 5000 m^3/s to 10000 m^3/s. The Jamuna is about 5 km wide in the study area.

3.3 Hydrogeology

3.3.1 The Groundwater Reservoir

The study area is underlain by a good aquifer system in the context of a groundwater supply for irrigation and other purposes. **Total 295 bore logs** of the study area have been collected from different organisations to delineate the hydrostratigraphy of the study area (Figure 10). Groundwater Circle of Bangladesh Water Development Board (BWDB) drilled **18 exploratory boreholes** in the study area the depth of which varies between 92 to 312m. Information of deep aquifer has been revealed from the study of exploratory bore logs of about 312m depth in or around the study area. Other 277 bore logs were collected from Bangladesh Agricultural Development Corporation (BADC). The wells were drilled for irrigation purposes.

The aquifer system includes a surface aquitard, overlying the aquifers of main interest. Below the surface clays and silts are a series of sand beds which range from fine-grained to coarse-grained in nature. In general the entire sequence down to some 120 metres below ground level becomes coarser with depth. Below 120m, there are very fine sand to medium sand with occasional coarse sand and gravels up to a depth of about 312 metres. Little exploration has been undertaken at depths greater than 312m. The deep tubewells drilled by BADC extend to a depth of between 60 and 110 metres from the surface. In the context of the present study, the aquifer of main interest is the one composed of the fining upward sequences. Figure 10 shows the borehole location map of the study area.

Rockworks-15® was used to construct 3D model, fence diagram and hydrostratigraphic cross-sections of the subsurface aquifer system. Figure 11 gives the 3D model of the study area. Figure 13 and 14 show the fence diagram and hydrostratigraphic cross-sections of the study area. It is clear from the 3D model, fence diagram and hydrostratigraphic sections that the whole study area is underlain by a continuous aquifer of over 100m thick. The aquifer consists of sands which range in size from very fine sand to medium sand. Coarse sand and gravel layer occur sporadically within the aquifer. Occasional discontinuous clay and silt aquitards occur within the aquifer.

The three layer aquifer model (UNDP, 1982) is the most commonly used conceptual model which has been applied to define the aquifer system of the study area (Table 2).

Table 2. The three layer aquifer model (after UNDP 1982)

Layer	Description	Lithology	Thickness (m)
1	Upper Clay and Silt	clay and silt	0-41
2	Composite aquifer	Very fine to fine sand	0-58
3	Main aquifer	Medium to coarse sand and gravel	75+

Upper Clay and Silt layer is an aquitard which lies on the surface of the study area. This layer is either absent or very thin (1-2m) in some parts adjacent to the Jamuna River. The thickness of the surface layer is variable ranging from less than 1 m to over 41 m. This layer comprises mainly silty clay and silt with some intercalations of fine sand and clay lenses. The whole system therefore would be expected to behave as an aquitard rather than as an aquiclude. This assessment is borne out by the rapidity of the water table reaction to rainfall events.

The Composite Aquifer is the uppermost aquifer composed mainly of very fine to fine sand and some time of medium sand with occasional clay layer. The thickness of this layer in the study area varies from 0 to 58m.

The Main Aquifer is the lowest aquifer considered in the present study. The aquifer appears to be fairly uniform over a wide lateral extent and to be composed mainly of medium grained sands with some coarse sands and gravels. Occasionally, very fine to fine sand and silty laminations are reported to occur. It is probable that, given the nature of the depositional environment, silty laminations are wide-spread occurrences. The effect of the silt layers may be to limit vertical flow within the aquifer, thereby inducing some horizontal flow. The bottom of this zone has not been encountered in any of the bore hole in the study area. The thickness of this layer is more than 75m in most part of the study area.

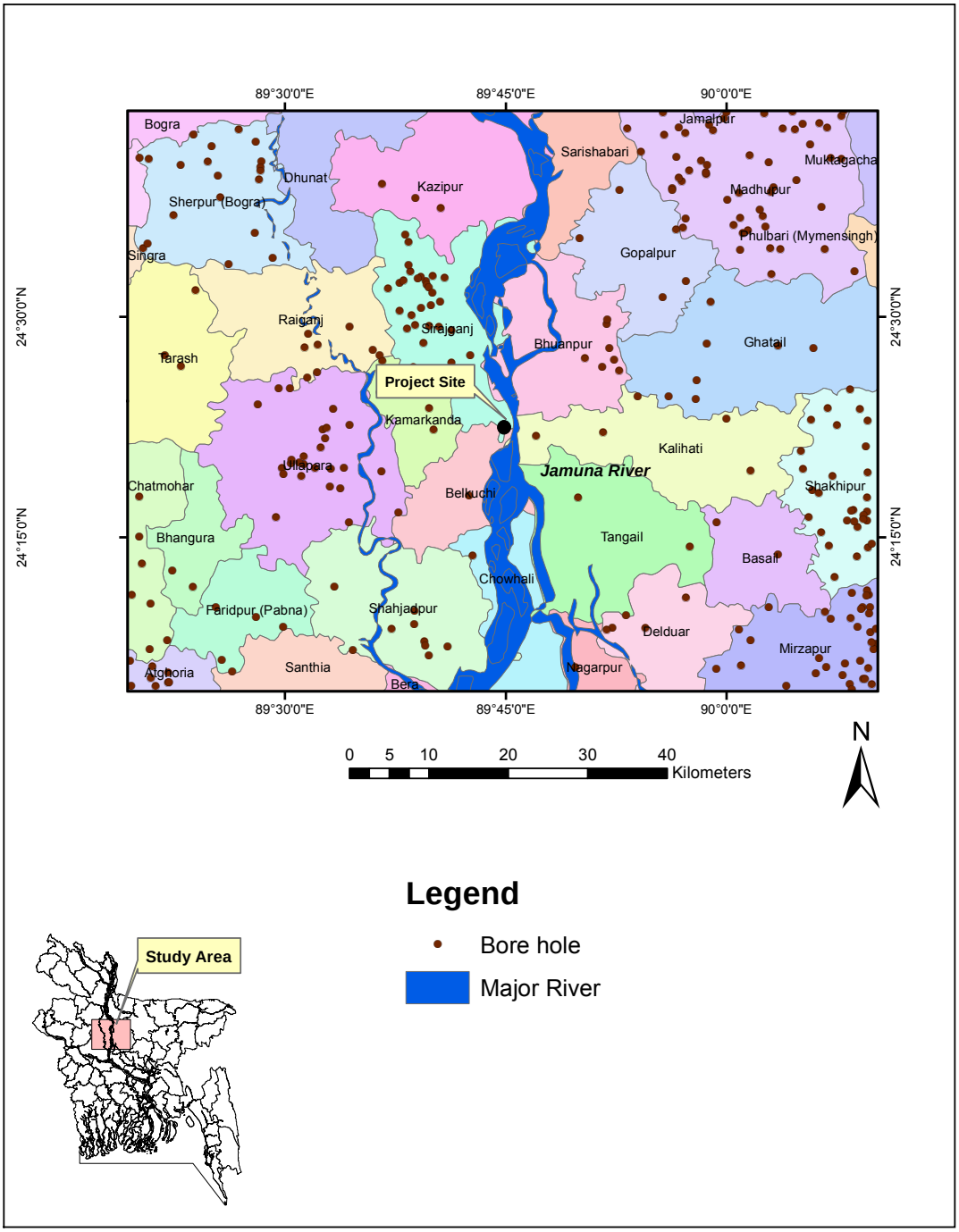

Figure 10. Borehole location map of the study area

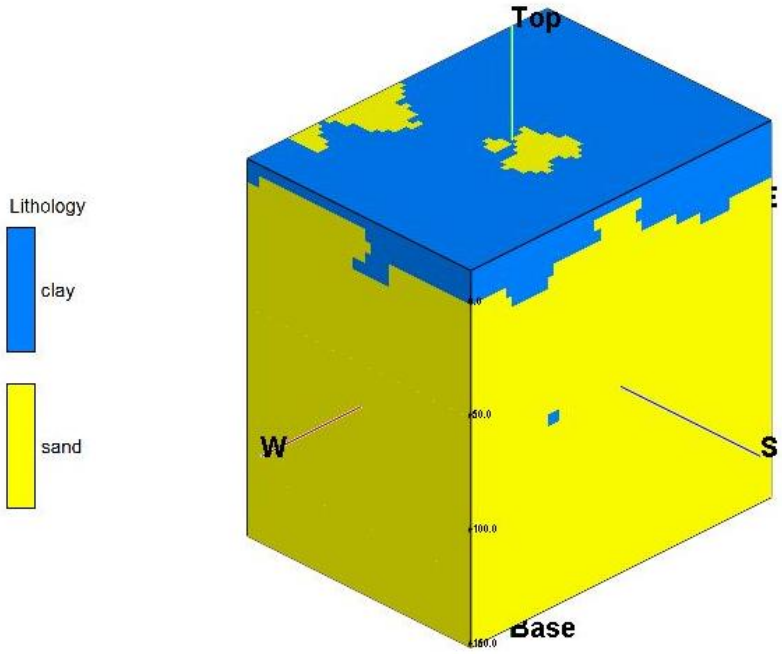

Figure 11. 3D model of the aquifer system constructed using Rockworks-15®

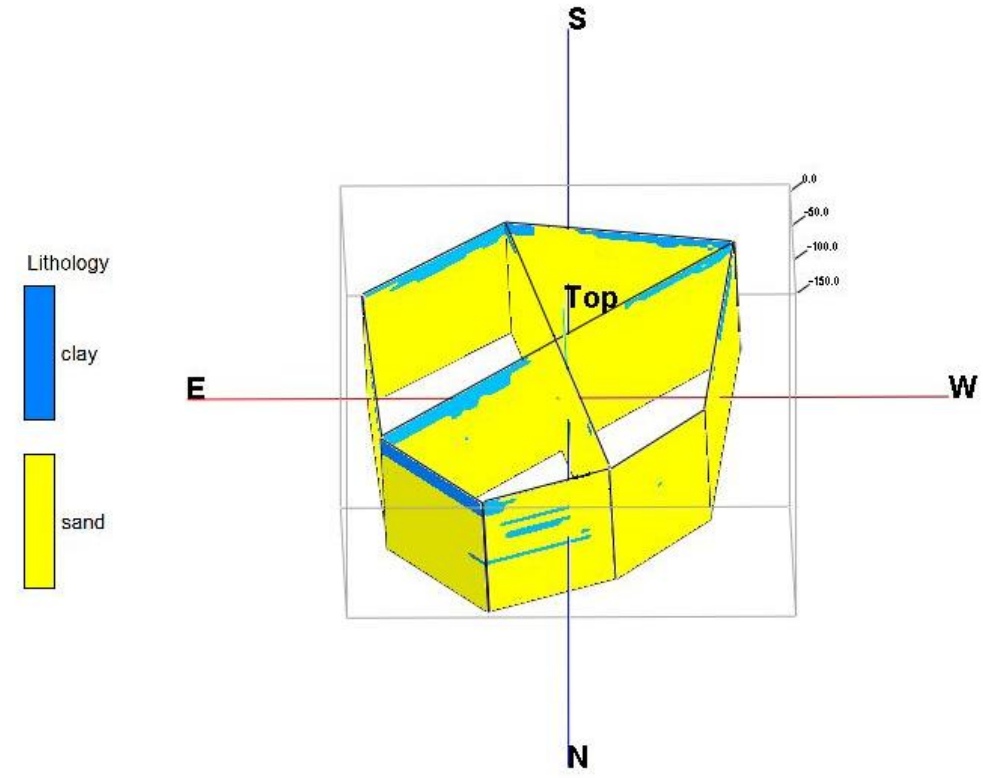

Figure 12. Fence diagram of the aquifer system constructed using Rockworks-15®

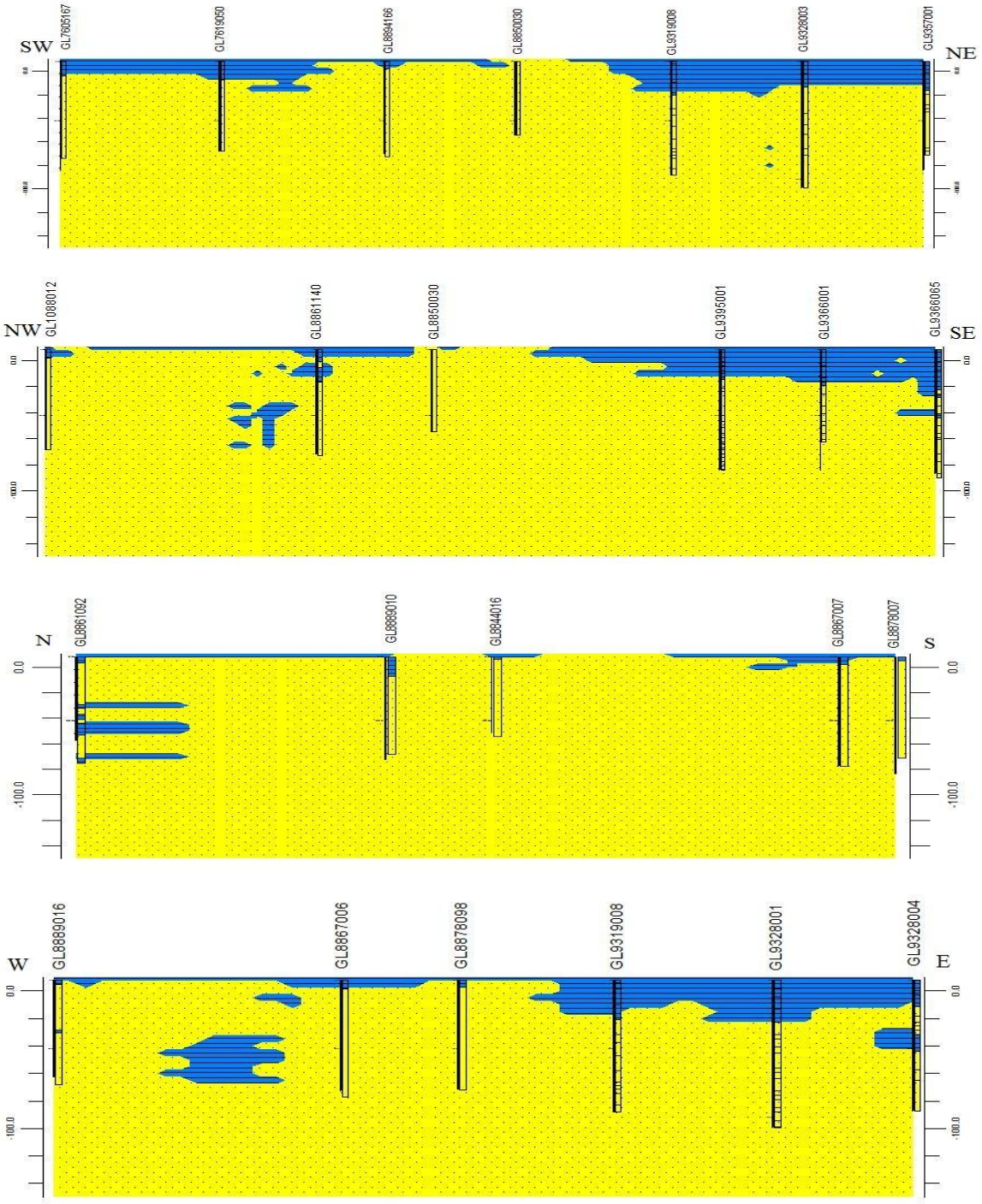

Figure 13. Hydrostratigraphic sections of the aquifer system

3.3.2 Groundwater Movement

Water table contour maps for both dry and wet seasons have been drawn for the study area based on the water level monitoring data of observation wells. Observation wells may be dug well or piezometer. Dug wells are often shallow and in most cases do not represent the water level in the aquifer and therefore, dug well data were not used in preparing the water table contour maps.

In the dry season (April or May) water level elevation reaches to the minimum. Figure 14 gives the water table contour map of minimum elevation. The highest elevation of about 12.5m generally occurs in the Madhupur and the Barind tracts. The lowest elevation of about 5m occurs in the southern part. Groundwater in dry season moves from river to aquifer on the both side of Jamuna River.

In the wet season (August or September) groundwater level reaches to its maximum. Figure 15 shows the water table contour map of maximum elevation. The highest elevation of water table generally occurs in the northern part which is about 18m. Movement of groundwater is also from river to aquifer on the both side of the river.

In both dry and wet seasons groundwater moves from northeast to southwest in Sirajganj area and northwest to southeast in Tangail area.

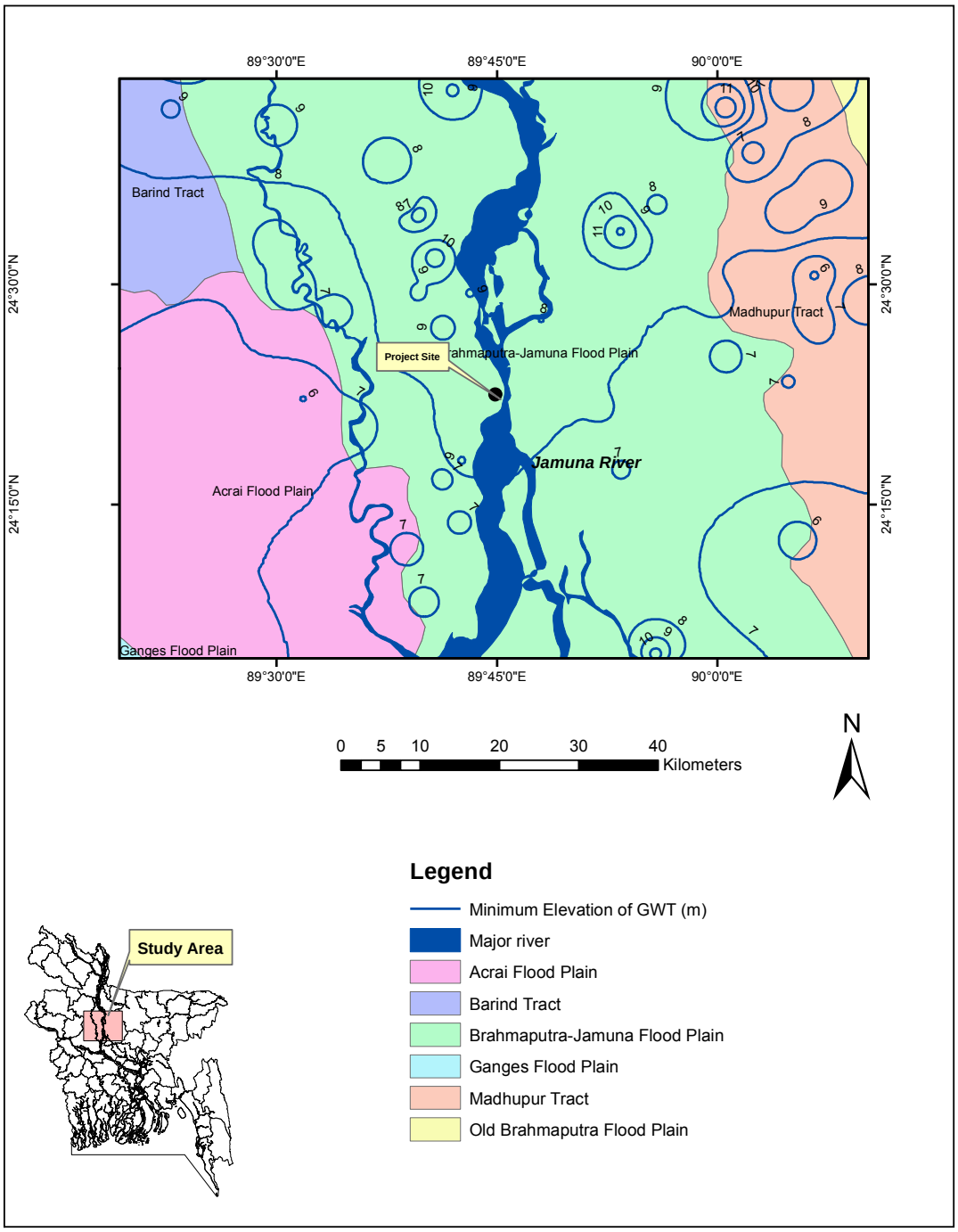

Figure 14. Water table contour map of minimum elevation

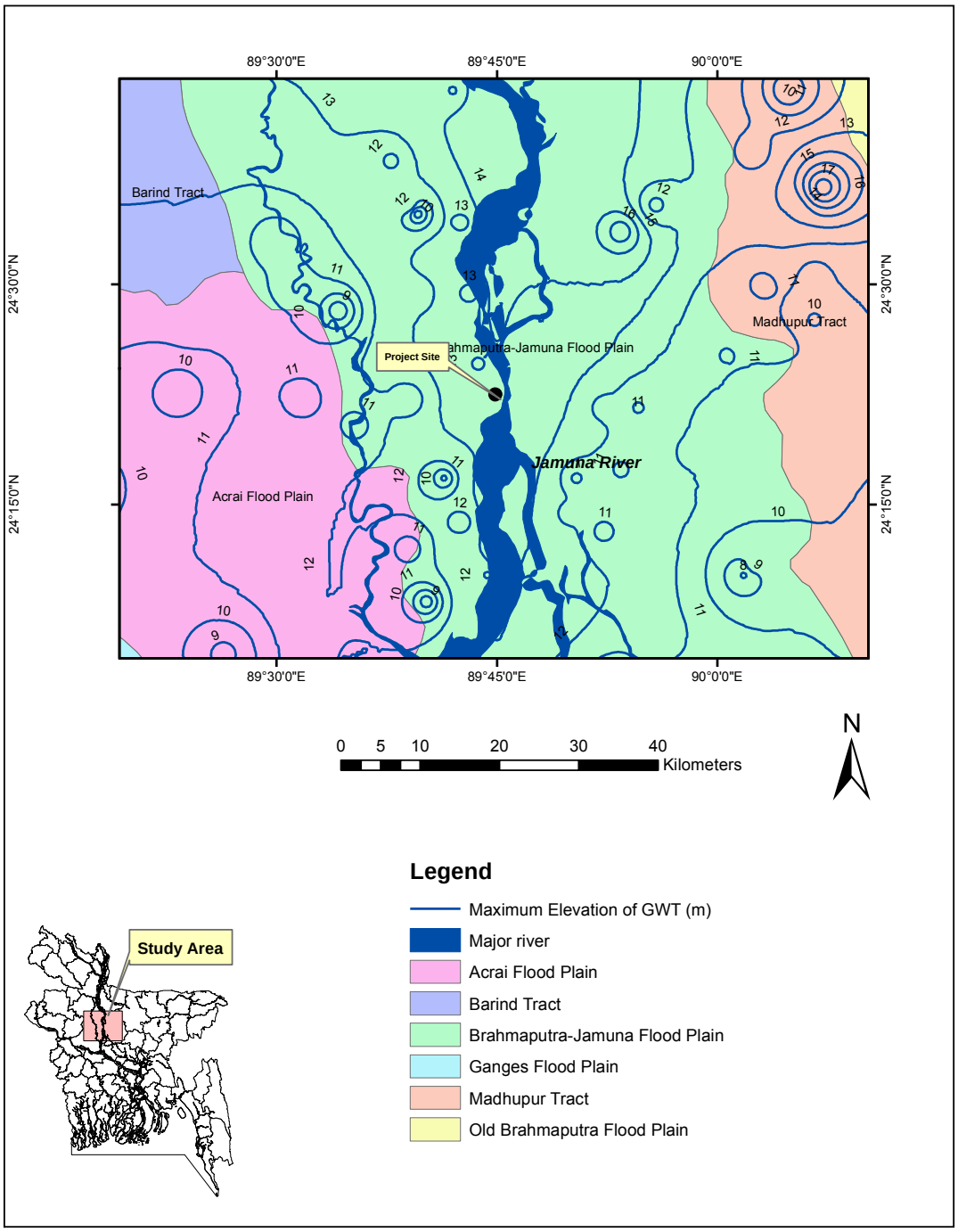

Figure 15. Water table contour map of maximum elevation

3.3.3 Groundwater Recharge and Evapotranspiration

Recharge means the replenishment of groundwater storage that has been depleted by withdrawal with tubewells and natural processes. The natural losses are due to outflows to rivers, canals, beels, haors and other depressed water bodies. The loss of water due to evaporation from water table and transpiration by plants also attribute to depletion of groundwater storage. Rainwater, floodwater, and irrigation return flow into the under-ground reservoir are the main sources of recharge to groundwater.

Recharge to groundwater depends on different physical settings, climatic conditions and hydraulic properties related to soil and aquifer. In the study area, during June to September, recharge occurs primarily through vertical percolation from relatively large amounts of rainfall and stored water within bunds around the paddy field and floodwater in places. However, during this period infiltration rate is lower in the non-cultivated, high lands and forests. Low topographic relief, slow drainage with large areas of relatively pervious soil and permeable underlying sediments are conducive to high recharge.

Rate of percolation at the start of the rainfall is high enough to bring the soil stratum to field capacity. After the field capacity of the soil is attained, water starts to percolate to the groundwater reservoir and the groundwater level starts to rise. Once the water table reaches the ground surface, recharge starts rejecting in places mainly during August and September when there is no space for further storage.

No specific and co-ordinated investigations have been carried out in the study area to define and quantify the individual processes of groundwater recharge. Much of the present understanding of the recharge process is based on studies elsewhere in Bangladesh and also on direct inference from existing monitoring data.

The development of the groundwater model for this study depended upon a preliminary understanding of the dominant modes of recharge. Existing data suggests that the groundwater reservoir of the study area is replenished or depleted by several distinct processes described below.

Rainfall and evapotranspiration process

Records of groundwater levels have shown that the water table is very close to the land surface throughout the year and that there is a strong correlation between fluctuations in level and the highly seasonal rainfall pattern. In addition, the aquifer piezometry indicates that natural groundwater gradients across the study area are always very small which suggests that lateral movement of groundwater within the study area is consequently small and much less than the groundwater recharge rates inferred for the area. These factors strongly imply that a major proportion of recharge is derived from the vertical percolation of rainfall, while losses from the aquifer are most likely to result from direct evaporation or evapotranspiration from the water table.

Inundation due to river-overtopping

Numerous temporary or permanent surface-water bodies exist in the area. It is probable that they rest on impermeable silts and clays and are relatively insignificant in relation to the volumes of regional groundwater recharge from other sources. For this reason this possible mechanism of recharge has been ignored in the groundwater model.

The available well-monitoring data has shown that, during the monsoon season, groundwater levels rise above regional ground level in some part of the study area which coincides with the areas subject to regional seasonal river inundation.

Figure 5 shows the flood hazard map of the study area. No data are available regarding the depths of flooding across these areas or the rate of rise and fall of water levels as the rivers overtop their banks and subsequently recede. Comparison of field levels and embankment levels however, suggests that standing water depths may be as great as 1 metres in parts of the area, but are normally expected to be in the range of 0.5 to .75 metres. The significant extent and frequency of flooding represents a regionally important source of groundwater recharge.

Hydraulic continuity between the aquifer and rivers

The water table contour maps (Figure 14 and 15) show that the groundwater flow lines are influenced by the alignment of the River Jamuna. Fluctuations of groundwater levels are characteristically greater in the vicinity of the river than elsewhere and correspond

closely, both in amplitude and elevation, to the fluctuating stage of the Jamuna River. The above factors strongly suggest that river leakage is important, at least locally, as a source of aquifer recharge. Bearing in mind the distribution of surface lithologies and the density of embankments and drainage lines traversing the study area it is possible that leakage between the aquifer and rivers is a widespread phenomenon.

Estimation of Recharge

The study of UNICEF (1993) estimated mean monthly recharge of Sirajganj Upazila by analysing groundwater level data and rainfall data. This recharge rate is assumed to be valid for the whole study area. Table 3 gives the mean monthly recharge data of the study area.

Table 3. Mean Monthly Recharge Rate of the study area

Month	Recharge (mm) of Sirajganj	Recharge (mm) of Tangail
January	20	8
February	22	9
March	48	22
April	128	119
May	180	173
June	183	179
July	182	152
August	155	101
September	103	51
October	40	12
November	23	9
December	21	8
Yearly Recharge	**1104**	**844**

Estimation of evapotranspiration

A large number of more or less empirical methods have been developed over the last 50 years by numerous scientists and specialists worldwide to estimate evapotranspiration from different climatic variables. Penman method (Ponce 1989) is widely used method to evaluate potential evapotranspiration of any area using meteorological data. These data include mean monthly temperature, mean monthly net radiation, relative humidity and wind velocity.

Karim and Akaond (1982) estimated mean monthly potential evapotranspiration of the study area based on modified Penman method. Table 4 gives the mean monthly potential evapotranspiration of the study area.

Table 4. Mean Monthly Evapotranspiration Rate of the study area.

Month	Potential Evapotranspiration (mm)
January	86.8
February	106.7
March	163.4
April	188.7
May	181.4
June	133.8
July	132.7
August	122.7
September	123.0
October	94.9
November	95.4
December	81.5
Yearly Evapotranspiration	**1510.9**

3.3.4 Hydrograph Analysis

Groundwater level observation well data have been collected from BWDB. These wells are either dug well or piezometer. Generally, water level data of these wells are collected at an interval of seven days. They provide very clearly the trend of water level in the study area. The fluctuation of water level in the study area is very much steady and regular. The lowest elevation of water level occurs during dry season particularly in the month of April or May. The groundwater level reaches to the highest elevation generally in the month of August or September. The fluctuation of water table varies between 4 to 7 metres in the study area. Higher fluctuation generally occurs in wells closer to the river Jamuna which indicates hydraulic connectivity between the river and the aquifer. Figure 16 gives the location of Observation wells whose data were used in this study. Figure 17 to 49 give the hydrographs of the observation wells in the study area.

The regularity of hydrographs over a long period indicates that the effect of present groundwater development in the study area has not disturbed the natural water balance of the study area significantly. However, future groundwater development potential in the study area can be investigated using modelling technique.

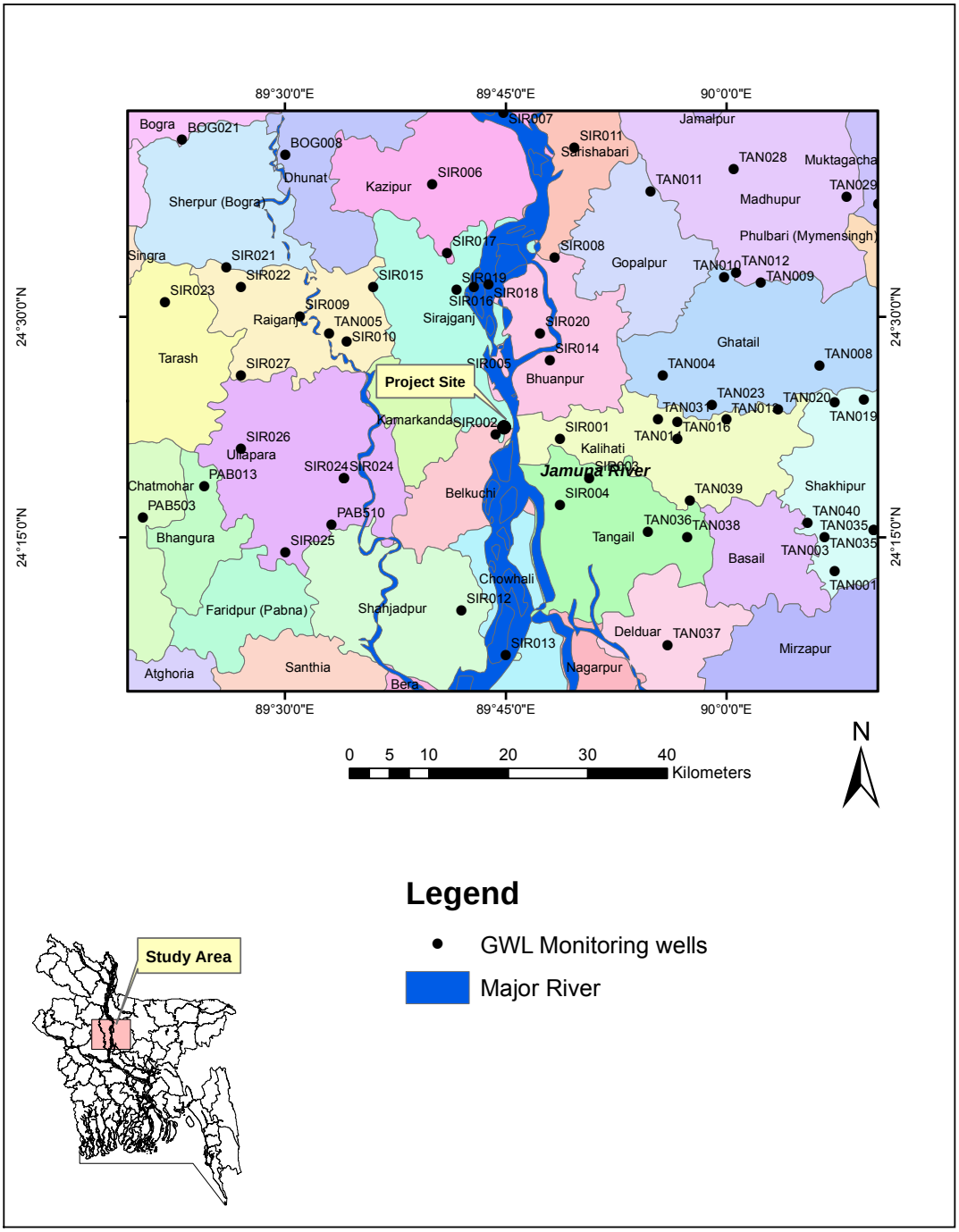

Figure 16. Location of Groundwater level Monitoring wells.

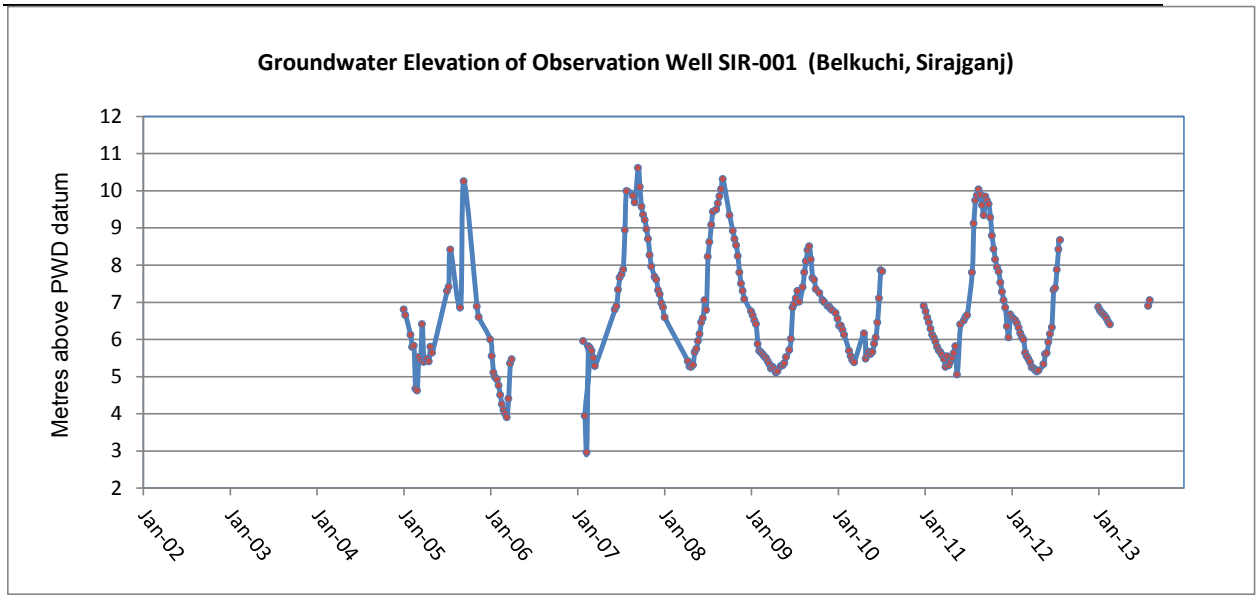

Figure 17. Groundwater level hydrograph of SIR-001

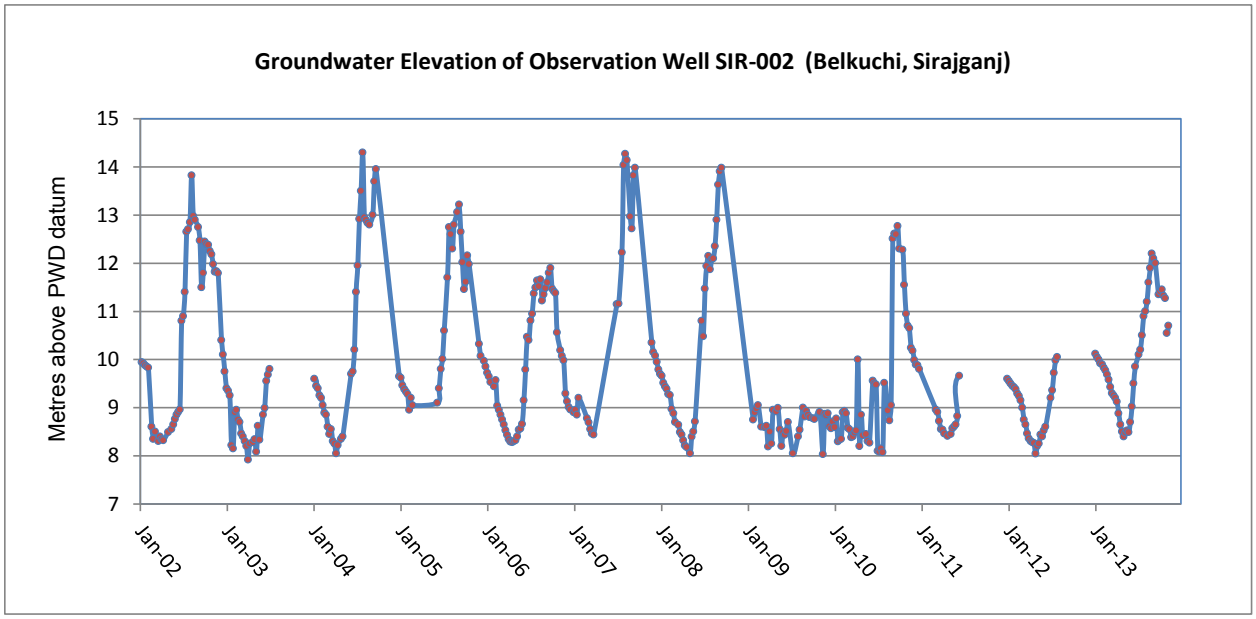

Figure 18. Groundwater level hydrograph of SIR-002

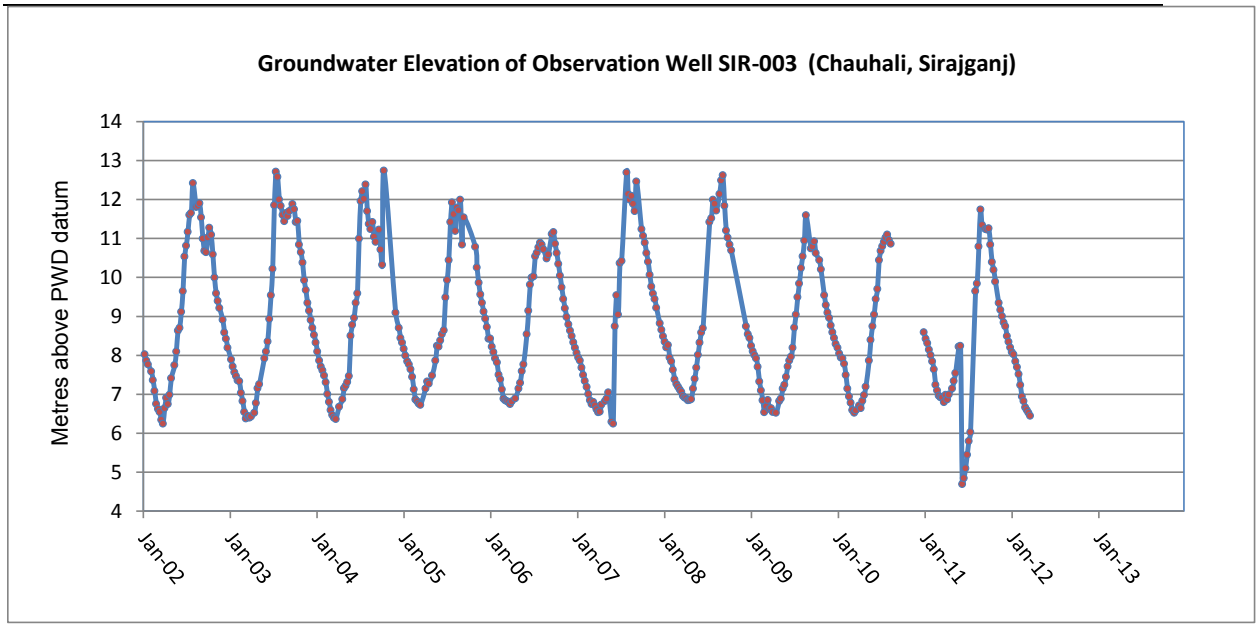

Figure 19. Groundwater level hydrograph of SIR-003

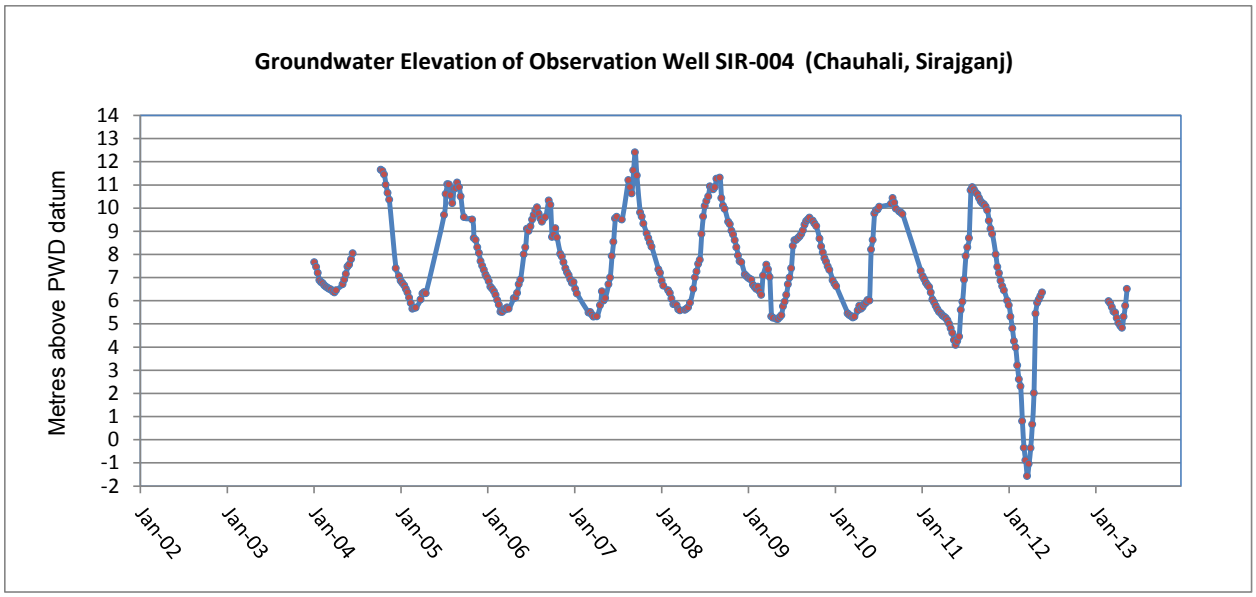

Figure 20. Groundwater level hydrograph of SIR-004

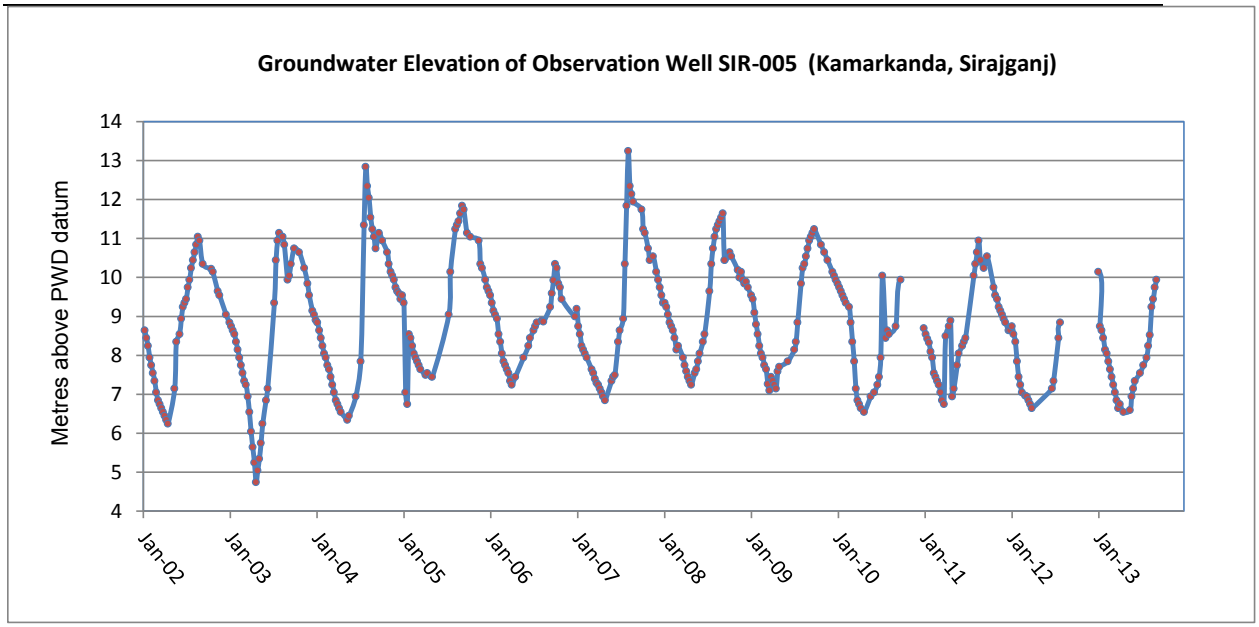

Figure 21. Groundwater level hydrograph of SIR-005

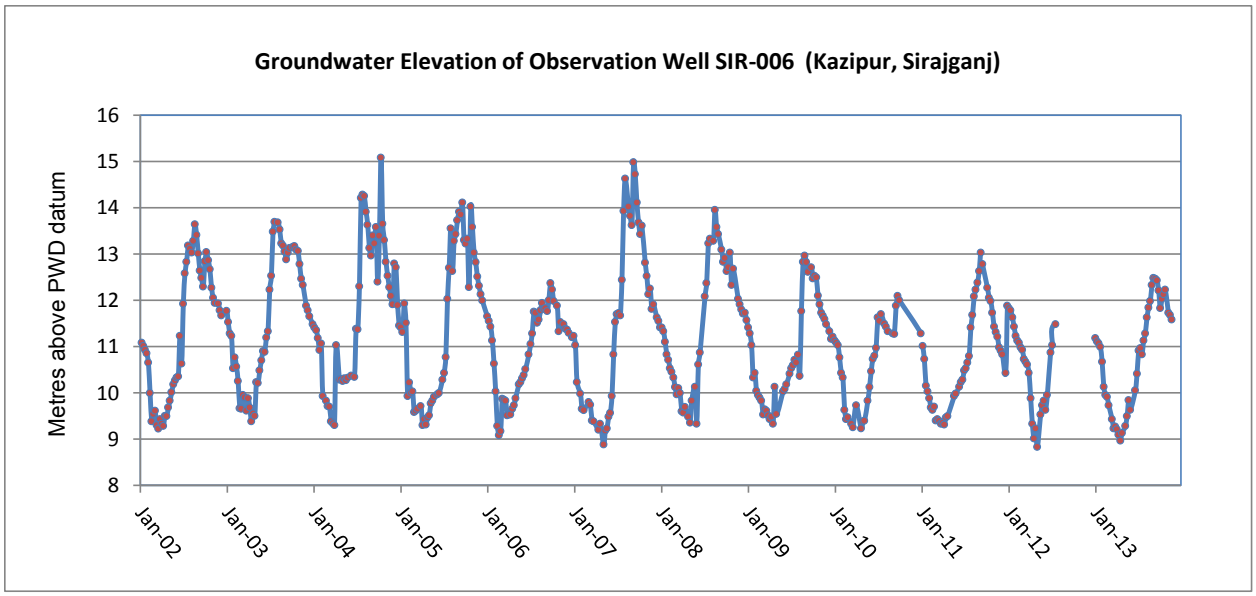

Figure 22. Groundwater level hydrograph of SIR-006

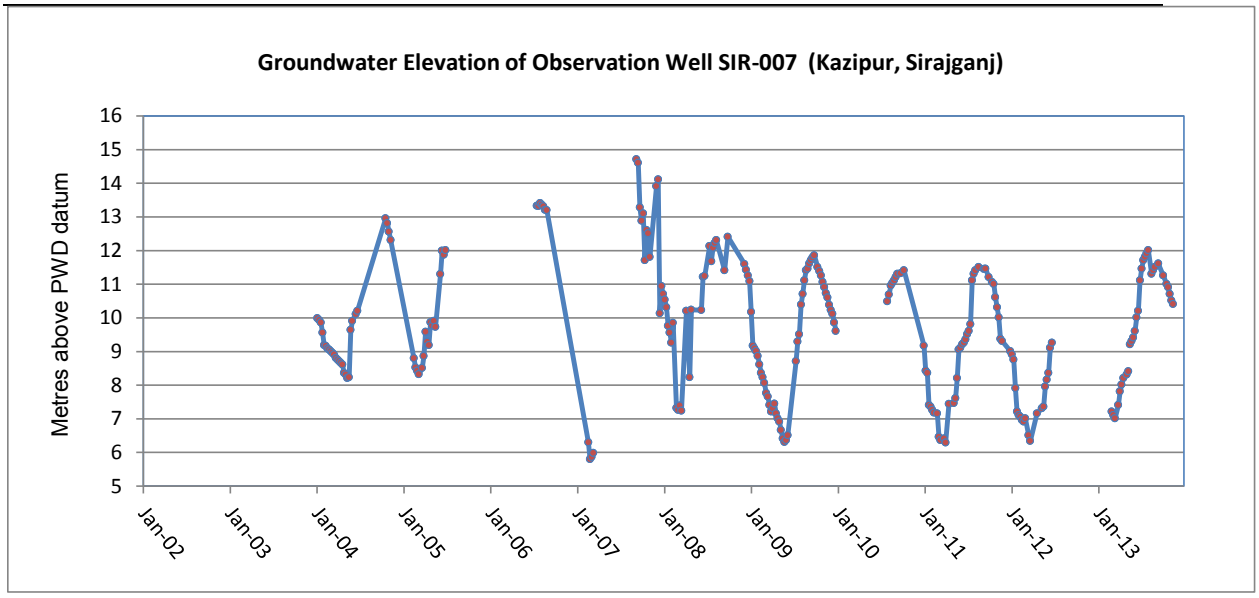

Figure 23. Groundwater level hydrograph of SIR-007

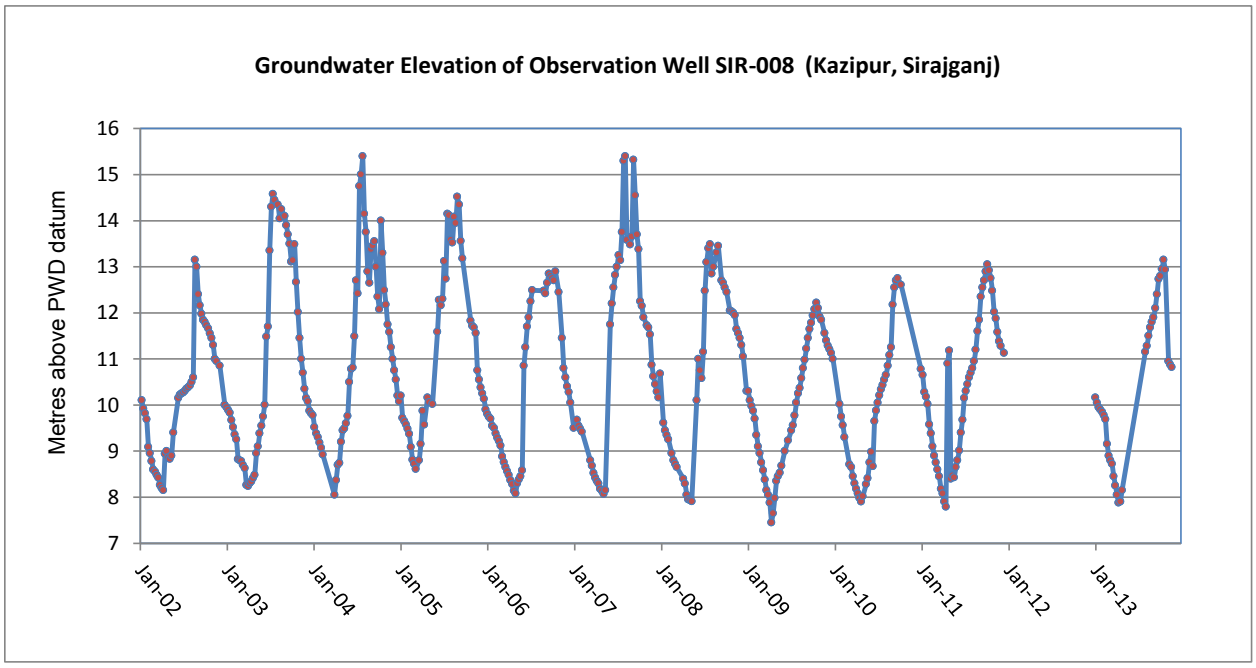

Figure 24. Groundwater level hydrograph of SIR-008

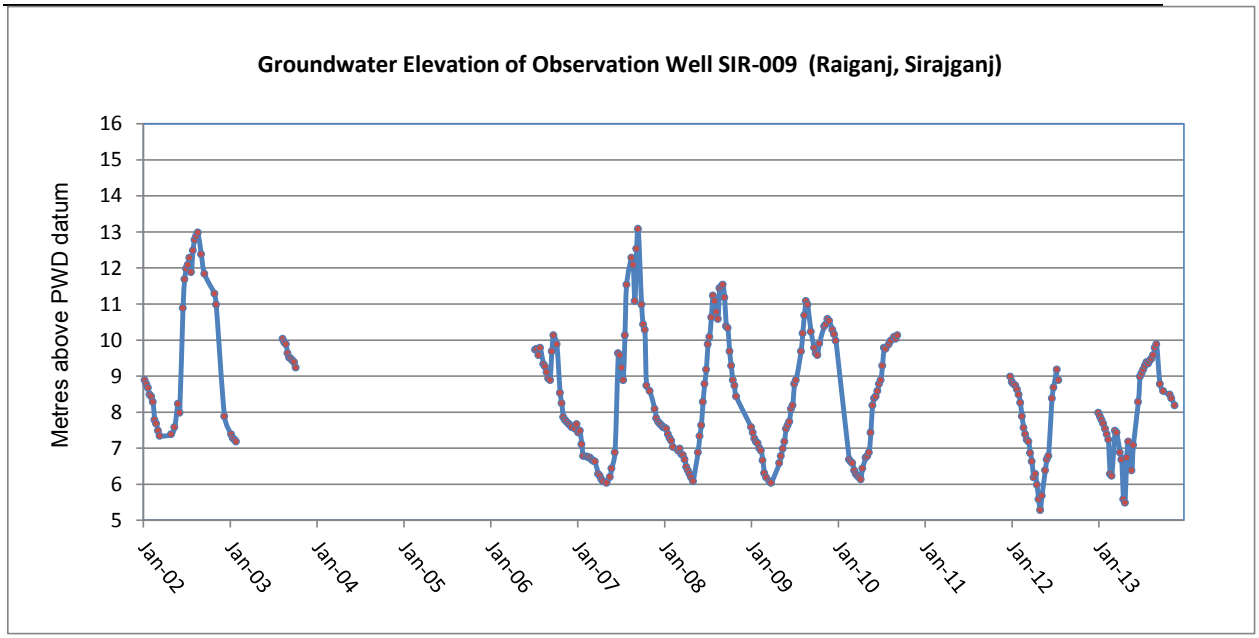

Figure 25. Groundwater level hydrograph of SIR-009

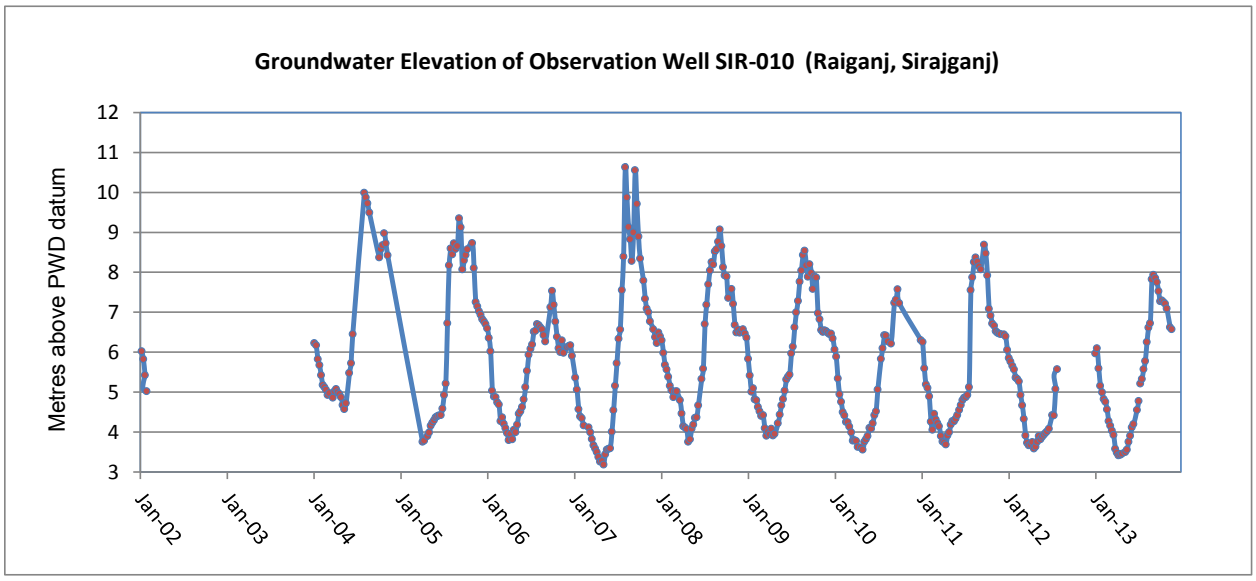

Figure 26. Groundwater level hydrograph of SIR-010

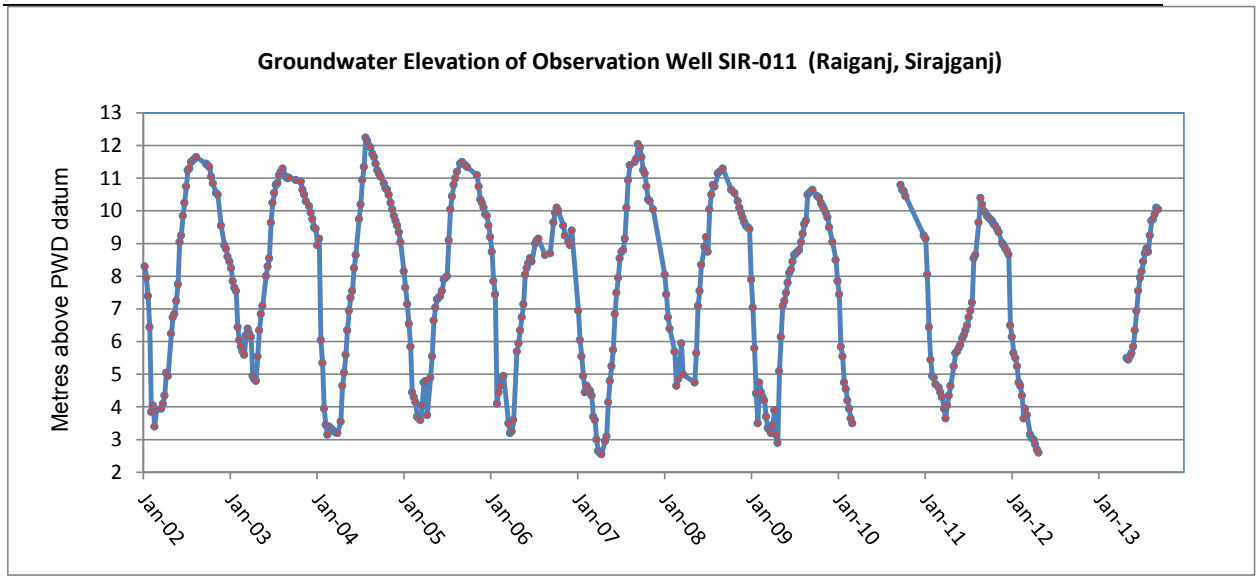

Figure 27. Groundwater level hydrograph of SIR-011

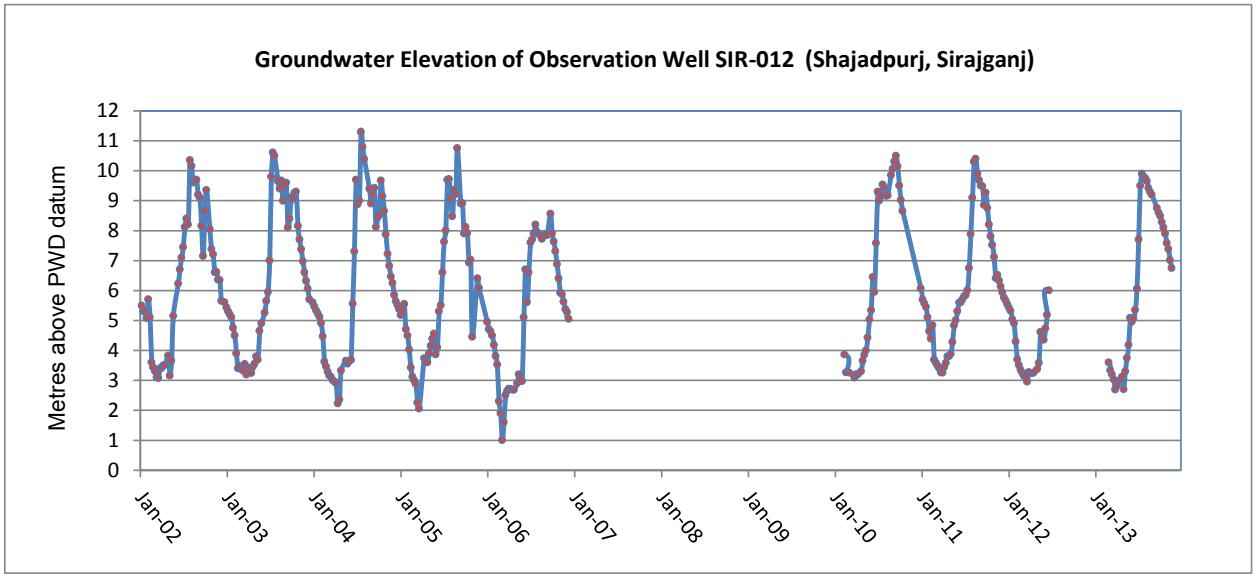

Figure 28. Groundwater level hydrograph of SIR-012

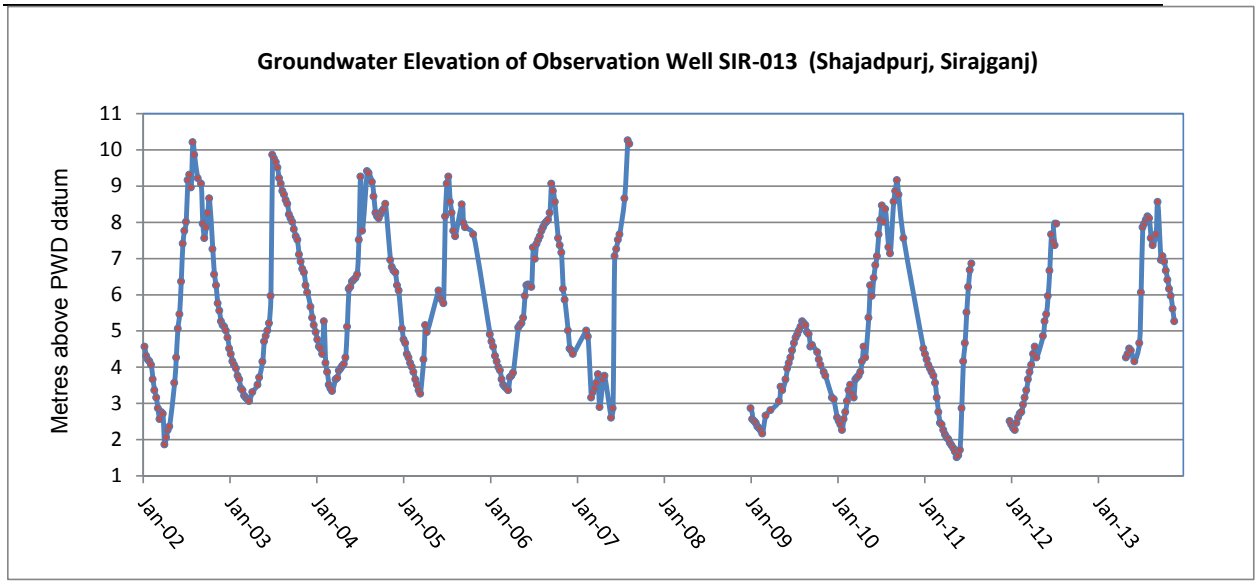

Figure 29. Groundwater level hydrograph of SIR-013

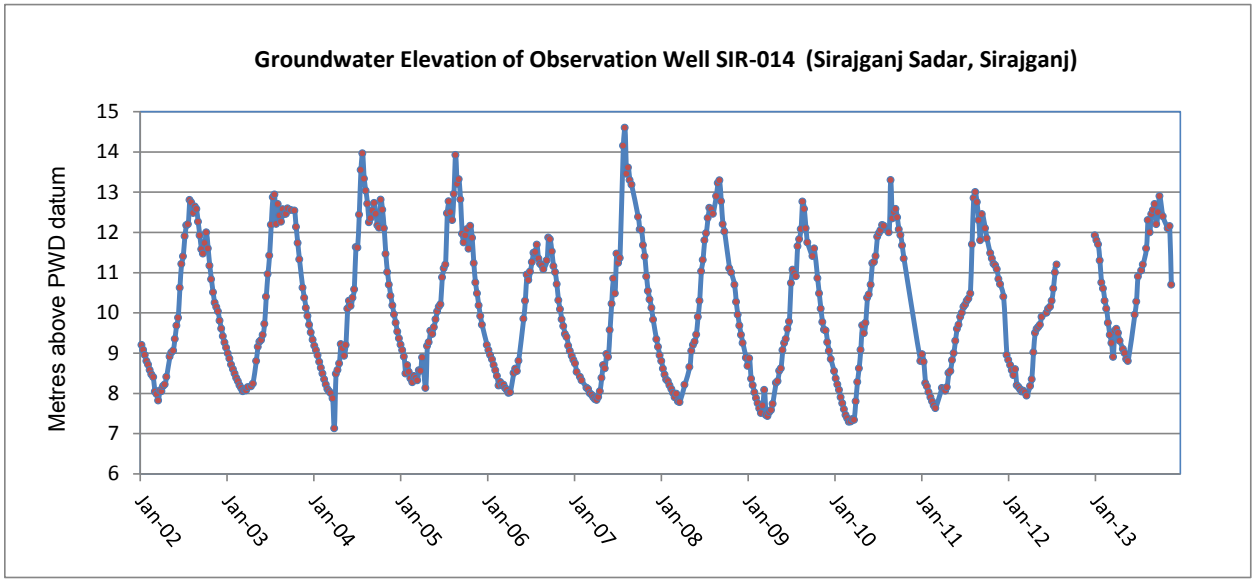

Figure 30. Groundwater level hydrograph of SIR-014

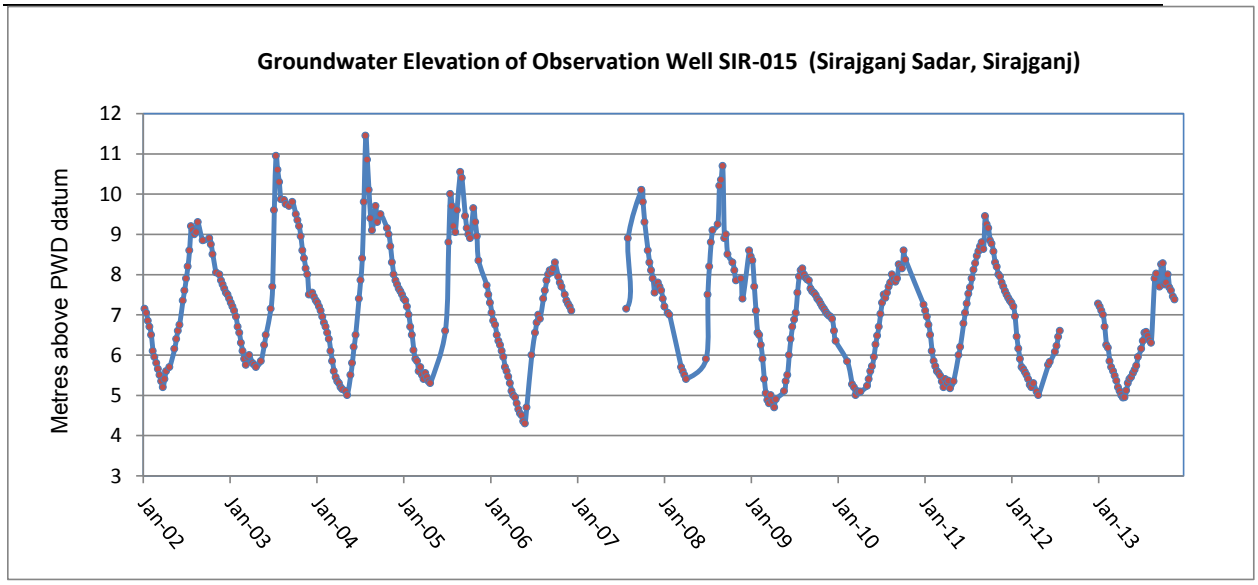

Figure 31. Groundwater level hydrograph of SIR-015

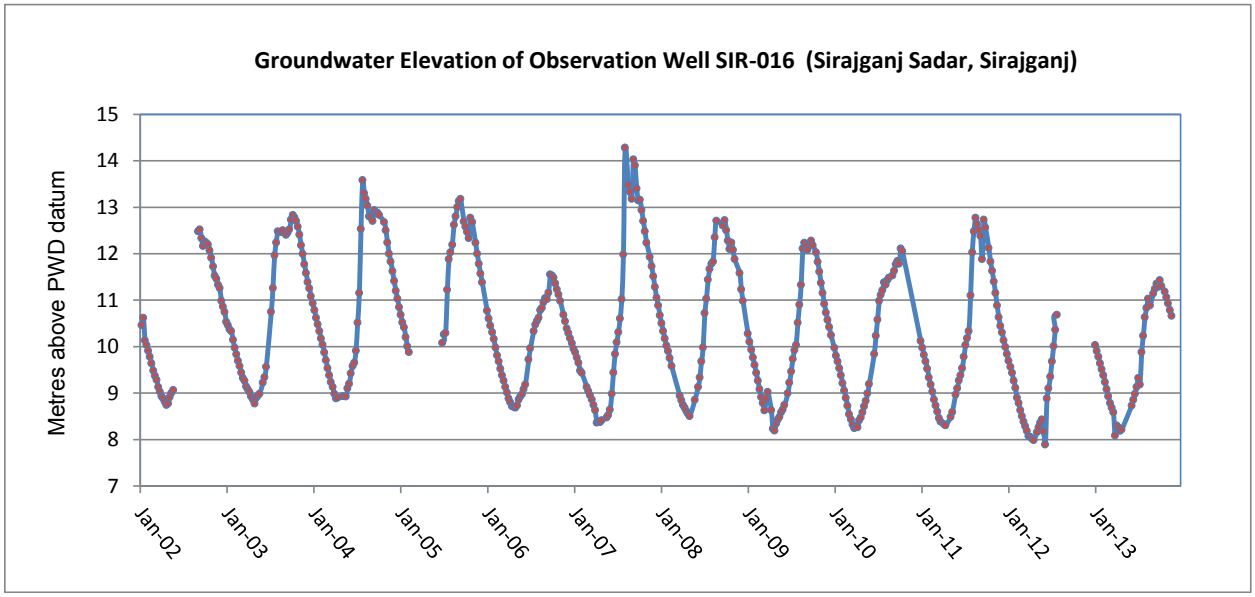

Figure 32. Groundwater level hydrograph of SIR-016

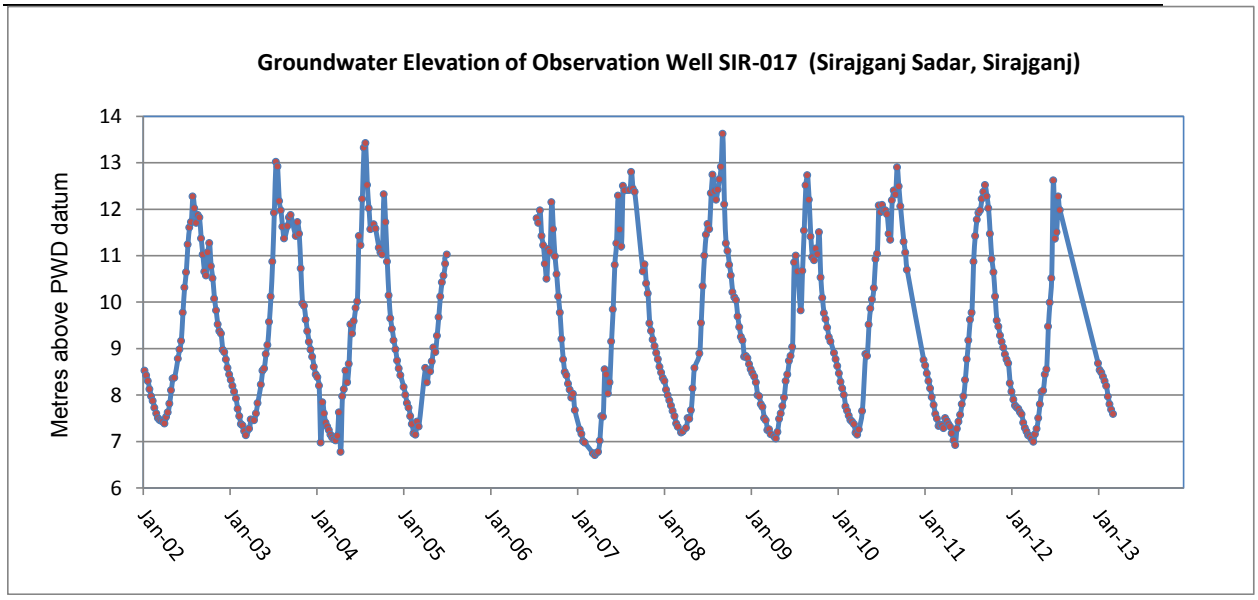

Figure 33. Groundwater level hydrograph of SIR-017

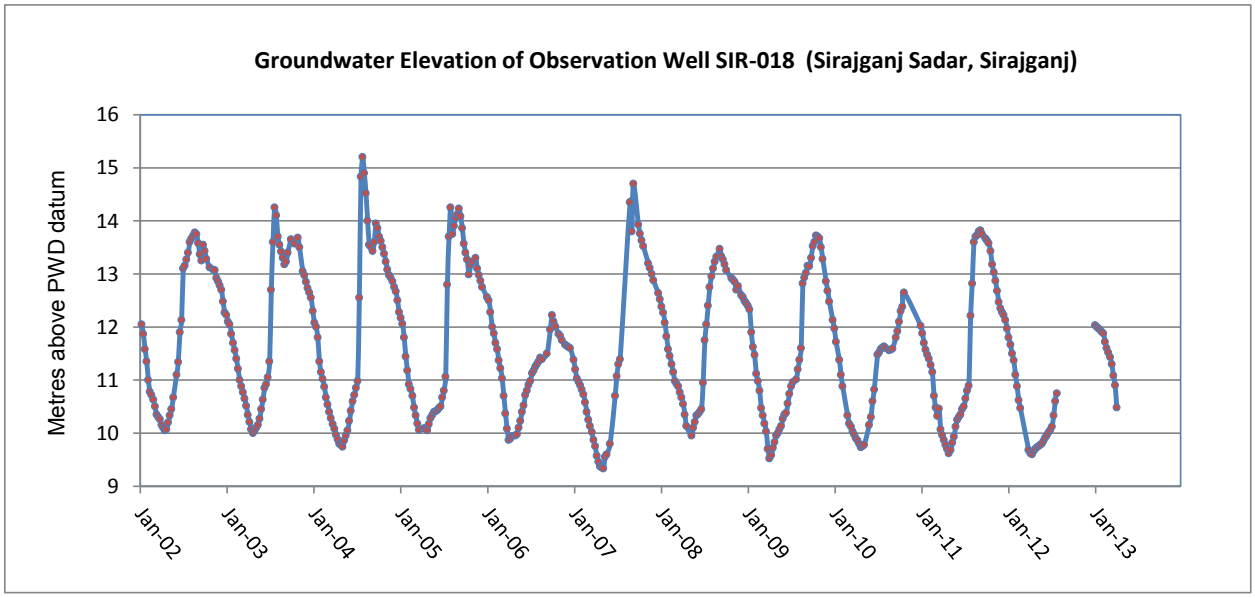

Figure 34. Groundwater level hydrograph of SIR-018

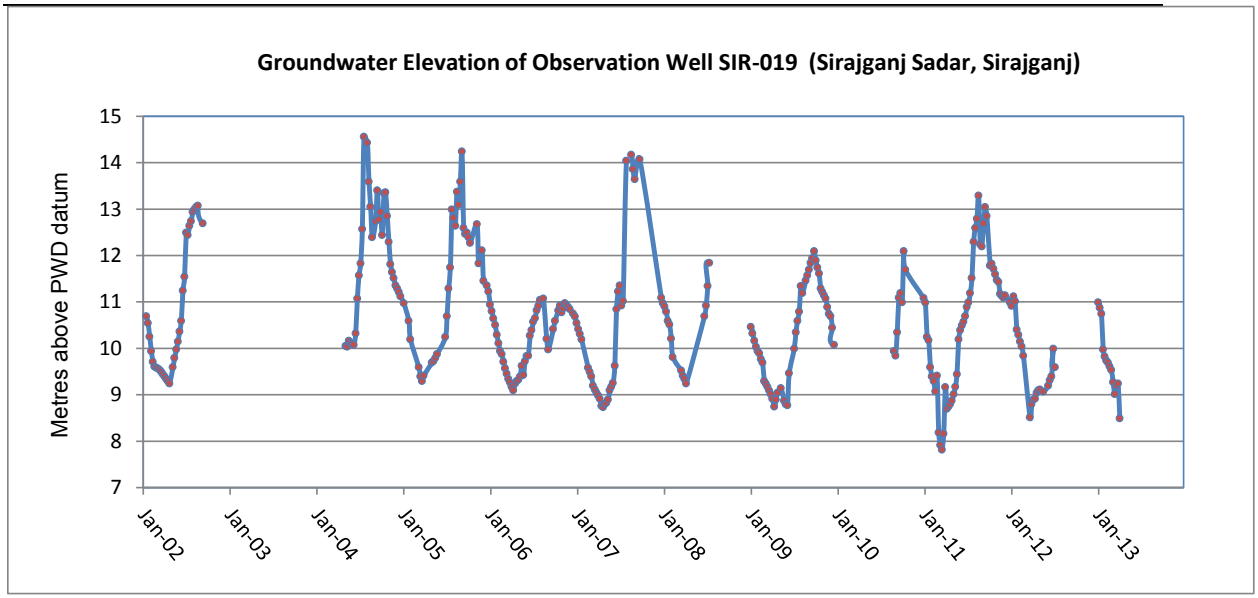

Figure 35. Groundwater level hydrograph of SIR-019

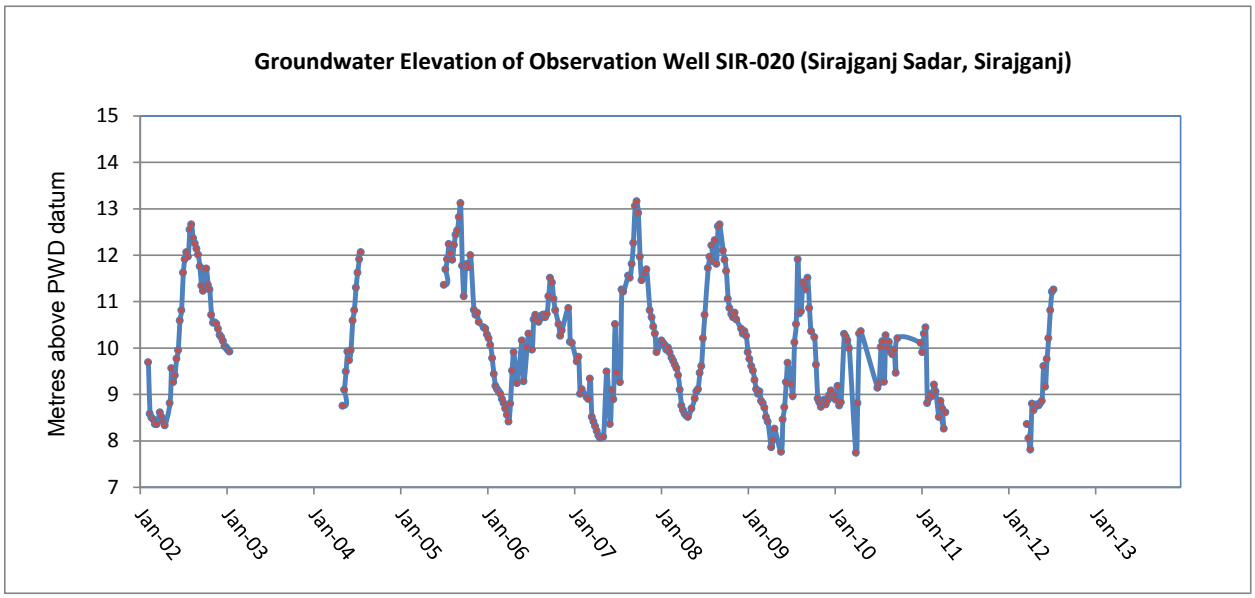

Figure 36. Groundwater level hydrograph of SIR-020

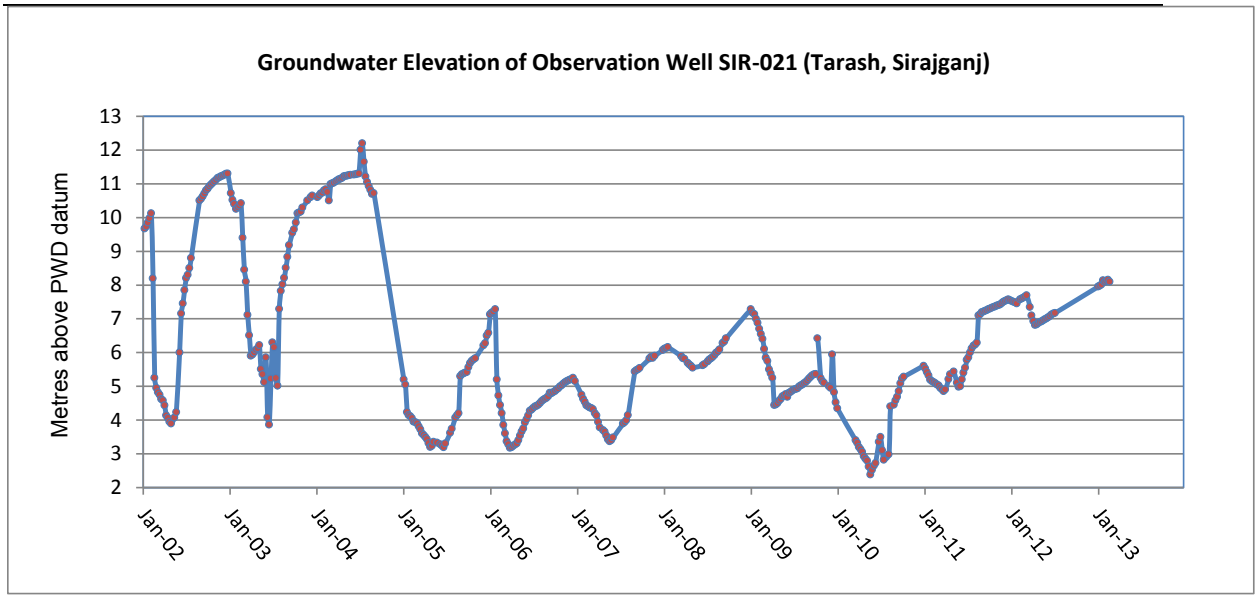

Figure 37. Groundwater level hydrograph of SIR-021

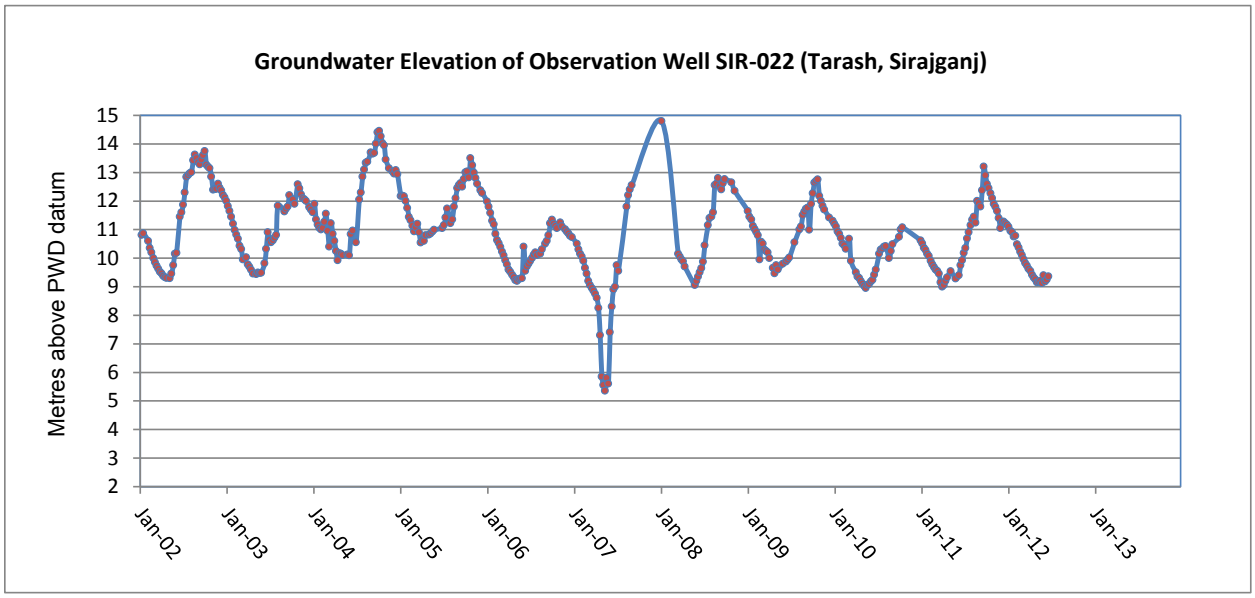

Figure 38. Groundwater level hydrograph of SIR-022

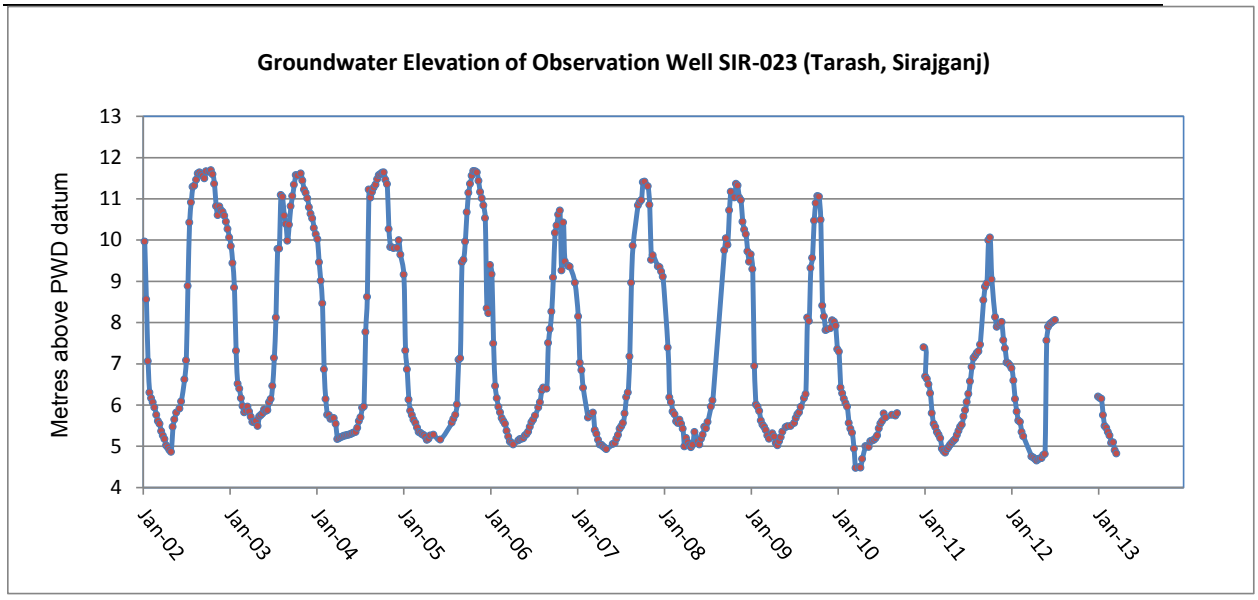

Figure 39. Groundwater level hydrograph of SIR-023

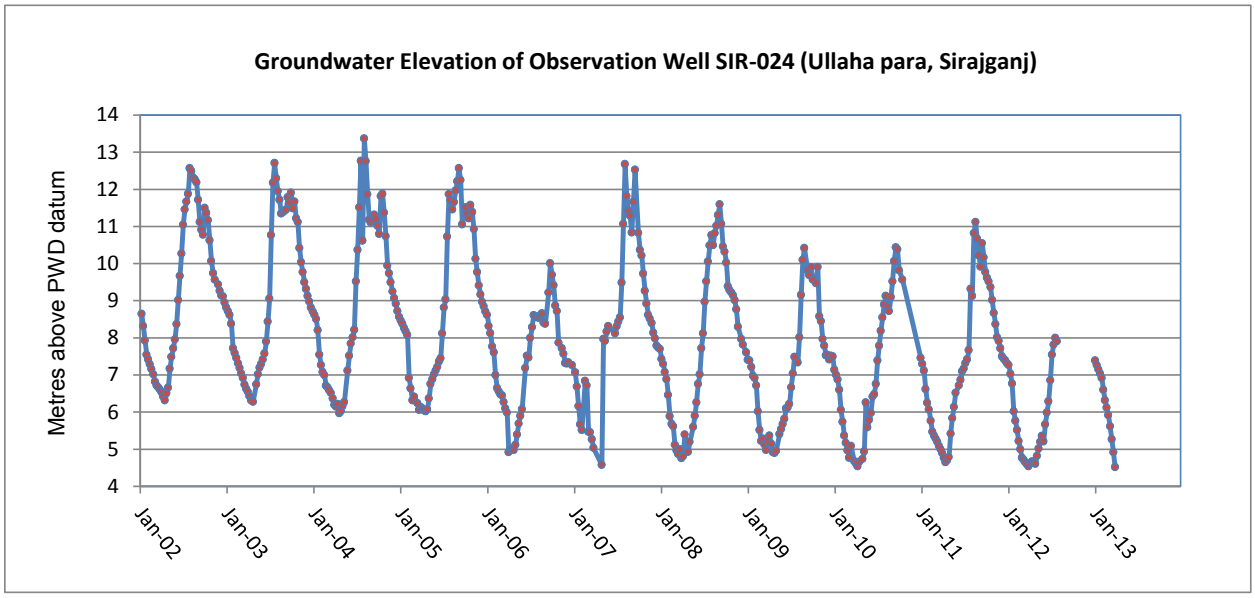

Figure 40. Groundwater level hydrograph of SIR-024

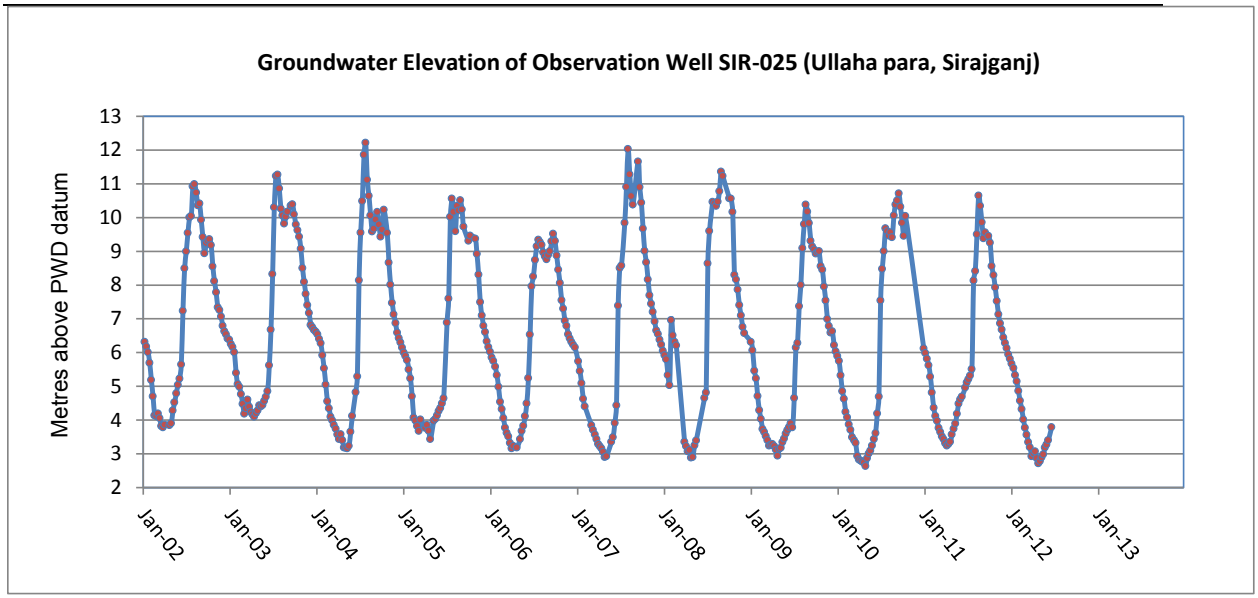

Figure 41. Groundwater level hydrograph of SIR-025

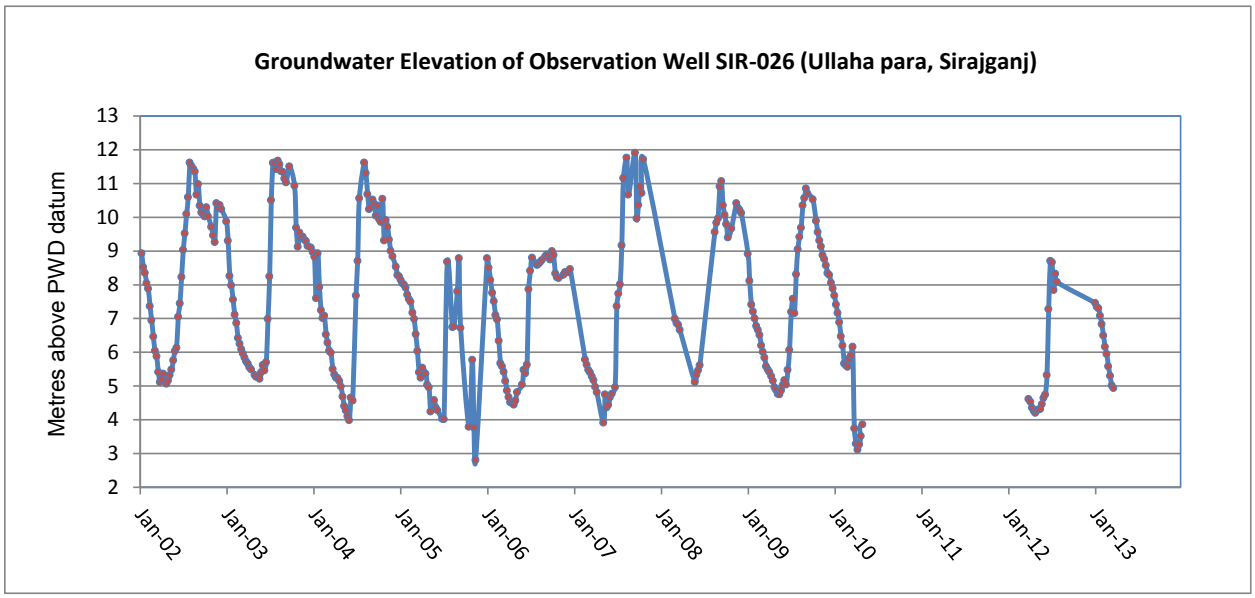

Figure 42. Groundwater level hydrograph of SIR-026

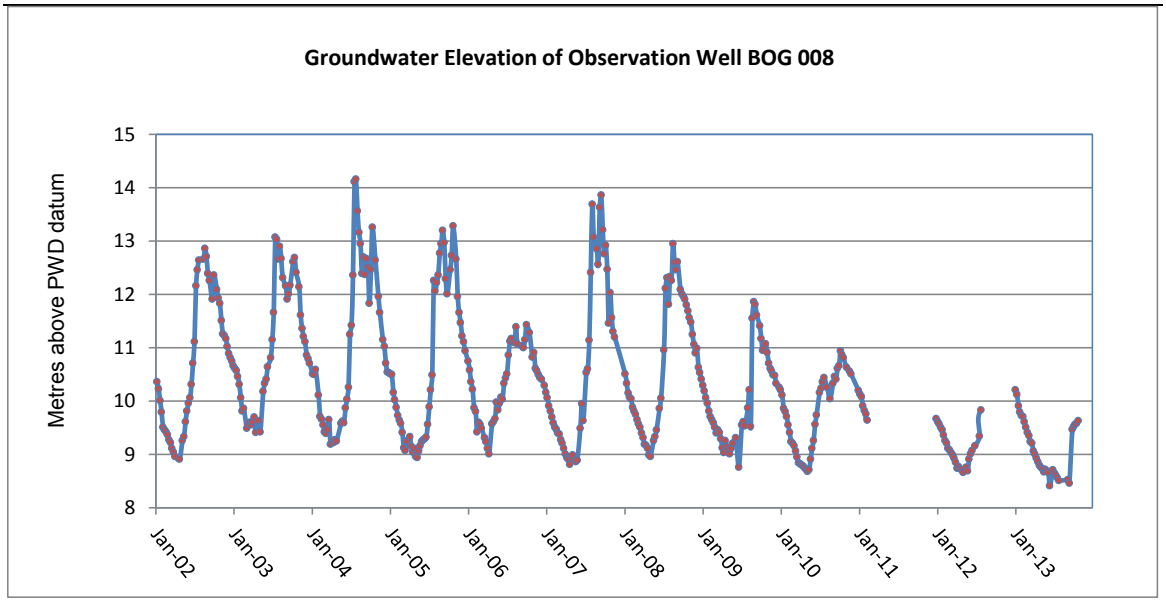

Figure 43. Groundwater level hydrograph of BOG-008

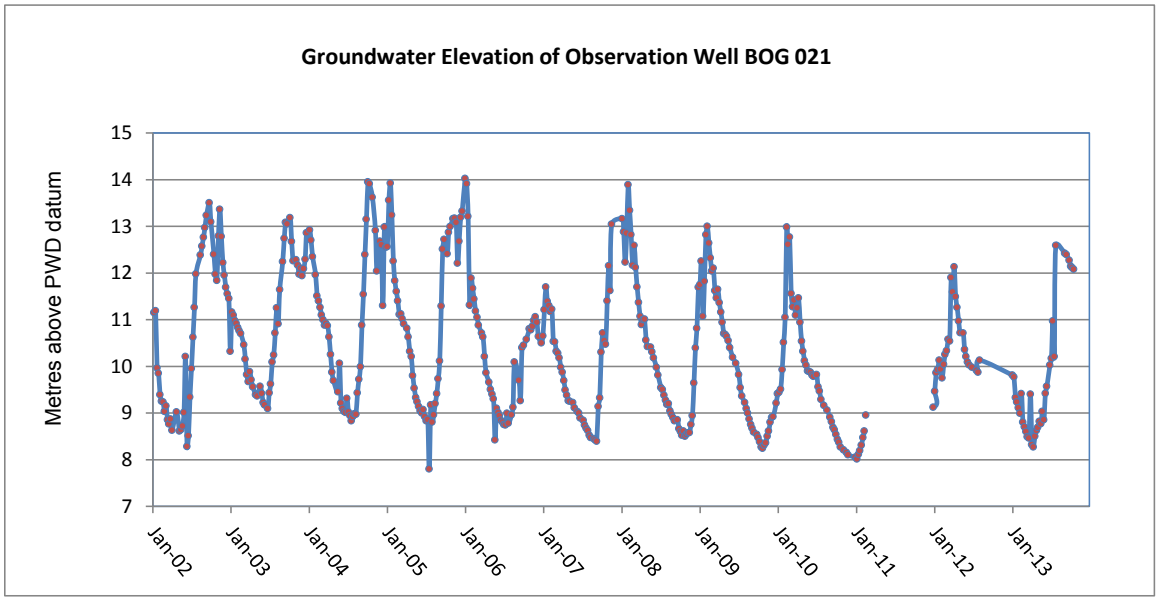

Figure 44. Groundwater level hydrograph of BOG-021

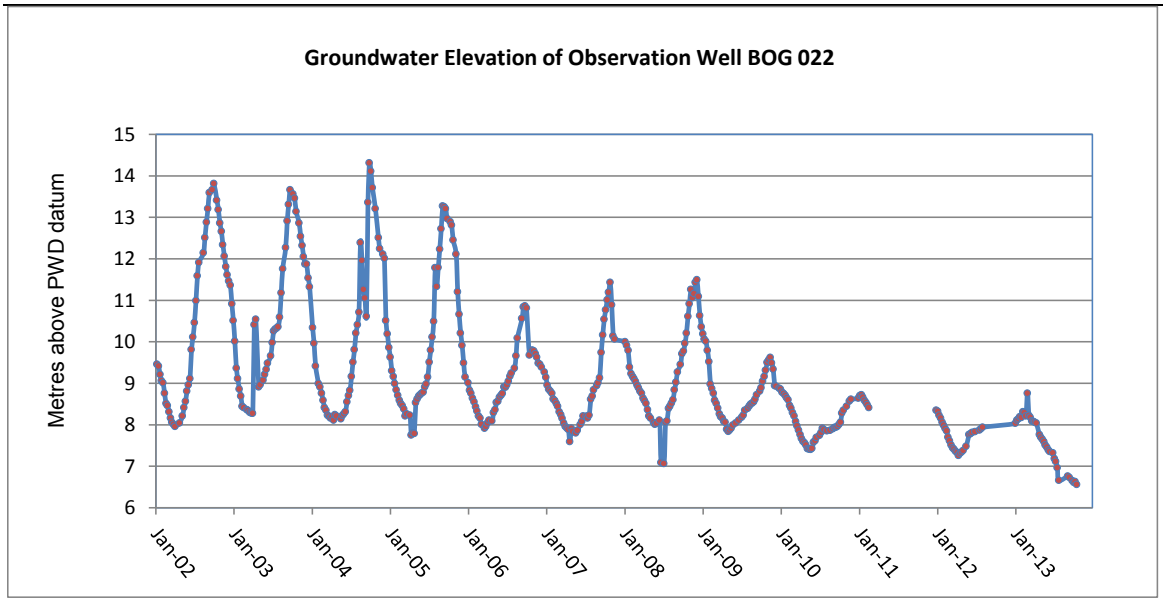

Figure 45. Groundwater level hydrograph of BOG-022

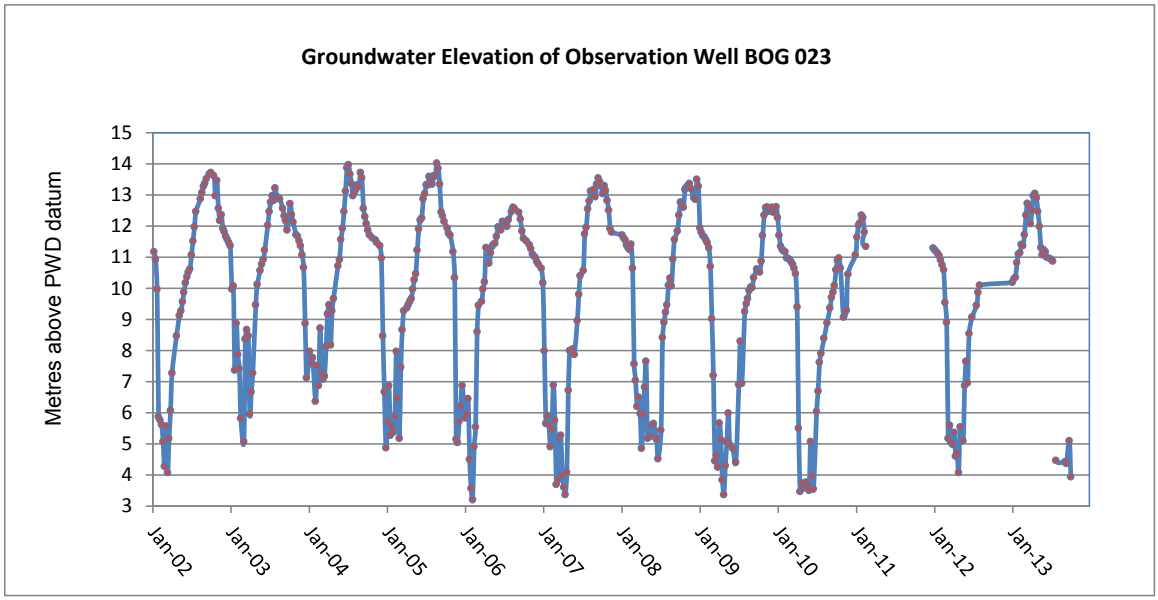

Figure 46. Groundwater level hydrograph of BOG-023

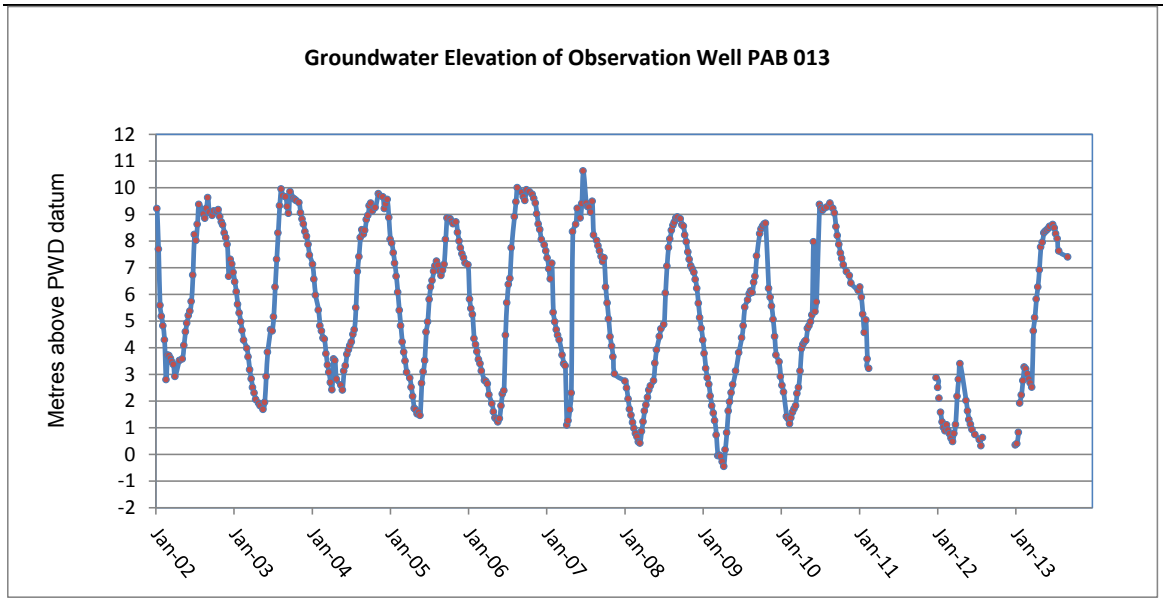

Figure 47. Groundwater level hydrograph of PAB-013

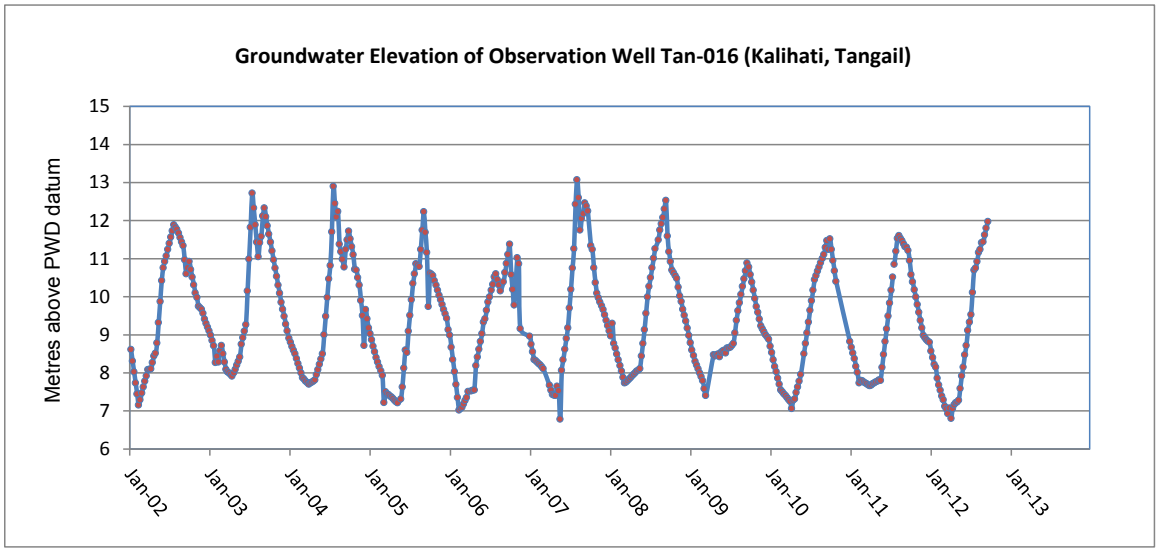

Figure 48. Groundwater level hydrograph of TAN-016

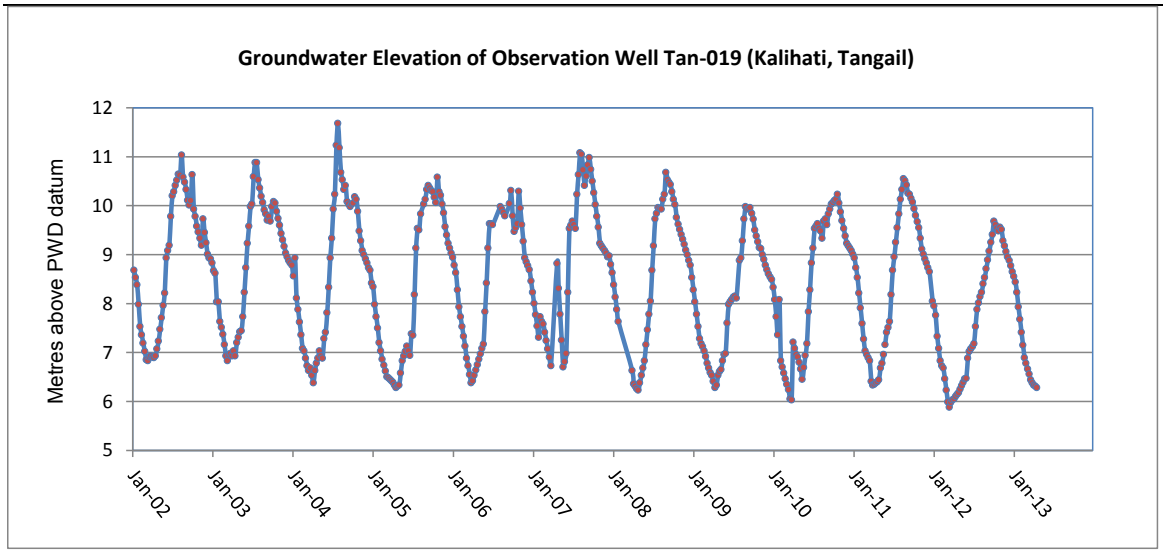

Figure 49. Groundwater level hydrograph of TAN-019

3.3.5 Aquifer Properties

Aquifer properties are important parameter for developing a groundwater model. Pumping test data are required for determining aquifer properties. For the present study pre-existing aquifer properties data were collected from different reports. Aquifer property data of Sirajganj Sadar and surrounding Upazilas were collected from the reports of BWDB (BWDB 1989 & BWDB 1999) and IWM (IWM 2009).

IWM (2009) reanalysed the pumping test data of the study area. It extrapolated the values of aquifer properties of different point for the Upazilas in the modelled area. Table 5 gives the extrapolated values of aquifer properties for different Upazilas of Sirajganj.

Table 5. Extrapolated values of aquifer properties for different Upazilas of Sirajganj (IWM 2009).

District	Upazila	Transmissivity (m^2/day)	Horizontal Permeability (m/day)	Storativity /Specific Yield
Sirajganj	Belkuchi	2600	56	0.04
	Chauhali	2500	45	0.05
	Kamarkanda	2500	52	0.06
	Kazipur	1600	54	0.03
	Raiganj	1100	32	0.08
	Shahajadpur	1175	36	0.10
	Sirajganj Sadar	3000	84	0.05

Table 6. Aquifer properties of different locations in or around the modelled area (Source: BWDB 1989 & BWDB 1994).

Location	Date of testing	Duration in minute	Static Water level below GS (m)	Discharge l/s	Maximum drawdown (m)	Specific Capacity l/s/m	Horizontal Permeability (m/day)	Transmissivity (m^2/day)	Storativity /Specific Yield	Type of data	Method used for analysis
PA-04 Vill. Dariapur U.Z. Shajadpur Sirajganj	15/5/93 To 21/5/93	2880	5.5	47.57	2.15	20.1	55	2400	0.05	Continuous pumping drawdown data	Jacob st. line
PA-20 Vill. Parabai, U.Z. Sirajganj Sirajganj	28/4/93 To 01/05/93	4320	5.16	31.8	1.7	18.7	68.88	1966	-	Continuous pumping drawdown data	Logan's Calulation
PA-21 Vill. Chala U.Z. Belkuchi Sirajganj	18/5/93 To 23/5/93	5760	4.32	26.4	2.25	11.73	84.9	1233	-	Continuous pumping drawdown data	Logan's Calulation
BO-11 BADC B-29 Vill. Chalapara, U.Z. Dhanut Bogra	19/3/85	4320	4.21	42	2.63	13.6	70	2300	0.09	Continuous pumping drawdown data	Jacob st. line
PA-05 BADC B-196 Vill. Sadiangar, U.Z. Shajadpur Sirajganj	14/2/79	3200	4.31	49.8	4.31	35.93	114	3000	0.05	Continuous pumping drawdown data	Jacob st. line
PA-07 BADC P-94 Vill. Chandiakona U.Z. Raiganj Sirajganj Dinajpur	27/2/79	3200	4.1	52.3	5.28	15.4	33	1000	0.02	Continuous pumping drawdown data	Jacob st. line

4. EXISTING AND FUTURE GROUNDWATER ABSTRACTION

4.0 Introduction

The ultimate purpose of the model is to evaluate the extent to which groundwater resource of the study area can support the withdrawal of water at a rate 1240 m^3/h continuously from subsurface aquifer. Groundwater is currently abstracted on a wide scale throughout the study area for agricultural use and also for domestic and industrial purposes. Available data indicate that abstraction for irrigation water overshadows that for other uses and is likely to become even more dominant as the development of irrigated agriculture becomes more widespread. This study has therefore involved an evaluation of both the present and future dry season irrigation and an estimate of resulting water requirements as irrigated agriculture in the study area approaches full development.

This chapter firstly reviews the existing level of groundwater abstraction and secondly, an assessment of likely scale of future demand on groundwater as irrigated agriculture is increased.

4.1 Existing Groundwater Abstractions

Groundwater abstraction in the study area can be classified into following types:

a. Irrigation

(i) Deep Tubewells (DTWs) : generally 100m depth, designed and equipped with turbine pumps to deliver approximately 55 l/s (2 cusec).

(ii) Shallow Tubewells (STWs) : generally 40-50m depth, designed and equipped with surface mounted centrifugal pumps (operate by suction lift) to deliver approximately 15 l/s (0.5 cusec).

b. Rural Water Supply

(i) Hand dug wells: Traditional form of groundwater abstraction but are rapidly being replaced by Hand pump tubewells.

(ii) Hand pumps Tubewells (HTWs)

c. Municipal and industrial

A small number of wells constructed by municipal authorities to provide water in urban or suburban areas.

The rate at which groundwater abstraction occurs in the study area has been derived from the analysis of the number of tubewells known to exist. Bangladesh Agricultural Development Corporation (BADC) has been conducting survey and monitoring of irrigation equipment since 1999. The recent survey report (BADC 2013) showed that 316 DTWs and 27298 STWs area operated in the study area irrigating 67,833 ha of land. Table 11 gives the number of DTWs and STWs in the study area and the area irrigated by that equipment. It has been observed that the source of most of the water used for irrigation is groundwater.

Table 7. Number of DTWs, STWs and LLPs in the study area (BADC 2013).

District	Upazila	DTWs		STWs		Total area (ha) irrigated by DTWs and STWs
		No.	Area Irrigated (ha)	No.	Area Irrigated (ha)	
Sirajganj	Sirajganj Sadar	161	3483	4884	12771	16254
	Kamarkanda	13	178	3696	6832	7010
	Belkuchi	6	95	4421	6850	6945
Tangail	Bhuapur	16	337	2580	5831	6168
	Kalihati	59	1088	5327	16283	17371
	Tangail Sadar	61	1150	6390	12935	14085
Total		**316**	**6331**	**27298**	**61502**	**67833**

In terms of the volume of water pumped, actual groundwater abstraction from the study area is considerably less than the installed capacity might imply because irrigation pumping only occurs during a fraction of the year. Unfortunately, no reliable or consistent information exists regarding either the normal season for irrigation pumping or the average daily pumping period. Previous investigations estimated seasonal pumping periods of between 450 hours/year (IECO, 1980) and 900 hours/year (UNDP 1982).

By assuming that each well is capable of delivering its design yield of 15 and 55 l/s for STW and DTW, respectively, the annual abstraction has been calculated. The scope of the present study has not permitted a detailed determination of actual tubewell pumping calendars to be obtained which is necessary precursor to convert installed capacity into actual abstractions. Therefore, a conservative approach has had to be taken in view of the wide range of unknowns and hence a seasonal pumping period of 1050 hours/year has been used. In this study five months of pumping season and a daily pumping duration of 7 hours has been adopted.

Water withdrawn each day for domestic and municipal purposes has been estimated from the number of people living in the study area. It has been estimated that each person in rural area uses about 40 litres of water per day. By multiplying the number of people with estimated consumption of water per day by person abstraction for domestic and municipal uses has been estimated. The population data were collected from the population census of 2011 (BBS 2011). The present national growth rate of population in Bangladesh is 1.07% per year (BBS 2011) was used to estimate the present population. Table 8 gives present abstraction of groundwater in the study area.

Table 8. Present abstraction of groundwater for irrigation, domestic and municipal purposes

District	Upazila	No of DWTs	Groundwater Abstraction by DTWs (m^3/yr)	No of SWTs	Groundwater Abstraction by STWs (m^3/yr)	Population of 2011	Estimated Population 2014	Groundwater Abstraction Domestic & Municipal Uses (m^3/yr)	Total Groundwater Abstraction (m^3/yr)
Sirajganj	Sirajganj Sadar	161	3.35E+07	4884	2.77E+08	555155	567099	8.28E+06	3.19E+08
	Kamarkanda	13	2.70E+06	3696	2.10E+08	138645	141628	2.07E+06	2.14E+08
	Belkuchi	6	1.25E+06	4421	2.51E+08	352835	360426	5.26E+06	2.57E+08
Tangail	Bhuapur	16	3.33E+06	2580	1.46E+08	189913	193999	2.83E+06	1.52E+08
	Kalihati	59	1.23E+07	5327	3.02E+08	410293	419120	6.12E+06	3.20E+08
	Tangail Sadar	61	1.27E+07	6390	3.62E+08	521104	532315	7.77E+06	3.83E+08

4.2 Future Groundwater Abstractions

It is assumed that the increase of groundwater abstraction for irrigation takes place at a rate of 1% per year until it reaches to a saturation point at which all the cultivable land is irrigated groundwater. The abstraction of water for domestic and municipal purposes also increased with the increase in population. The national growth rate of population has been considered for calculating the annual increase in groundwater abstraction. For each year, the rate of abstraction of groundwater for domestic purposes increased by 1.07% in the model. Table 9 and 10 give the projected future abstraction of groundwater in different Upazilas of Sirajganj and Tangail districts.

Table 9. Projected abstraction of groundwater for irrigation, domestic and municipal purposes (Sirajganj District).

Year	Sirajganj Sadar			Kamarkanda			Belkuchi		
	Groundwater Abstraction for irrigation (m^3/yr)	Groundwater Abstraction Domestic and Municipal Uses (m^3/yr)	Total Groundwater Abstraction (m^3/yr)	Groundwater Abstraction for irrigation (m^3/yr)	Groundwater Abstraction Domestic and Municipal Uses (m^3/yr)	Total Groundwater Abstraction (m^3/yr)	Groundwater Abstraction for irrigation (m^3/yr)	Groundwater Abstraction Domestic and Municipal Uses (m^3/yr)	Total Groundwater Abstraction (m^3/yr)
1st	3.10E+08	8.28E+06	3.19E+08	2.12E+08	2.07E+06	2.14E+08	2.52E+08	5.26E+06	2.57E+08
2nd	3.13E+08	8.37E+06	3.22E+08	2.14E+08	2.09E+06	2.16E+08	2.54E+08	5.32E+06	2.60E+08
3rd	3.17E+08	8.46E+06	3.25E+08	2.17E+08	2.11E+06	2.19E+08	2.57E+08	5.38E+06	2.62E+08
4th	3.20E+08	8.55E+06	3.28E+08	2.19E+08	2.13E+06	2.21E+08	2.60E+08	5.43E+06	2.65E+08
5th	3.23E+08	8.64E+06	3.32E+08	2.21E+08	2.16E+06	2.23E+08	2.62E+08	5.49E+06	2.68E+08
6th	3.26E+08	8.73E+06	3.35E+08	2.23E+08	2.18E+06	2.25E+08	2.65E+08	5.55E+06	2.70E+08
7th	3.29E+08	8.83E+06	3.38E+08	2.25E+08	2.20E+06	2.28E+08	2.67E+08	5.61E+06	2.73E+08
8th	3.33E+08	8.92E+06	3.42E+08	2.28E+08	2.23E+06	2.30E+08	2.70E+08	5.67E+06	2.76E+08
9th	3.36E+08	9.02E+06	3.45E+08	2.30E+08	2.25E+06	2.32E+08	2.73E+08	5.73E+06	2.79E+08
10th	3.39E+08	9.11E+06	3.49E+08	2.32E+08	2.28E+06	2.34E+08	2.76E+08	5.79E+06	2.81E+08
11th	3.43E+08	9.21E+06	3.52E+08	2.34E+08	2.30E+06	2.37E+08	2.78E+08	5.85E+06	2.84E+08
12th	3.46E+08	9.31E+06	3.56E+08	2.37E+08	2.32E+06	2.39E+08	2.81E+08	5.92E+06	2.87E+08
13th	3.50E+08	9.41E+06	3.59E+08	2.39E+08	2.35E+06	2.42E+08	2.84E+08	5.98E+06	2.90E+08
14th	3.53E+08	9.51E+06	3.63E+08	2.42E+08	2.37E+06	2.44E+08	2.87E+08	6.04E+06	2.93E+08
15th	3.57E+08	9.61E+06	3.66E+08	2.44E+08	2.40E+06	2.46E+08	2.90E+08	6.11E+06	2.96E+08
16th	3.60E+08	9.71E+06	3.70E+08	2.46E+08	2.43E+06	2.49E+08	2.92E+08	6.17E+06	2.99E+08
17th	3.64E+08	9.82E+06	3.74E+08	2.49E+08	2.45E+06	2.51E+08	2.95E+08	6.24E+06	3.02E+08
18th	3.73E+08	9.92E+06	3.83E+08	2.55E+08	2.48E+06	2.58E+08	2.98E+08	6.31E+06	3.05E+08
19th	3.82E+08	1.00E+07	3.92E+08	2.61E+08	2.50E+06	2.64E+08	3.01E+08	6.37E+06	3.08E+08
20th	3.92E+08	1.01E+07	4.02E+08	2.68E+08	2.53E+06	2.71E+08	3.04E+08	6.44E+06	3.11E+08

Table 10. Projected abstraction of groundwater for irrigation, domestic and municipal purposes (Tangail District).

Year	Bhuapur			Kalihati			Tangail Sadar		
	Groundwater Abstraction for irrigation (m^3/yr)	Groundwater Abstraction Domestic and Municipal Uses (m^3/yr)	Total Groundwater Abstraction (m^3/yr)	Groundwater Abstraction for irrigation (m^3/yr)	Groundwater Abstraction Domestic and Municipal Uses (m^3/yr)	Total Groundwater Abstraction (m^3/yr)	Groundwater Abstraction for irrigation (m^3/yr)	Groundwater Abstraction Domestic and Municipal Uses (m^3/yr)	Total Groundwater Abstraction (m^3/yr)
1st	1.50E+08	2.83E+06	1.52E+08	3.14E+08	6.12E+06	3.20E+08	3.75E+08	7.77E+06	3.83E+08
2nd	1.51E+08	2.86E+06	1.54E+08	3.17E+08	6.18E+06	3.24E+08	3.79E+08	7.85E+06	3.87E+08
3rd	1.53E+08	2.89E+06	1.56E+08	3.21E+08	6.25E+06	3.27E+08	3.83E+08	7.94E+06	3.90E+08
4th	1.54E+08	2.92E+06	1.57E+08	3.24E+08	6.32E+06	3.30E+08	3.86E+08	8.02E+06	3.94E+08
5th	1.56E+08	2.96E+06	1.59E+08	3.27E+08	6.39E+06	3.33E+08	3.90E+08	8.11E+06	3.98E+08
6th	1.57E+08	2.99E+06	1.60E+08	3.30E+08	6.45E+06	3.37E+08	3.94E+08	8.20E+06	4.02E+08
7th	1.59E+08	3.02E+06	1.62E+08	3.34E+08	6.52E+06	3.40E+08	3.98E+08	8.28E+06	4.06E+08
8th	1.60E+08	3.05E+06	1.63E+08	3.37E+08	6.59E+06	3.44E+08	4.02E+08	8.37E+06	4.10E+08
9th	1.62E+08	3.08E+06	1.65E+08	3.40E+08	6.66E+06	3.47E+08	4.06E+08	8.46E+06	4.15E+08
10th	1.64E+08	3.12E+06	1.67E+08	3.44E+08	6.73E+06	3.50E+08	4.10E+08	8.55E+06	4.19E+08
11th	1.65E+08	3.15E+06	1.68E+08	3.47E+08	6.81E+06	3.54E+08	4.14E+08	8.64E+06	4.23E+08
12th	1.67E+08	3.18E+06	1.70E+08	3.51E+08	6.88E+06	3.58E+08	4.18E+08	8.74E+06	4.27E+08
13th	1.69E+08	3.22E+06	1.72E+08	3.54E+08	6.95E+06	3.61E+08	4.23E+08	8.83E+06	4.31E+08
14th	1.70E+08	3.25E+06	1.74E+08	3.58E+08	7.03E+06	3.65E+08	4.27E+08	8.93E+06	4.36E+08
15th	1.72E+08	3.29E+06	1.75E+08	3.61E+08	7.10E+06	3.68E+08	4.31E+08	9.02E+06	4.40E+08
16th	1.74E+08	3.32E+06	1.77E+08	3.65E+08	7.18E+06	3.72E+08	4.35E+08	9.12E+06	4.44E+08
17th	1.75E+08	3.36E+06	1.79E+08	3.69E+08	7.26E+06	3.76E+08	4.40E+08	9.21E+06	4.49E+08
18th	1.80E+08	3.39E+06	1.83E+08	3.78E+08	7.33E+06	3.85E+08	4.44E+08	9.31E+06	4.53E+08
19th	1.84E+08	3.43E+06	1.88E+08	3.87E+08	7.41E+06	3.95E+08	4.49E+08	9.41E+06	4.58E+08
20th	1.89E+08	3.47E+06	1.92E+08	3.97E+08	7.49E+06	4.04E+08	4.53E+08	9.51E+06	4.63E+08

5.0 GROUNDWATER FLOW MODEL

5.1 Introduction

Groundwater models are representation of a real system or processes that approximately simulates the relevant excitation-response relation of the real world system and offer a quantitative evaluation of groundwater resources through a correct mathematical and physical framework (Bear and Bachmat 1991). They describe the groundwater flow and transport processes using mathematical equations based on certain simplifying assumptions. These assumptions typically involve the direction of flow, geometry of the aquifer, the heterogeneity or anisotropy of sediments or bedrock within the aquifer, the contaminant transport mechanisms and chemical reactions.

The basis for modelling three dimensional groundwater flow forms the integrated modelling package MODFLOW (Harbaugh and McDonald 1996). MODFLOW was originally developed by the U.S. Geological Survey (McDonald and Harbaugh, 1988). The MODFLOW model uses the block-centred finite-difference approximation to simulate transient, or time-varying, flow in three dimensions in a heterogeneous and anisotropic porous medium. Steady-state conditions can also be simulated. The principal axes of hydraulic conductivity must be aligned with the coordinate directions, and water of constant density is assumed. Wells, rivers, drains, evapotranspiration, and recharge can be simulated and are represented as head dependent source or sink terms in which the head outside the model is user specified. Layered aquifers can be represented in the so-called quasi-three-dimensional approximation. Nodes in this approximation can change from being confined to unconfined, and vice versa, as the computation progresses.

MODFLOW is a generalized tool with comprehensive applicability range usable to accommodate the hydrological conditions and related problems of the study area. Aquifer hydraulic parameters, boundary conditions, initial conditions, and stresses are required model input. The input is from text files with the data laid out in a prescribed order and format. The input data must correspond to the specified grid structure. The primary model output is the head at each model node.

5.2 Mathematical and Conceptual Basis of the Model

Groundwater modeling begins with a conceptual understanding of the physical problem. The next step in modeling is translating the physical system into mathematical terms. In general, the results are the familiar groundwater flow equation and transport equations. The governing flow equation for three-dimensional saturated flow in saturated porous media is:

$$\frac{\partial}{\partial x}\left(K_{xx}\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(K_{yy}\frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial z}\left(K_{zz}\frac{\partial h}{\partial z}\right)-Q=S_s\frac{\partial h}{\partial t}$$

where,

Kxx, Kyy, Kzz = hydraulic conductivity along the x,y,z axes which are assumed to be parallel to the major axes of hydraulic conductivity;

h = piezometric head;

Q = volumetric flux per unit volume representing source/sink terms;

Ss = specific storage coefficient defined as the volume of water released from storage per unit change in head per unit volume of porous material.

Conceptual Model

The conceptual model was developed using data from regional geologic reports and site-specific data. Figure 50 is a schematic three dimensional section illustrating the flow model conceptualization. The model comprises three layers. The Upper Clay and Silt layer comprises clay and silt and its thickness varies from 0 and 41m in the study area. Recharge from rainfall and surface water bodies infiltrates through this layer. Evapotranspiration from the area by which water is lost from the aquifer system also occurs from this layer. This Upper Clay and Silt layer is fully cut by the Jamuna River. Below this layer is the Composite aquifer. The thickness of this aquifer varies from 0 to 58m in the modeled area. The bottom of the Jamuna River also cuts this layer and therefore, the river is well connected with this aquifer. The third layer is the Main aquifer the bottom of which has not been encountered by any bore hole in the study area. The Main aquifer is extended throughout the whole study area.

Figure 50 shows that the aquifers receive water from the river during wet season when the river stage is higher than the groundwater level of the surrounding aquifer. This influent condition of the river contributes highly in recharging the aquifer when huge monsoonal rain water flows through the river. But in dry season river stage falls down to a level which is lower than the surrounding aquifer. This effluent condition of the river results in the loss of groundwater from the aquifer to the river.

5.3 Selection of the Model Area

In construction of the model, the first stage was to define the modelled area and boundary conditions in accordance with natural physical features or limits. The flow pattern in the study area has been examined while setting the boundaries of the modelled area. Physical boundaries and the regional groundwater divide are often used as the boundary of the modelled area. However, in this study it was not convenient to use the physical boundaries of the system as the project site is far away from them.

In transient simulation boundaries may be arbitrarily set far from the area of interest (centre of the grid) as long as the stresses to the system will not reach the boundaries during the simulation. This type of boundary is known as distant boundary (Anderson and Woessner, 1992). In the present study distant boundaries were selected in the north, south, east and west of the modelled area.

Impermeable rock typically forms the lower boundary of the modelled area. But in the study area the bottom of the aquifer has not been encountered in any bore hole. Taking conservative view the bottom of the modelled area was set at -150m in spite of the fact that the bottom is deeper and could be extended more than -300m as observed in one hole in Tangail Sadar.

5.4 Model Geometry and Boundary Conditions

Groundwater model development includes creation of a conceptual model including definition of model grid, model layers and their respective hydrogeologic parameters, model boundaries and boundary conditions, and model sources and sinks. The conceptual model is then converted to a finite difference, transient, multi-layer model using the USGS MODFLOW 2000 software.

Model Grid

The model covered an entire area defined by BTM coordinates of 455436 to 495436 East and 684649 to 714649 North. The area of about 40×30 km^2 was divided into coarse grid of 60 rows and 80 columns. The model grid consists of 4800 active cells, spaced at 500m along rows and 500m along the columns, covering an area of about 4800 km^2 (Figure 51). All kinds of data related to hydrogeological parameters and aquifer geometry were used to build the model grid network. The model parameters were needed to be defined for each of the 4800 active square cells. In addition, the time variant parameters such as recharge, abstraction and boundary conditions were needed to be specified for monthly time steps.

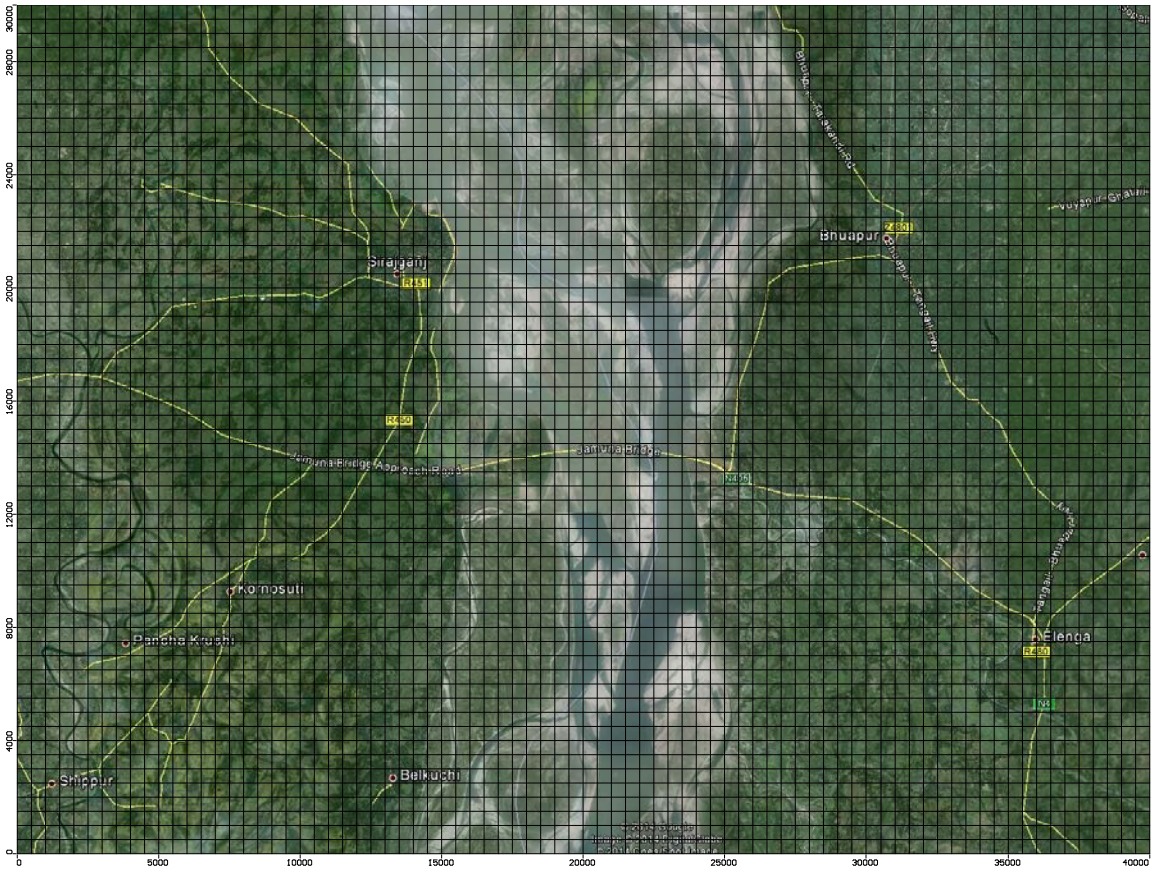

Figure 51. Model grid.

Three layers are included in the model. Layer 1 comprises low permeability clays and silts. Layer 2 comprises more permeable very fine sand to fine sand. Layer 3 comprises medium to coarse sand and gravel. Different hydrogeological parameters were assigned

for each of the modelled layer (Table 10). Parameters that have been incorporated to the model are: mean horizontal and vertical permeability of each layer, storage-coefficients, specific yield and porosity of each layer. Domenico (1972) gives the ranges of values for Ss for different lithologies. Heath (1983) gives the values of hydraulic conductivities for different lithologies. Morris and Johnson (1967) and also Fetter (2001) give the values of specific yield for different lithologies. Johnson and Morris (1962) give the values of porosity for different lithologies. Domenico & Schwartz (1990) gives the values of effective porosity for different lithologies. Figure 52 gives the three dimensional view of the modelled area.

Table 11. Hydrogeological parameter settings for the model.

Layer	Lithology	Thickness (m)	Kx m/d	Ky m/d	Kz m/d	Ss (1/m)	Sy (%)	Effective porosity (%)	Total porosity (%)
1	Clay and silt	0-41	3	3	0.3	0.0001	0.05	0.06	0.5
2	Very fine to fine sand	0-58	20	20	2	0.0001	0.18	0.18	0.2
3	Medium to coarse sand and gravel	75+	50	50	5	0.007	0.25	0.27	0.3

Explanation: Kx = Hydraulic conductivity in the x direction, Ky = Hydraulic conductivity in the y direction, Kz = Hydraulic conductivity in the z direction, Sy = Specific yield, Ss = Specific storage.

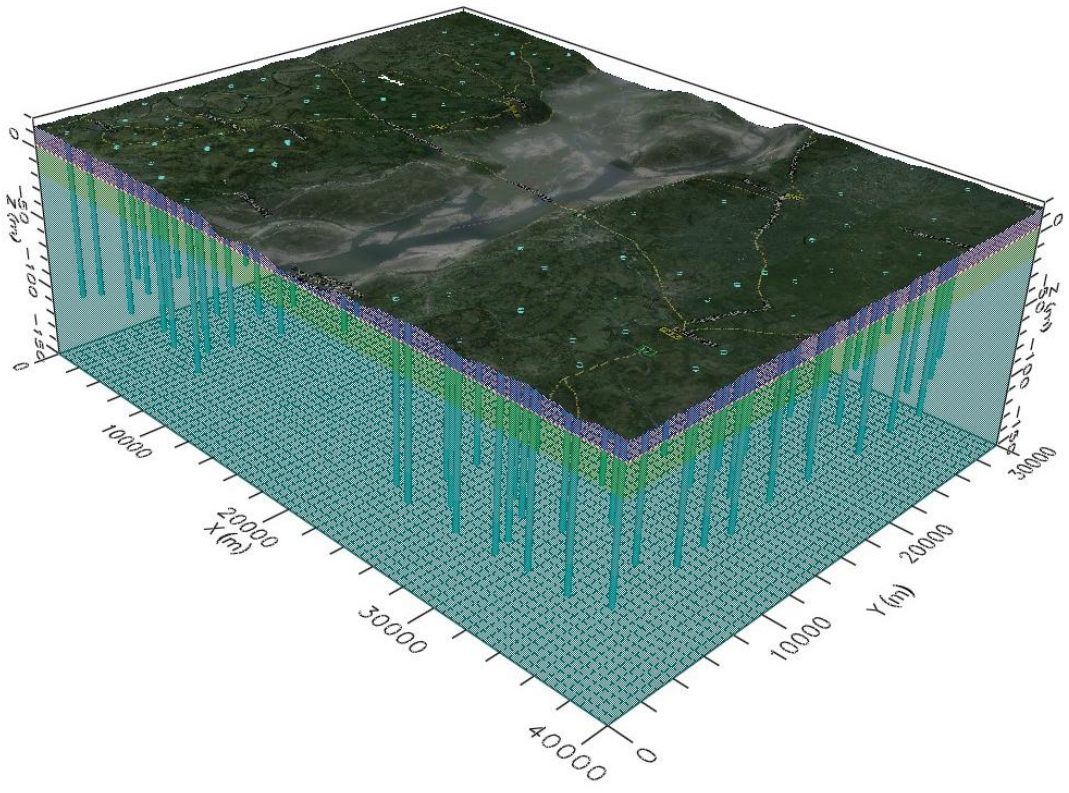

Figure 52. 3D view of the study area.

Boundary Conditions

Every model requires an appropriate set of boundary conditions to represent the system's relationship with the surrounding systems. In the case of a groundwater flow model, boundary conditions will describe the exchange of flow between the model and the external system. Boundary conditions may be of head controlled, gradient controlled or flow (water flux) controlled.

The river boundary condition is used to simulate the influence of a surface water body on the groundwater flow. Rivers may either contribute water to the groundwater system, or act as groundwater discharge zones depending on the hydraulic gradient between the surface water body and the groundwater system. The Jamuna River has a distinct influence on the water balance of the study area. The river boundary was set up along its tract in the north and middle part of the study area. Monthly average river stage at Sirajganj (SW 49) was considered to develop the transient flow model with a time step of one month. Width, length and depth of the channels were implicated to the model. River stage data was also incorporated to the model.

Recharge estimates have been derived directly from the UNICEF (1993) Upazila base estimation. Evapotranspiration estimates made by Karim and Akond (1982) for the study area were incorporated in the model. These data were imported to the model as MODFLOW package file for the top layer only.

For flow modelling dynamic equilibrium conditions were adopted using monthly time steps. Thus average quantity of recharge, evapotranspiration and abstraction were incorporated in the model for each time steps. These parameters vary seasonally for changes in weather conditions. Groundwater abstraction has been specified for individual modelled layers and grid cells. In the study area, the rate of abstraction from tubewells for urban and irrigation use are specified for individual cells.

Municipal and domestic wells pumps water throughout the whole year whereas irrigation wells pump water only in dry season.

5.5 Calibration and Sensitivity Analysis

It is unlikely to find all well-defined parameters associated with the simulated water balance components. Uncertainties with the simulated results may arise through a lack of data, imprecision of data and the extrapolation of data defined on the field scale to the regional scale of the model. So, it becomes necessary for the model to undergo a process of calibration, which involves the continuous comparison of the model response with the equivalent known response of the real aquifer system. The close understanding of the modeller with the real aquifer is significant for better approximation of the real system to the model system. By cross matching the hydrographs of the observation wells the model is calibrated to represent the present ground water conditions. Figure 53 and 54 give the matching of modelled water table with the observed water table in the study area.

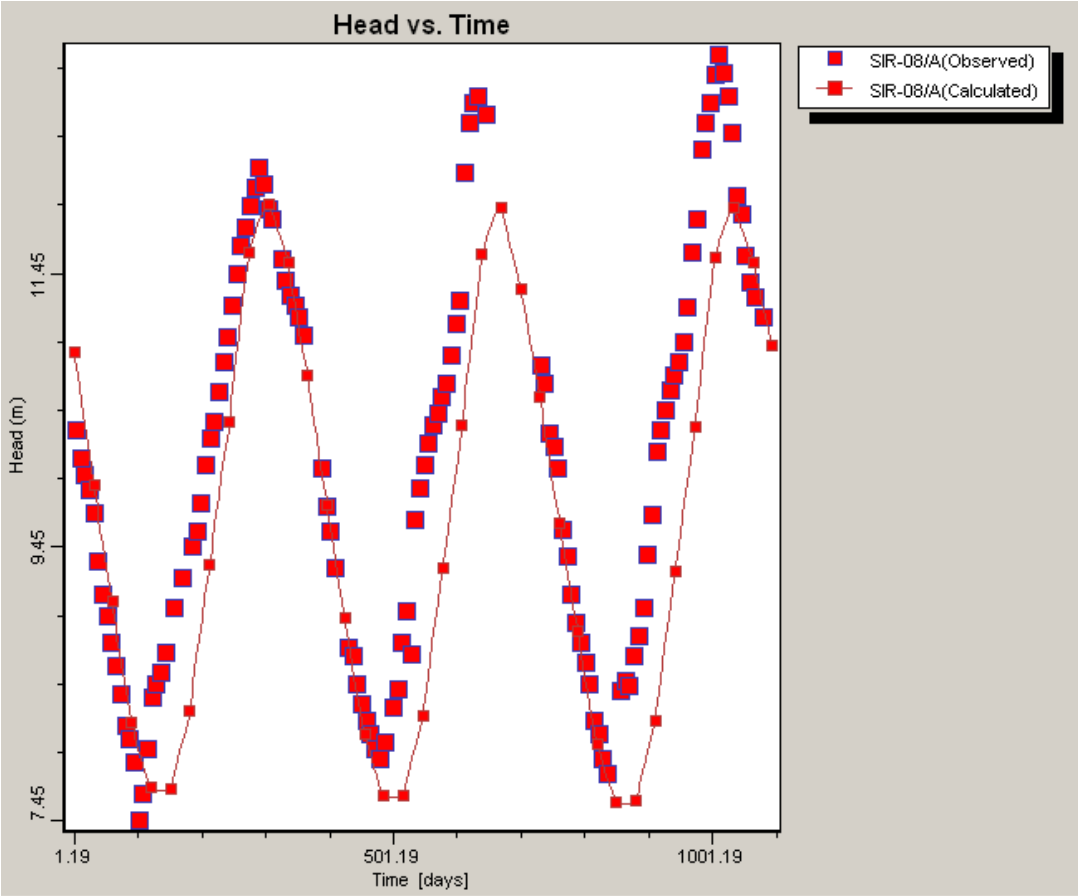

Figure 53. Matching of observed and calculated hydrographs of SIR-08.

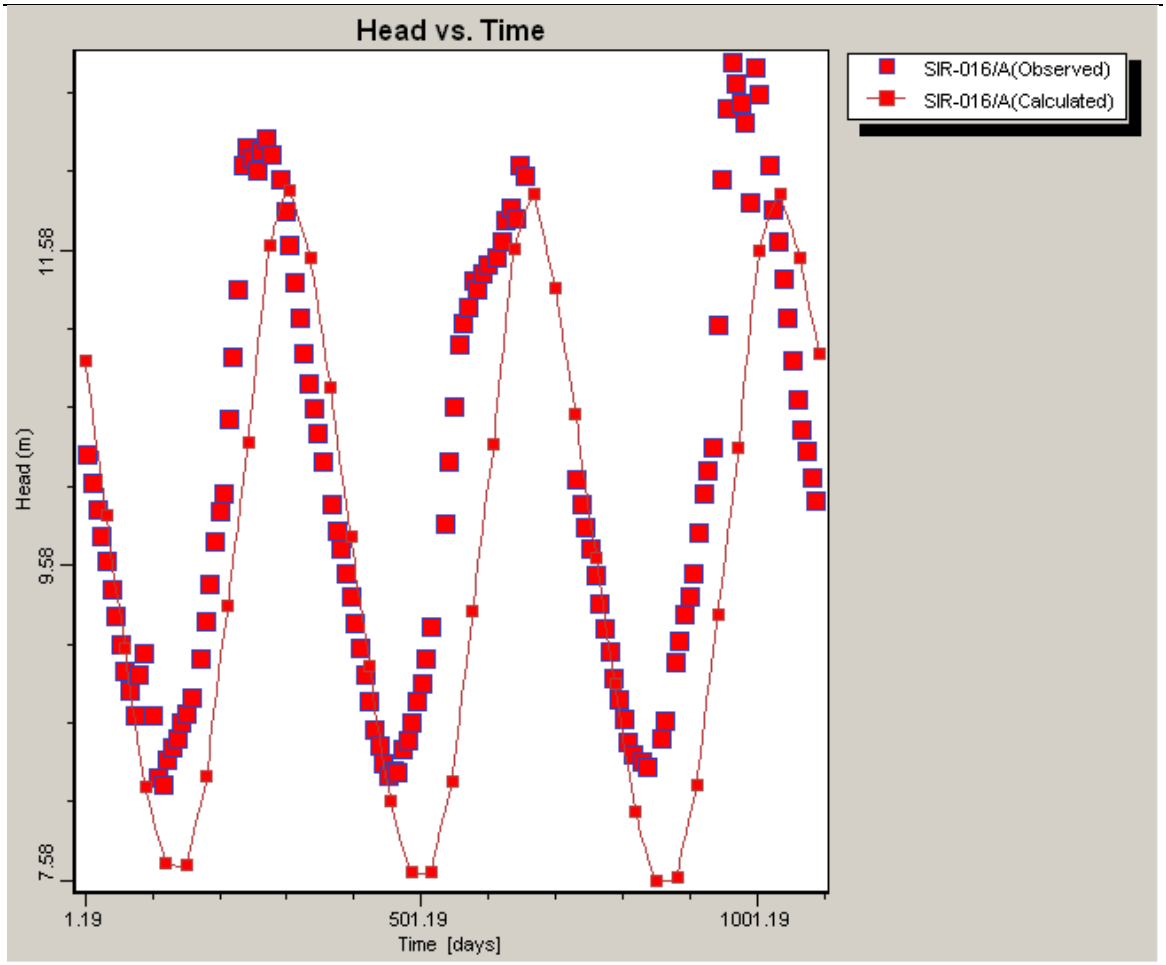

Figure 54. Matching of observed and calculated hydrographs of SIR-016

For calibrating the model adjustment of model input data such as storage parameter and recharge was made.

A sensitivity analysis is the process of varying model input parameters over a reasonable range and observing the relative change in model response. Typically, the observed change in hydraulic head is noted. Model sensitivity analysis was conducted by changing storage parameters and hydraulic conductivity. It has been observed that model is very much sensitive to storage parameter. Hydraulic conductivity also very slightly influences the model response.

5.6 Model Simulated Groundwater Table

After calibration and sensitivity analysis the model simulated the present groundwater table of the study area. Figure 55 gives the model simulated present groundwater table for the month of May.

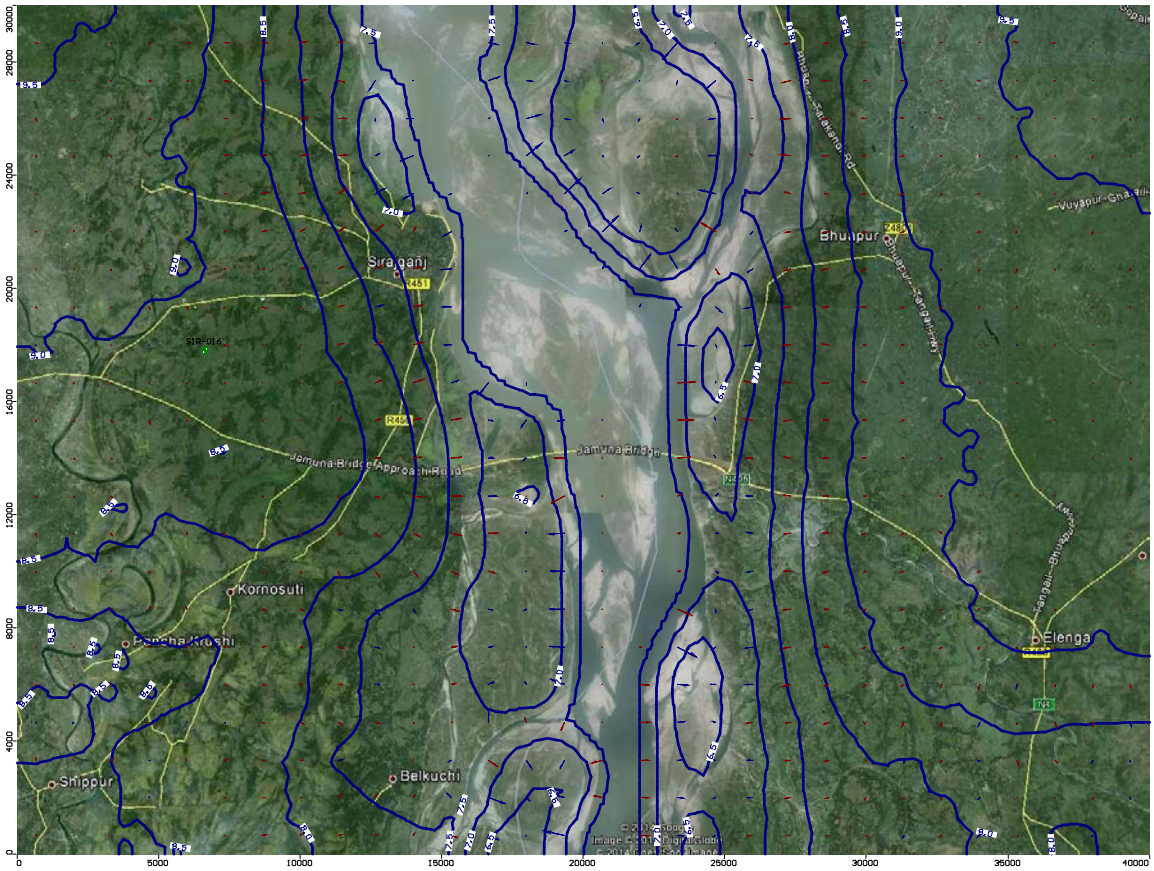

Figure 55. Model simulated water table contour map of dry season.

With the present abstraction of about 600 m^3/hour in the project site, minor change in water table has been observed in the project area in both dry and wet seasons.

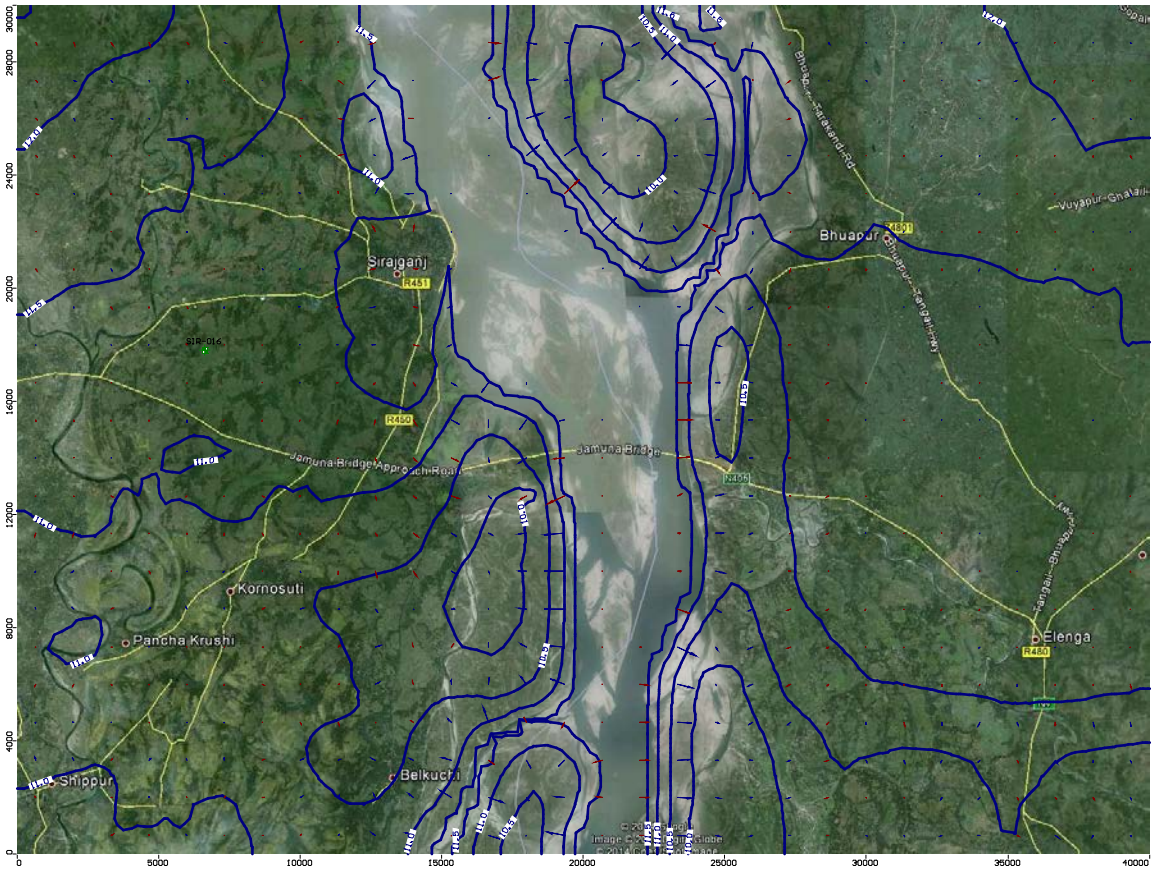

Figure 56. Model simulated water table contour map of wet season

6.0 MODEL PREDICTION

6.1 Introduction

The main objective of this study is to predict the consequence of pumping water from the project site at the rate of 1240 m^3/hour (or 29760 m^3/day). After calibration the model was run to predict the results of groundwater abstraction by the pumping wells located at the proposed site of the power plant on the bank of the River Jamuna. The model was run for 20 years. Abstraction of water was increased by introducing new wells after each run to maintain predicted future water demand.Ten pumping wells with discharge of 29760 m^3/day were introduced in and around the power plant and the previously calibrated model was run to find out the results of pumping.

6.2 Arrangement of Wells

Well layout is very important while planning well field for groundwater abstraction. The size and shape of the catchment of a well field depends on the well layout. First objective is to minimise the effects on existing wells. The second objective in planning the well layout is to maximise the use of river water by inducing lower head at the bottom of the river. Interference of wells depends on the distance between production wells. The higher the space among the pumping wells, the lower the well interference. In closely spaced wells drawdown in wells will be higher which may cause higher pumping cost, higher cost for well construction and higher possibility of well failure around the project site. Ten wells with a discharge of 29760 m^3/day were introduced at the project site in the modelled area. The wells were arranged in two ways (Figure 57):

First Scenario: wells are set in a line over a distance of 1km.

Second scenario: wells are kept in cluster over a distance of about 400m.

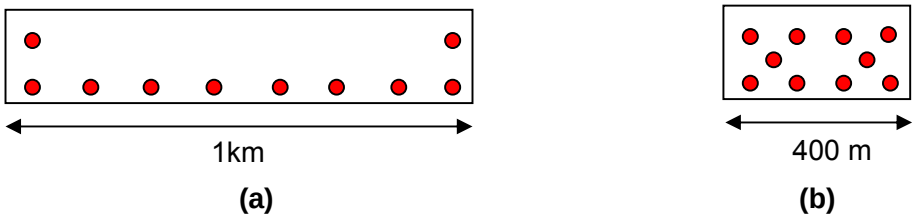

Figure 57.Arrangement of wells (a) in line and (b) in cluster.

6.3 Model Prediction

First scenario

For wells arranged in line the model is run for 20 years. Figure 58 shows the modelled groundwater level of dry season (May) after 20 years of pumping. The modelled minimum elevation of groundwater table occurs in the month of May. The River Jamuna is influent even in the dry season. Due to lowering of the head, water from the river bed passes into the aquifer in areas adjacent to the pumping wells. In about 3 km^2 area surrounding the pumping wells of the proposed power plant water level may decline by 0.5 to 1 m from the existing water level forming a cone of depression. Figure 59 gives the zoomed in view of the project site for dry season.

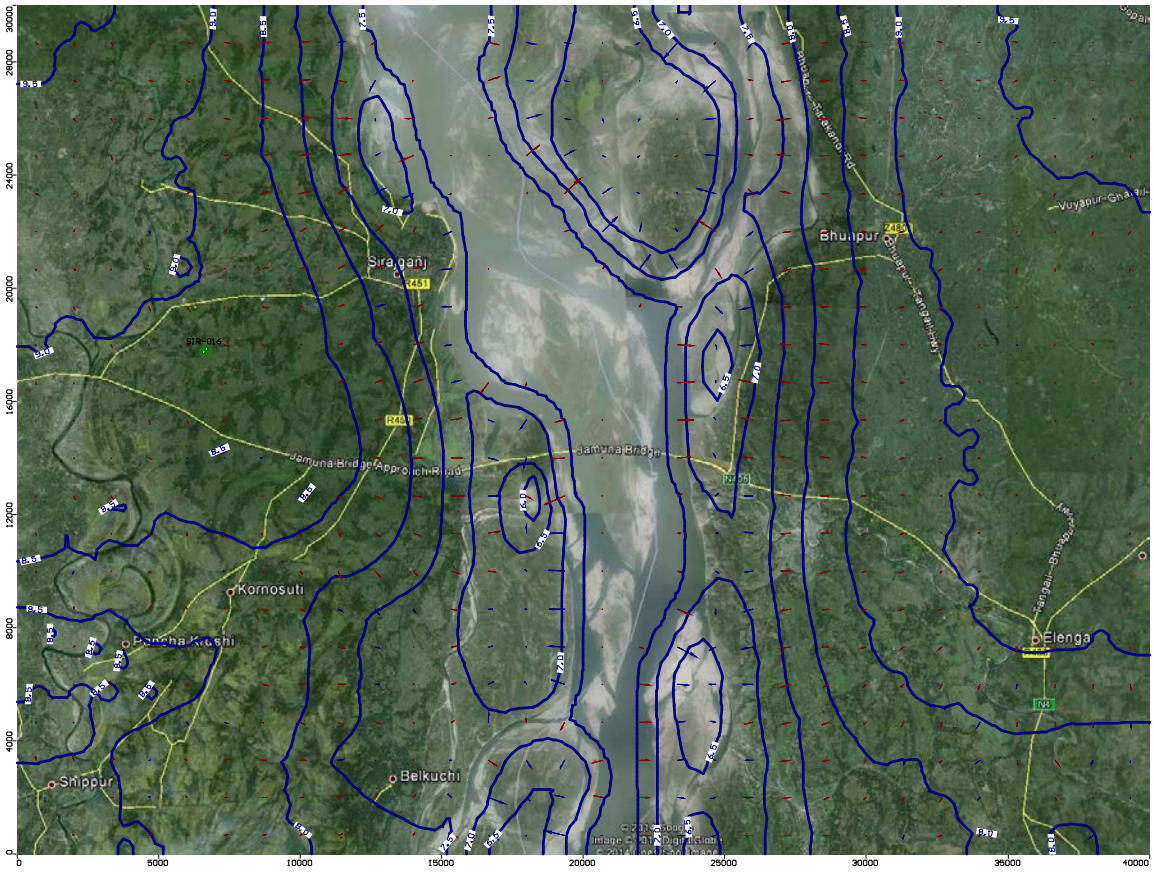

Figure 58. Modelled dry season (May) water table contour map after 20 years of pumping (wells arranged in line).

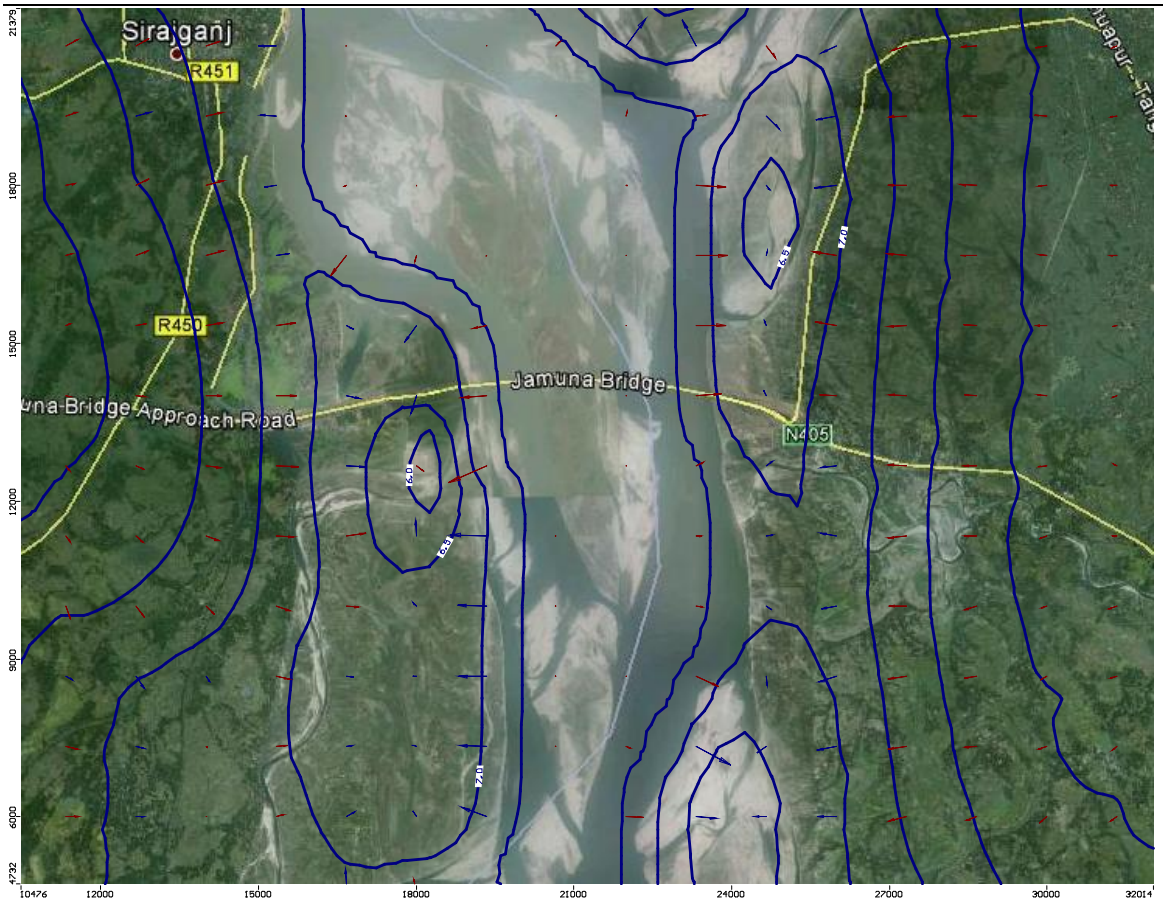

Figure 59. Zoomed in modelled dry season (May) water table contour map after 20 years of pumping (wells arranged in line).

It has been observed that the water mostly comes from the river in both dry and wet seasons. Over the past 50 years the Jamuna river flow at Bahadurabad (SW-46) in the wet period varied between 30000 and 50000 m^3/s and in the dry period 3000 and 12000 m^3/s (Rajib et. al. 2011). The average discharge of the river is about 20,000 m^3/s (Bristow, 2009; Gupta, 2008; Schumm and Winkley, 1994). It could be assumed that the minimum and maximum discharge of Jamuna River varies between 3000 m^3/s and 50000 m^3/s respectively, near Bangabandhu Jamuna Bridge. To satisfy the need of water of the power plant for a day, a fraction of a second to maximum 10 second's discharge is quite sufficient.

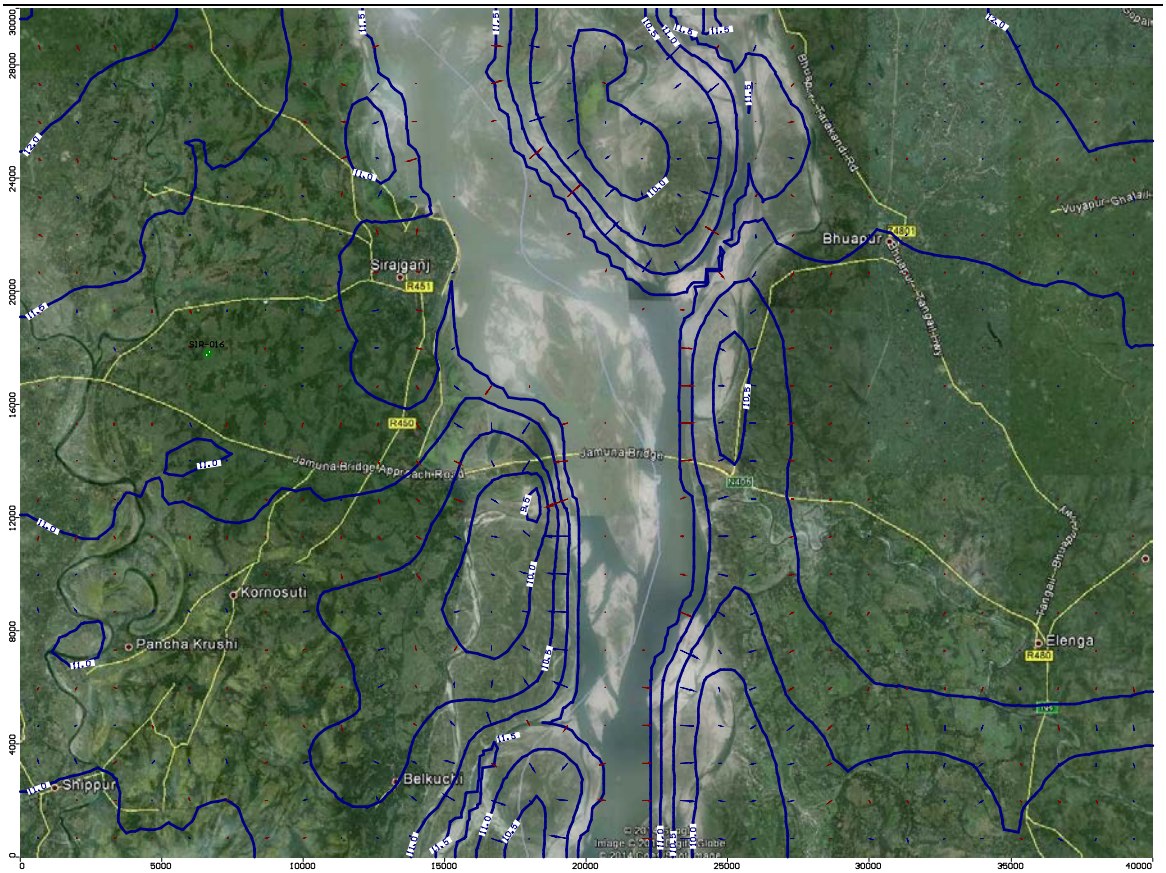

Figure 60. Modelled wet season (September) water table contour map after 20 years of pumping (wells arranged in line).

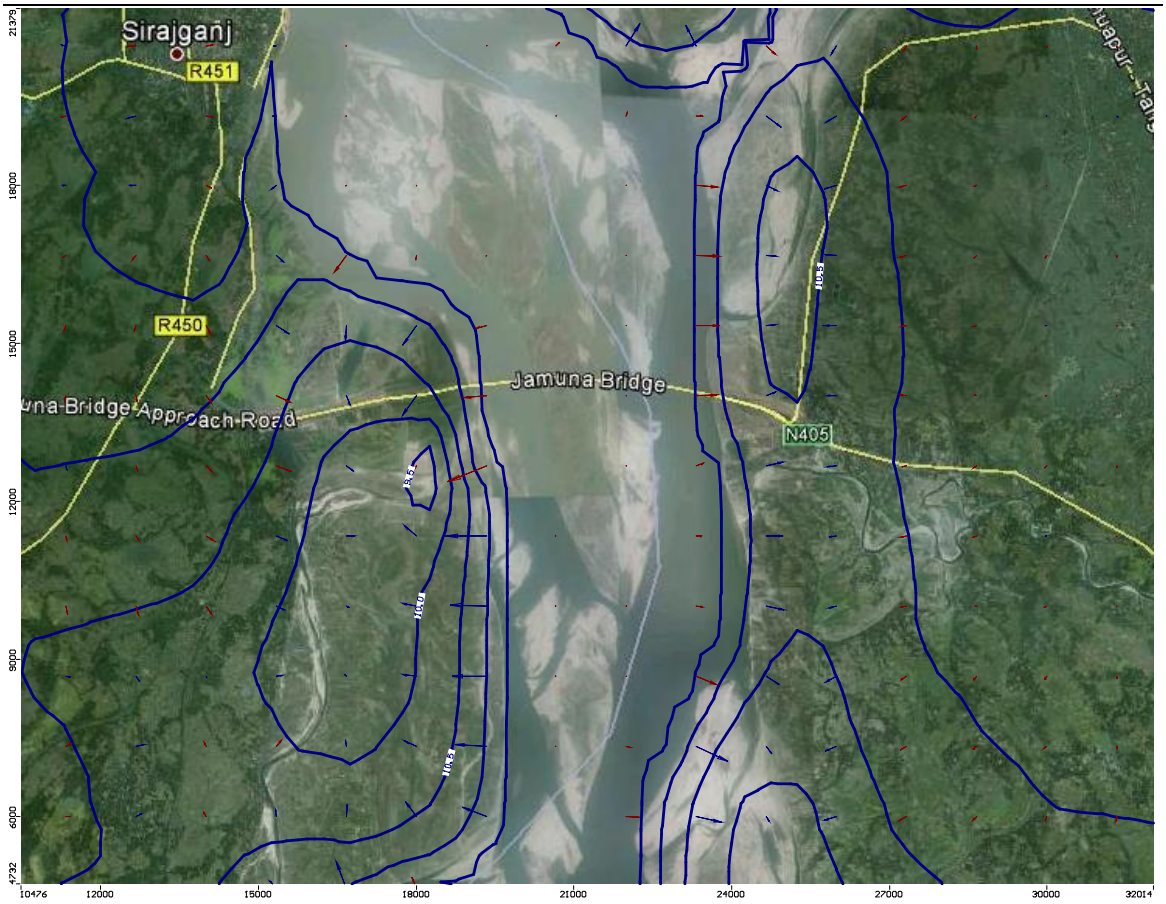

Figure 60. Zoomed in modelled wet season (September) water table contour map after 20 years of pumping (wells arranged in line).

Second scenario

For wells arranged in cluster the model is again run for 20 years. Figure 61 shows the modelled groundwater level of dry season (May) after 20 years of pumping. The modelled minimum elevation of groundwater table occurs in the month of May.

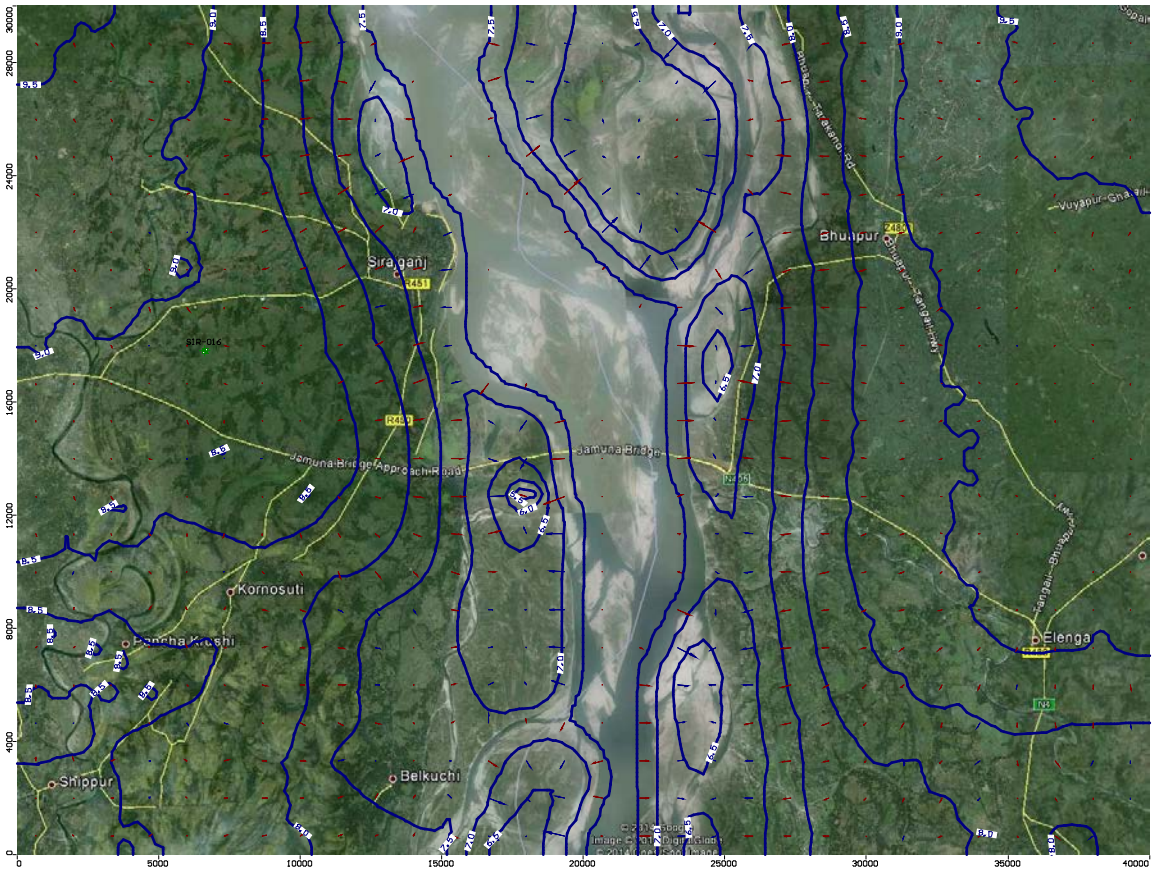

Figure 61. Modelled dry season (May) water table contour map after 20 years of pumping (wells arranged in cluster)

As the wells are arranged in cluster drawdown is at least 0.5m higher in the vicinity of the pumping wells in comparison to first scenario. Figure 62 gives the zoomed view of the water table contour map of the project site. The cone of depression is asymmetric and it is extended to the eastern side of the project site. In about 3 km^2 area surrounding the pumping well of the proposed power plant water level may decline by 0.5 to 1.5 m from the existing water level.

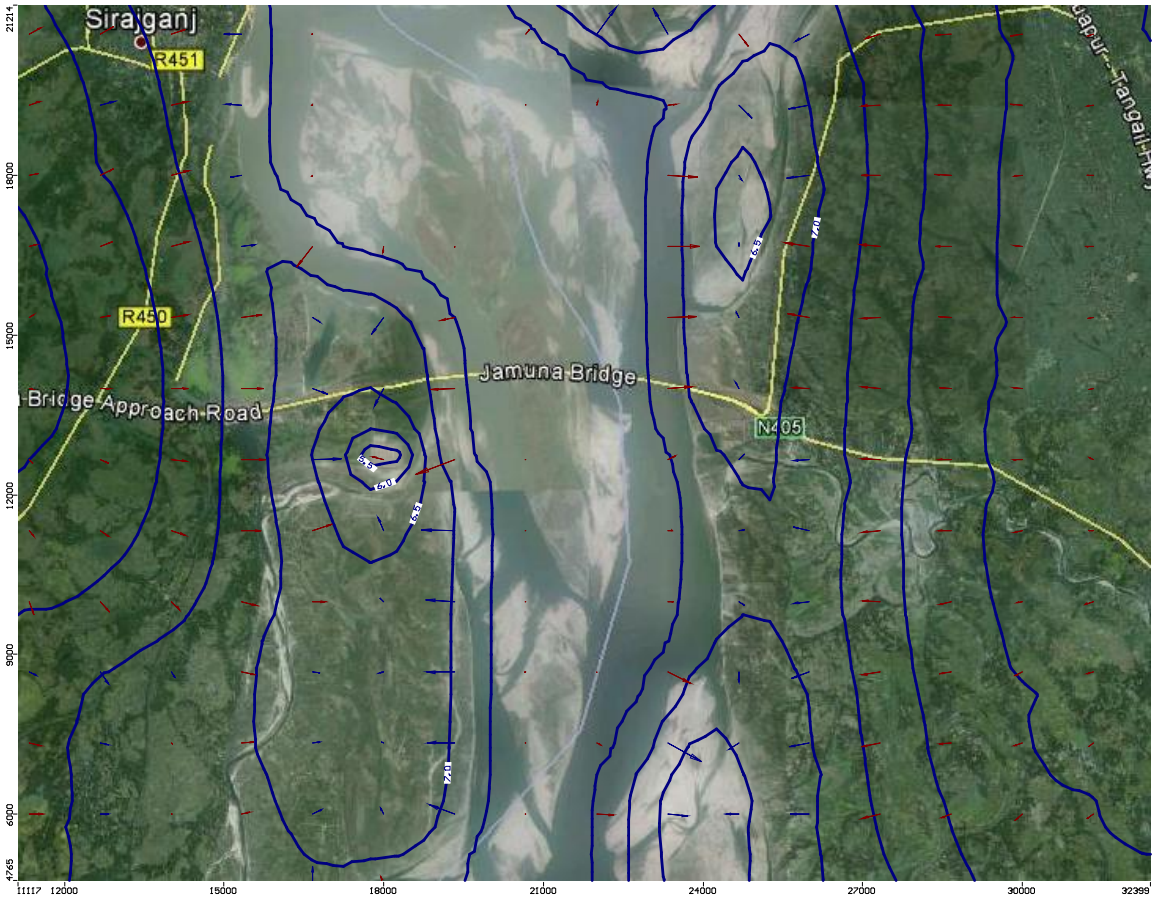

Figure 62. Zoomed in modelled dry season (May) water table contour map after 20 years of pumping (wells arranged in cluster)

The modelled maximum elevation of groundwater table occurs in the month of September (Figure 63). Figure 64 gives the zoomed view of the project site for wet season.

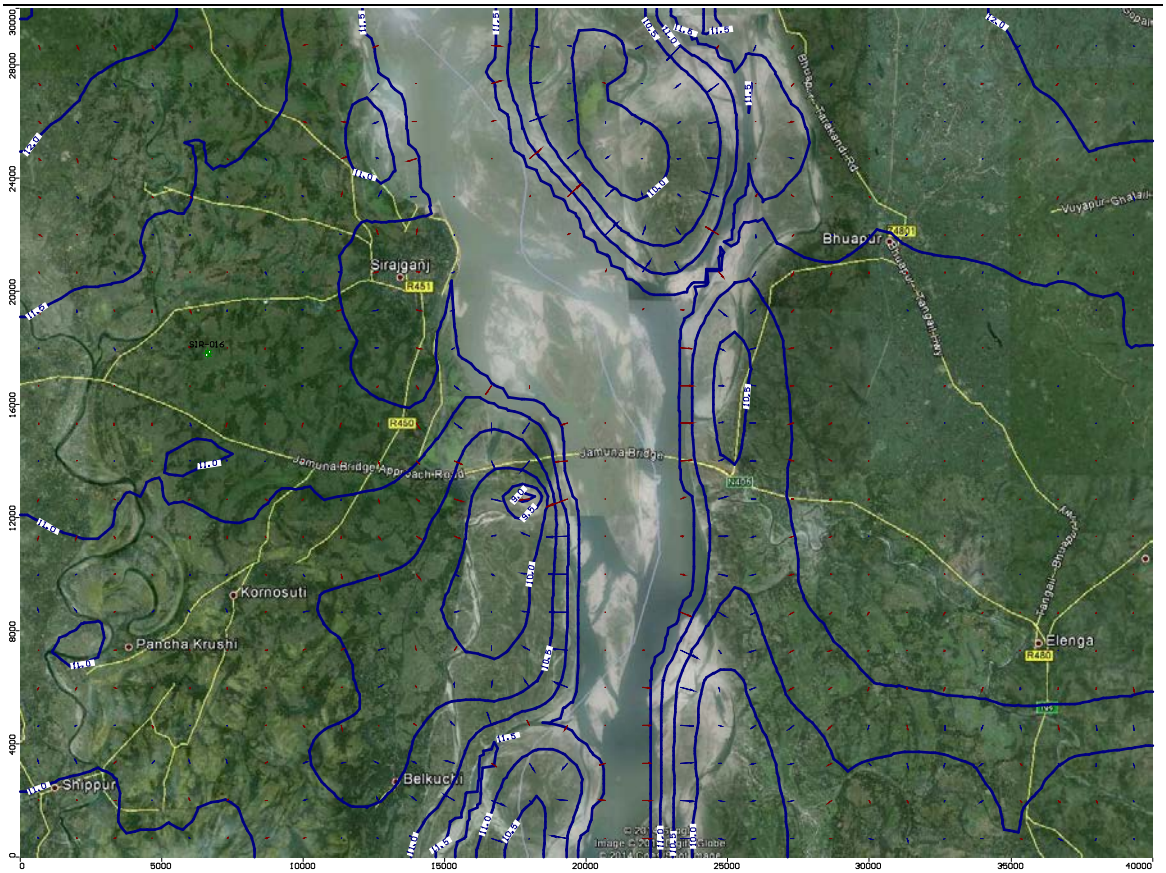

Figure 63. Modelled wet season (September) water table contour map after 20 years of pumping (wells arranged in cluster)

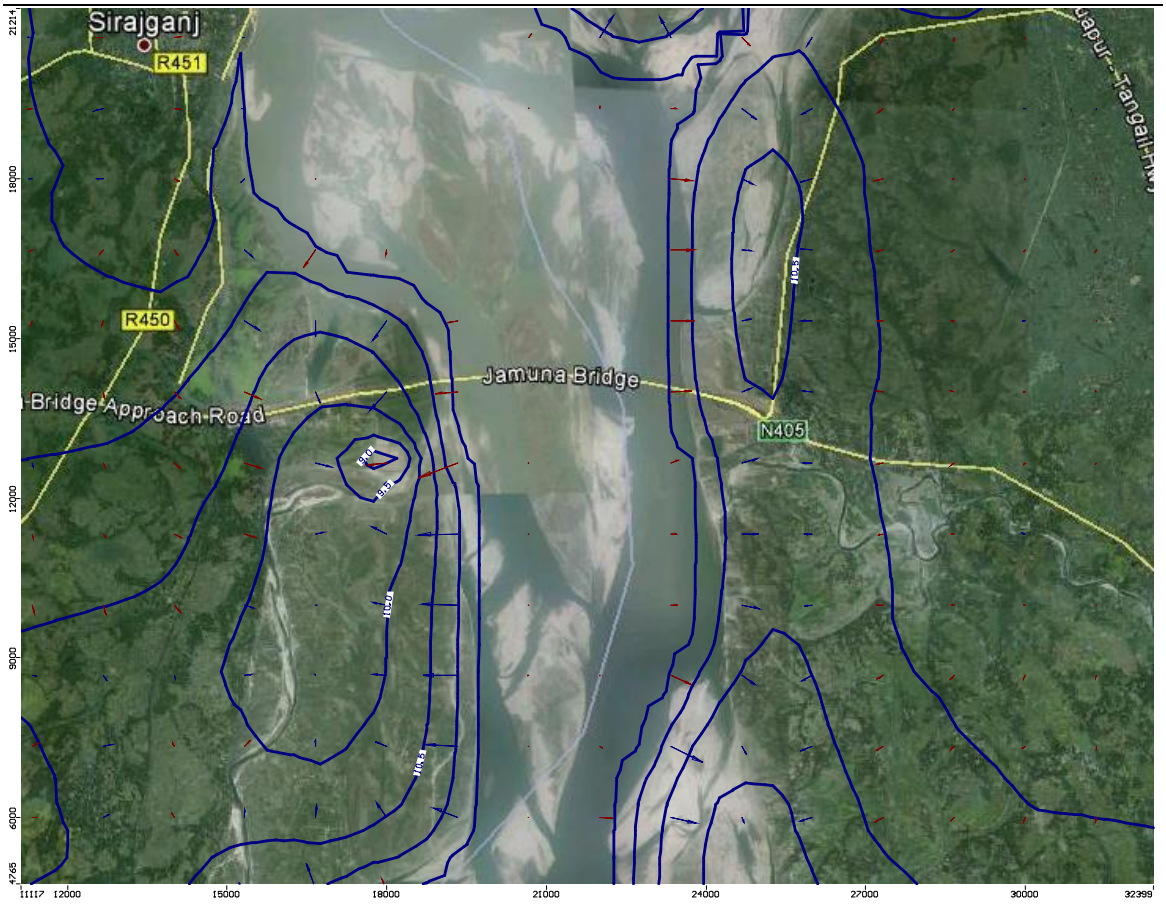

Figure 64. Zoomed in modelled wet season (September) water table contour map after 20 years of pumping (wells arranged in cluster)

The MODFLOW results generated through this modeling effort reflect only assumed conditions based on site data, collected data or literature values. The model predicted that the minimum groundwater elevation in the dry season occurs in the month of May. In spite of minor lowering of the water table in the pumping well in the proposed power station and surrounding areas, the pumping well are able to withdraw adequate quantity of water from the aquifer. The maximum elevation of water level occurs in September or October. In the wet season the Jamuna River recharges the aquifer. The pumping well in the proposed power plant will get plenty of water supplies from the river and water level in the pumping well will rise substantially. The aquifer is fully recharged in wet season.

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APPENDIX I : Model Input Files

1. Pumping Wells at the Project Site

Stop Time (Day)	Start Time (Day)	Well Discharge (m^3/d)
0	31	-2976
31	59	-2976
59	90	-2976
90	120	-2976
120	151	-2976
151	181	-2976
181	212	-2976
212	243	-2976
243	274	-2976
274	304	-2976
304	335	-2976
335	365	-2976

2. Irrigation DTWs

Stop Time (Day)	Start Time (Day)	Well Discharge (m^3/d)
0	31	-1386
31	59	-1386
59	90	-1386
90	120	-1386
120	151	0
151	181	0
181	212	0
212	243	0
243	274	0
274	304	0
304	335	0
335	365	-1386

3. Municipal Wells

Stop Time (Day)	Start Time (Day)	Well Discharge (m^3/d)
0	31	-1500
31	59	-1500
59	90	-1500
90	120	-1500
120	151	-1500
151	181	-1500
181	212	-1500
212	243	-1500
243	274	-1500
274	304	-1500
304	335	-1500
335	365	-1500

3. Recharge Boundary

Stop Time (Day)	Start Time (Day)	Recharge Rate (mm/yr)
0	31	240
31	59	264
59	90	576
90	120	1536
120	151	2160
151	181	2196
181	212	2184
212	243	1860
243	274	1236
274	304	480
304	335	276
335	365	252

4. EVT Boundary

Stop Time (Day)	Start Time (Day)	EVT (mm/yr)	Extinction Depth (m)
0	31	1041.6	3
31	59	1280.4	3
59	90	1960.8	3
90	120	2264.4	3
120	151	2176.8	3
151	181	1605.6	3
181	212	1592.4	3
212	243	1472.4	3
243	274	1476	3
274	304	1138.8	3
304	335	1144.8	3
335	365	978	3

5. River Boundary

Stop Time (Day)	Start Time (Day)	River Stage (m)
0	31	7.5
31	59	7.1
59	90	7.6
90	120	8.2
120	151	9.3
151	181	10.8
181	212	12.35
212	243	13.1
243	274	11.68
274	304	10.3
304	335	8.46
335	365	7.65

Annex-4.6: DOE Test Results of Air Quality

Govt. of the People's Republic of Bangladesh
Department of Environment
Office of the Director, Rajshahi Division
Paribesh Bhaban, Nishindara, Bogra – 5800

Analysis sheet of Air Quality monitoring

SL. No	Sampling Location	Date	Code No.	SPM $\mu g/m^3$	SOx $\mu g/m^3$	NOx $\mu g/m^3$	Remarks
1.	**225 MW Combined cycle power plant.** Shirajgang. (In front of Existing power Plant).	25/09/2013	1409	144.12	23.10	28.45	Result is within limit.
2.	**225 MW Combined cycle power plant.** Shirajgang. (In front of Main Get).	25/09/2013	1410	135.25	16.65	22.15	,,
	Standards as per ECR'2005	-	-	200	120	100	-

Note; during the sampling the sky was cloudy & it was half rainy.

Lab. Asst/S. Coll.

21.10.13
Senior Chemist

Director

Annex-4.7: Noise Level at Project site

Govt. of the People's Republic of Bangladesh
Department of Environment
Office of the Director, Rajshahi Division
Paribesh Bhaban, Nishindara, Bogra – 5800

Analysis sheet of **Sound monitoring**

SL.No	Sampling Location	Date	Code No.	Time	Sound (dBa)	Remarks
1.	**225 MW Combined cycle power plant.** Shirajgang. (In front of Existing power Plant).	25/09/2013	1412	2:00 PM	82-86	Result is not within limit.
2.	**225 MW Combined cycle power plant.** Shirajgang. (In front of East boundary wall).	25/09/2013	1413	2:20 PM	69-73	"
3.	**225 MW Combined cycle power plant.** Shirajgang. (In front of Main Get).	25/09/2013	1414	2:30 PM	56-61	Result is within limit
	Standards as per ECR'97			-	70 (dBa)	

Lab. Asst/S. Coll.

21.10.13
Sr. Chemist

Director

Annex-4.8.1: DOE Test Results of Jamuna River Water Quality

Govt. of the People's Republic of Bangladesh
Department of Environment
Office of the Director
Nishindara, Bogra-5800.
www.doe-bd.org

Subject:-Analysis Sheet of River Water Sample.

Sampling Location	Date	Name of water source	Code	Tem. 0C	pH	DO (mg/l)	BOD (mg/l)	COD (mg/l)	Turbidity (NTU)	Cl (mg/l)	TS (mg/l)	TDS (mg/l)	SS (mg/l)	E.C (µmos/cm)	Remarks
Jamuna River, (Surface). Near 225 MW Combined cycle power plant at Sirajganj.	25/10/2013	River	1416	29.6	7.72	5.1	1.0	12	44.8	65	230	170	60	328	All the parameters are within limit
Jamuna River, (3 m depth). Near 225 MW Combined cycle power plant at Shirajganj.	25/10/2013	River	1417	28.7	7.70	5.0	1.0	10	46.2	60	220	170	50	321	DO
As per ECR-97					6-9	4.5-8	50	-	-	150-600	2200	-	150	1200	

Lab. Assistant/S.Coll

21.10.13
Senior Chemist

Director

Annex-4.8.2: DOE Test Results of Ground Water Quality at Project site

Government of the People's Republic of Bangladesh
Department of Environment
Office of the Director
Nishindara,Bogra-5800.
www.doe-bd.org

Subject:-Analysis Sheet of Ground Water Sample of 225 MW Combined cycle power plant, Shirajgang.

Sampling Location	Date	Lab Code	Temp.	P^H	E.C	DO	BOD	COD	TS	TDS	SS	Iron	Arsenic	Turbidity	T-Hardness	Chloride	Remarks
225 MW Combined cycle power plant. Shirajgang. (Ground water sample)	25/09/13	1415	28.5	7.23	532	5.1	0.1	>4	320	270	50	0.26	Nill	8.2	160	78	All the parameters are within limit.
Standards as per ECR´97			20-30	6.5-8.5	1200	6	0.2	4	2100	-	150	0.1-2.0	0.05	10	200-500	150-600	

Note; All the unit in mg/l, except Temp ^{0}C, EC (µmos/cm), Turbidity NTU, T. Coli colonies N/100 ml

Lab. Assistant/S.Collector

21.10.13
Senior Chemist

22/10/2013
Director

Annex-6.16.2: Questionnaire for Socio-Economic and Environmental Issues

SOCIO-ECONOMY SURVEY
Saidabad, Serajgonj

Respondent Identification

Centre: Serajgonj ☐ ID: ☐☐☐☐

Date: ☐☐☐☐☐☐ Photograph No: ☐☐☐☐

Name of head of household.....Father's /Husband Name.....

Village/Moholla.....Union/Word.....

Upazila.....District.....

mvjvg/Av`ve| Avgvi bvg.....| Awg .....bvgK GKwU M‡elbv ms¯v †_‡K G‡mwQ| eZgv‡b Avgiv GB GjvKvq we`¨r †K‡›`i Dci Rwic KvR cwiPvjbv KiwQ|

Name of Respondents (DËi `vZv/`vÎxi bvg).....

we¯wiZ wVKvbvt.....

.....

.....

.....

.....

Respondents Category:

i) Direct impact of the Respondent [1]

ii) General impact of the Respondent [2]

Check by interviewer.....date.....Signature.....

Check by Supervisor .....date..... .Signature.....

Check by Quality Control.....date.....Signature.....

Background of the Respondents

01| Avcbvi/ (Lvbv cav‡bi) †ckv wK .....

02 eZgv‡b Avcbvi eqm KZ? (cY eQ‡i wjLb).....eQi

03| Avcwb wK KLbI ¯‡j wM‡q‡Qb? n¨v [1] bv [2] (05 G hvb)

04| Avcwb me”P †Kvb Kvk cvk K‡i‡Qb? .....

House Holds expenditure

05| Avcbv‡`i cwiev‡ii gvwmK Avq KZ?.....

06| Avcbv‡`i cwiev‡ii gvwmK e¨q KZ?.....

07| gvwmK e¨‡qi wewfb LvZ D‡jL Ki“b

K. †cvkvK.....UvKv L. Avmeve cÎ.....UvKv

M. †gngvb Avc¨vqb.....UvKv N. hvZvqvZ LiP.....UvKv

O. wPwKrmv e¨q.....UvKv P. exR, mvi, wKUbvkK.....UvKv

Q. Lv`¨.....UvKv R. we`¨r.....UvKv

S. Gj‡Kvnj/ZvgvK.....UvKv T. LvRbv/U¨v· .....UvKv

U. cwbi wej.....UvKv V. ewo fvov.....UvKv

W. wk¶v LiP.....UvKv X. Rvjvbx eve` LiP.....UvKv

me‡gvU LiP.....UvKv

Land owner ship of the Respondent

08| Avcbvi wbR¯ Rwg Av‡Q wK? n¨v [1] bv [2] (11 G hvb)

09| emZewo.....kZvsk| eZgvb gj¨.....UvKv

10| Kwl Rwg.....kZvsk| eZgvb gj¨.....UvKv

11| ch‡e¶b K‡i ewoi Qv`, †`lqvj Ges †g‡Si aib wjwce× Ki“b

	wUb	cvKv	Uvwj	gwU	evk	Qb/ ‡Mvjcv‡Z	cvU Lwo	KvV	Ab¨vb¨
Qv`	1	2	3		5	6	7	8	
‡`lqvj	1	2		4	5	6	7	8	
‡g‡S		2		4	5			8	

12| Avcbv‡`i cwiev‡i wbæwjwLZ m¤ú‡`i g‡a¨ †KvbwU Av‡Q?

(mvavibZ Avcwb wK wK †`‡Lb I †kv‡bb?)

K. †iwWI 01 L. †Uwjwfkb 02 M. evB mvB‡Kj 03

N. gUimvB‡Kj 04 O. †mjvB †gwkb 05 P. j¨vÛ †dvb 06

Q. †dvb 07 R. †iwdRv‡iUi 08 S. Mwo/UvK 09

T. wiKmvf¨vb 10 U. †bŠKv 11 V. Nwo 12

W. Avjgwi 13 X. LvU/weQvbv 14 Y. †Pqvi/teÄ 15

Z. ‡gvevBj 16

Demographical Profile of the Respondent

13| Avcbvi ^eewnK Ae¯v wKt? weewnZ [1] AweewnZ [2] weaev/wecwZK [3]
Zvjv Kcvß [4] wewQbv [5]

14| Avcbvi cwiev‡i m`m¨ msL¨v KZ.....Rb

15| ci“l KZ..... Rb, gwnjv KZ.....Rb, cvP eQ‡ii wb‡P wkïi msL¨v KZ.....Rb

Migration in and out

16| Avcbviv GB GjvKvq KZ w`b (gvm/ermi) hver emevm Ki‡Qb?.....

17| Avcbviv c‡e †Kv_vq wQ‡jb (ûeû wjLb)?.....

18| eZgv‡b GLv‡b Ae¯v‡bi Kvib D‡jL¨ Ki“b?.....

Water and Sanitation

19| Avcbv‡`i cwiev‡ii Lvevi cwbi cavb Drm wK?

K. evmvi wfZ‡i cvBc.....01 L. evmvi evB‡i cvBc.....02

M. bjKc/Mfxi bjKc.....03 N. Kqv.....04

O. cKi/Lvj/n`.....05 P. b`x.....06

Q. Ab¨vb¨.....

20| Avcbv‡`i GjvKv‡Z bjK‡ci cwb‡Z Av‡mwbK Aw‡Q wK?

n¨v [1] bv [2]

21| Avcbvi ewo‡Z cvqLvbvi aiY wK ?

K. †mdwU U¨v¼/AvawbK Uq‡jU.....01 L. Rjve×/ ¯¨ve j¨wUb.....02

M. wcU j¨wUb.....03 N. †Lvjv j¨wUb.....04

O. Sjš j¨wUb.....05 P. †Svc Svo/†Lvjv gvV.....06

Q. Ab¨vb¨.....

Treatment of the family members

22| Am¯¨ n‡j Avcwb ev Avcbvi cwiev‡ii m`m¨iv wPwKrmvi Rb¨ †Kv_vq hvb?

.....

23| GLv‡b Avcbv‡K †Kvb UvKv w`‡Z n‡qwQj wK? n¨v n‡j KZ UvKv D‡jL Ki“b.....UvKv|

24| Avcbv‡`i cwiev‡i mvavibZ wK wK AmL wemL nq?.....

.....

25| cavbZ wZbwU Am‡Li bvg µgvš‡q D‡jL Ki“b? 1| .....2|.....3|..... Ges wK Kvi‡b AmL nq D‡jL Ki“b.....

.....

Knowledge, Attitude, about the use of electricity

26| Avcbv‡`i evmvq we`¨r Av‡Q wK? n¨v 1 bv 2

27| Avcwb `qv K‡i ej‡eb Avcbv‡`i GjvKvq wK wK Kv‡R we`¨r e¨envi Kiv nq?

.....

.....

28| Avcbv‡`i GjvKvq wcWwe/cjx we`¨r mwgwZi gva¨‡g †h we`¨r mieivn Kiv n‡"Q Zvi fvj w`K¸wj wK wK?

.....

.....

.....

29| hw` Lvivc e‡j, Lvivc w`K¸wj wK wK?

.....

.....

30| Avcbv‡`i GjvKvq hw` bZb we`¨r †K› ¯vcb Kiv nq, †m‡¶‡Î Avcbvi cwZwµqv wK?

.....

.....

31| ivbvi Kv‡R Rvjvbx wnmv‡e wK e¨envi K‡ib?

K. KvV.....01 L. kl¨ AveRbv.....02

M. Me‡ii ¸wU.....03 N. Gjwc/Zij M¨vm.....04

O. B‡jKwUK wnUvi.....05 P. M¨vm.....06

Q. †K‡ivwmb.....07

32| Rvjvbx eve` gv‡m KZ e¨q nq.....UvKv

Environment impact of the society

* Direct impact of the Respondent ☐

33. Avcwb nqZ AeMZ Av‡Qb †h, Avcbv‡`i AwZ Kv‡Q GKwU we`¨r †K›` Av‡Q| G wel‡q Avcbvi gZvgZ wK?

.....

....

34. GB we`¨r †K›` Ae¯v‡bi Kvi‡b (kã `lb) mvavibZ Avcbv‡`i †Kvb Amweav nq wK? wK ai‡bi Amweav nq

.....

.....Probe wjLb|

35. D‡jwLZ mgm¨v¸wj Qvov Avi wK wK cwi‡ek MZ mgm¨v Av‡Q e‡j Avcwb g‡b K‡ib?

.....

..... Probe wjLb|

36. Avcwb wK g‡b K‡ib we`¨r †K›` ¯vc‡bi Kvi‡b Avcbv‡`i GjvKv‡Z AmL/wemL ew× †c‡qwQ ?

n¨v ☐1 bv ☐2

wK ai‡bi AmL ew× ‡c‡q‡Q.....

37. eZgvb Avcbvi wbR¯ evmv‡Z/GjvKv‡Z ev ¯vbxqfv‡e (Ab¨Î) mvavibZ wK wK ai‡bi MvQcvjv Av‡Q e‡j Avcwb hv‡bb|.....

38. eZgvb we`¨r †K›` ¯vc‡bi c‡e Avcbvi evmv ev GjvKv‡Z wK wK MvQcvjv wQj hv †`Lv‡M‡Q|

.....

* General impact of the Respondent ☐

39. Avcwb nqZ AeMZ Av‡Qb †h, (mvB`vev`) Avcbv‡`i GjvKv‡Z GKwU we`¨r †K›` Aew¯Z G wel‡q Avcbvi gZvgZ wK.....

.....Probe wjLb|

40. GB we`¨r †K›` Ae¯v‡bi Kvi‡b (kã `lb) mvavibZ Avcbv‡`i †Kvb Amweav nq wK? n‡j wK ai‡b Amweav nq?.....

.....Probe wjLb|

41. D‡jwLZ mgm¨v¸wj Qvov Avi wK wK cwi‡ek MZ mgm¨v Av‡Q e‡j Avcwb g‡b K‡ib?

.....

..... Probe wjLb|

42. eZgvb Avcbvi wbR¯ evmv‡Z/GjvKv‡Z ev ¯'vbxqfv‡e (Ab¨Î) mvavibZ wK wK ai‡bi MvQcvjv Av‡Q e‡j Avcwb hv‡bb|

.....

43. eZgvb we`¨r †K›` ¯'vc‡bi c‡e Avcbvi evmv ev GjvKv‡Z wK wK MvQcvjv wQj hv †`Lv‡M‡Q|

.....

.....

44. eZgvb Avcbvi wbR¯ evmv‡Z/GjvKv‡Z ev ¯'vbxqfv‡e (Ab¨Î) mvavibZ wK wK ai‡bi MvQcvjv Av‡Q e‡j Avcwb hv‡bb|

44. wK wK MvQ cvjv Awec`vcb (Av‡Q)	44. wK wK MvQ cvjv Awec`vcb (Av‡Q)	44. wK wK MvQ cvjv Awec`vcb (Av‡Q)|	45. wK wK MvQ cvjv wec`vcb

46. eZgv‡b GB MvQcvjv¸wj wec`vcb nIqvi c`vb wZbwU Kvib D‡jL Ki"b?
c_g KviY.....wØZxq KviY.....ZZxq/†kl KviY.....

47 ‡Kb Avc‡b Gi¡c g‡b
K‡ib?.....
(ûeû wjLb)

48. eZgv‡b Avcbv‡`i GjvKv‡Z wK wK cï ev RxeRš mvavibZ †`Lv hvq?

cï RxeRš bvg wb‡g D‡jL Ki"bt

48. wK wK Rxe/Rš Awec`vcb (Av‡Q)	48. wK wK Rxe/Rš Awec`vcb (Av‡Q)	48. wK wK Rxe/Rš Awec`vcb (Av‡Q)	49. wK wK Rxe/Rš wec`vcb

50. eZgv‡b GB cï I RxeRš wec`vcb nIqvi c`vb wZbwU Kvib D‡jL Ki“b?
c_g KviY.....wØZxq KviY.....ZZxq/†kl KviY.....

51. ‡Kb Avc‡b Gi¡c g‡b
K‡ib?.....
(ûeû wjLb)
52. eZgv‡b Avcbv‡`i GjvKv‡Z wK wK cwL mvavibZ †`Lv hvq?

cwLi bvg wb‡g D‡jL Ki“bt

52.wK wK cwL Awec`vcb (Av‡Q)	52.wK wK cwL Awec`vcb (Av‡Q)	52.wK wK cwL Awec`vcb (Av‡Q)	53. wK wK cwL wec`vcb

54. eZgv‡b GB cwL wec`vcb nIqvi c`vb wZbwU Kvib D‡jL Ki“b?
c_g KviY.....wØZxq KviY.....ZZxq/†kl KviY.....

55. ‡Kb Avc‡b Gi¡c g‡b
K‡ib?.....
(ûeû wjLb)
56. eZgv‡b Avcbv‡`i GjvKv‡Z wK wK gvQ mvavibZ †`Lv hvq?

gvQ¸wji bvg wb‡g D‡jL Ki“bt

56. wK wK gvQ Awec`vcb (Av‡Q)	56. wK wK gvQ Awec`vcb (Av‡Q)	56. wK wK gvQ Awec`vcb (Av‡Q)	57. wK wK gvQ wec`vcb

58. eZgv‡b GB gvQ¸wji wec`vcb nIqvi c`vb wZbwU Kvib D‡jL Ki“b?
c_g KviY.....wØZxq KviY.....ZZxq/†kl KviY.....

59. ‡Kb Avc‡b Gi¡c g‡b
K‡ib?.....
(ûeû wjLb)

60. Avcbvi Rvbvg‡Z Avcbv‡`i GjvKv‡Z HwZnwmK ¯vcbvi wb`kb †Kv_vI Av‡Q wK? n¨v [1] bv [2]

(hw` HwZnwmK ¯vcbv ev wb`kb _v‡K Zvn‡j wbw`ófv‡e D‡jL Ki“b)

1.....2.....3.....4.....

61. eZgv‡b Avcbv‡`i GjvKvq cwbi †jqvi KZ wdU wb‡P Av‡Q..... e‡j Avc‡b hv‡bb| Rwbbv/ej‡Z cwibv = [3]

62. c‡e Avcbv‡`i GjvKvq cwbi †jqvi KZ wdU Ae¯v‡b wQj.....e‡j Avc‡b hv‡bb| we`¨r ‡K›` ¯vcbvi c‡e|.....Rwbbv/ej‡Z cwibv = [3]

63. wK Kvi‡b GB Ae¯vi (A_¨vr cwbi †jqvi wb‡P Ae¯vb Ki‡Q) mwó n‡q‡Q e‡j Avcwb g‡b K‡ib|

Ae¯v mwói KviY..... Rwbbv/ej‡Z cviwQbv = [3]

(DËi `vZv‡K ab¨ev`
Rwb‡q mv¶vrKvi †kl Ki“b|)