Initial Environmental Examination Report

PUBLIC

Project Number: 56344-001
Draft
November 2023

Bangladesh: Paramount Solar Power Project

PART 4: Annexure

Prepared by Dynamic Sun Energy Private Limited for the Asian Development Bank (ADB).

Annexure

Annexure - 1

Site Clearance Certificate

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
পরিবেশ অধিদপ্তর
পাবনা জেলা কার্যালয়
সাং-নুরপুর বাইপাস, পাবনা সদর, পাবনা
www.doe.gov.bd

অবস্থানগত ছাড়পত্র

ছাড়পত্র নং: ২৩-১০০৮৭৫

পরিবেশগত ব্যবস্থাপনা নিশ্চিতকরণ সাপেক্ষে সংযুক্ত শর্তে নিম্নবর্ণিত প্রতিষ্ঠান/প্রকল্পের অনুকূলে অবস্থানগত ছাড়পত্র প্রদান করা হলো :

প্রতিষ্ঠান/প্রকল্পের নাম	:	ডাইনামীক সান এনার্জি প্রাইভেট লিমিটেড
উদ্যোক্তার নাম	:	অলক কুমার দাস, পরিচালক
সনাক্তকরণ নং	:	১৩৮৮৯০
প্রতিষ্ঠান/প্রকল্পের কার্যক্রম	:	সোলার পাওয়ার প্লান্ট (১০০ মেগা ওয়াট)
প্রতিষ্ঠান/প্রকল্পের শ্রেণী	:	Orange
প্রতিষ্ঠান/প্রকল্পের ঠিকানা	:	ভবানীপুর, হিমাইতপুর, পাবনা সদর, পাবনা
প্রদানের তারিখ	:	১৯ জুন ২০২৩
মেয়াদ উত্তীর্ণের তারিখ	:	১৮ জুন ২০২৪

এ ছাড়পত্র সনদের সাথে পৃথকভাবে সংযুক্ত প্রদত্ত শর্তাবলী যথাযথভাবে প্রতিপালন করতে হবে,
অন্যথায় ছাড়পত্র বাতিল/ক্ষতিপূরণ আদায়সহ যে কোন আইনানুগ ব্যবস্থা গ্রহণ করা হবে।

বিঃদ্রঃ এটি একটি সিস্টেম জেনারেটেড ছাড়পত্র এবং এতে কোনোরূপ স্বাক্ষরের প্রয়োজন নেই।

অবস্থানগত ছাড়পত্র জন্য প্রযোজ্য শর্তাবলী:

১ . এ ছাড়পত্র ১৭,৭৬৫৭২ বর্গমিটার জায়গায় সৌর বিদ্যুৎ উৎপাদন (১০০ মেগা ওয়াট) কার্যক্রম পরিচালনার জন্য কারখানার ভূমি উন্নয়ন, অবকাঠামো ও

যন্ত্রপাতি স্থাপন কার্যক্রম পরিচালনা করার ক্ষেত্রে প্রযোজ্য হবে।

২ . আইইই প্রতিবেদনে উল্লিখিত সকল মিটিগেশন মেজার্স যথাযথভাবে বাস্তবায়নপূর্বক সার্বক্ষণিক কার্যকরী রাখতে হবে।

৩ . অগ্নি নির্বাপনকল্পে কারখানায় যথোপযুক্ত ব্যবস্থাদি গড়ে তুলতে হবে। ফায়ার সার্ভিস কর্তৃক আলোচ্য কারখানার অনুকূলে সকল ধরনের নির্দেশনা বাস্তবায়ন করতে হবে।

৪ . বাংলাদেশ পরিবেশ সংরক্ষণ আইন ১৯৯৫ (সংশোধিত ২০১০) এবং পরিবেশ সংরক্ষণ বিধিমালা,২০২৩ এর সকল ধারা ও বিধি প্রতিপালন করতে হবে।

৫ . কঠিন বর্জ্য ব্যবস্থাপনা বিধিমালা, ২০২১ অনুসারে কারখানা সৃষ্ট কঠিন বর্জ্য পরিবেশসম্মতভাবে ব্যবস্থাপনা ও অপসারণ করার জন্য প্রয়োজনীয় ব্যবস্থা গ্রহণ করতে হবে। কারখানার স্থাপনা নির্মাণের জন্য ব্যবহৃত সকল নির্মাণ সামগ্রী ঢেকে রাখার ব্যবস্থা গ্রহণ করতে হবে এবং কারখানার নির্মাণ সামগ্রী পরিবহণকারী সকল যানবাহনকে যথাযথভাবে ঢেকে মালামাল পরিবহণ করতে হবে এবং এই সকল যানবাহনের চাকার মাধ্যমে যাতে কোন ধরনের কাদা বা ময়লা কারখানার বাইরে ছড়িয়ে না পরে সেই বিষয়েও প্রয়োজনীয় ব্যবস্থা গ্রহণ করতে হবে।

৬ . কারখানার ভূমি উন্নয়ন, অবকাঠামো ও যন্ত্রপাতি স্থাপন কর্মকান্ড পরিচালনা করার সময় শব্দ, তরল ও বায়বীয় বর্জ্য নিঃসরণ/নির্গমন মাত্রা যথাক্রমে শব্দ দূষণ (নিয়ন্ত্রণ) বিধিমালা-২০০৬, পরিবেশ সংরক্ষণ বিধিমালা, ২০২৩ এবং বায়ু দূষণ (নিয়ন্ত্রণ) বিধিমালা ২০২২-এ বর্ণিত মানমাত্রার মধ্যে রাখতে হবে।

৭ . কারখানার ভূমি উন্নয়ন, অবকাঠামো ও যন্ত্রপাতি স্থাপন কর্মকান্ড পরিচালনা করার মাধ্যমে মাটি, পানি ও বায়ু দূষণ করা যাবে না। একইসাথে কারখানা পরিচালনার সময় যাতে কারখানার কোন কর্মকান্ড দ্বারা মাটি, পানি ও বায়ু দূষণ না হয় সেই জন্যে প্রয়োজনীয় ব্যবস্থা গ্রহণ করতে হবে।

৮ . কারখানার ভূমি উন্নয়ন, অবকাঠামো ও যন্ত্রপাতি স্থাপন কর্মকান্ড পরিচালনার সময় মানব স্বাস্থ্যের জন্য ক্ষতিকর কোন উপাদান ব্যবহার করা যাবে না। কারখানার ভূমি উন্নয়ন, অবকাঠামো ও যন্ত্রপাতি স্থাপন কর্মকান্ড দ্বারা সৃষ্ট ধূলোবলি নিয়ন্ত্রণে দিনে কমপক্ষে দুইবার পানি ছিটানোর ব্যবস্থা গ্রহণ করতে হবে।

৯ . কারখানায় উপযুক্ত স্থানে বৃক্ষ রোপনের জন্য প্রয়োজনীয় ব্যবস্থা গ্রহণ করতে হবে।

১০ . কারখানাটিতে এনার্জি সেভিং LED বাল্ব ব্যবহার করতে হবে। একইসাথে কারখানাতে ব্যবহৃত পানি সাশ্রয়ের জন্য পানি সাশ্রয়ী প্রযুক্তির ব্যবহার করার জন্য প্রয়োজনীয় ব্যবস্থা গ্রহণ করতে হবে।

১১ . কর্মরত শ্রমিকদের জন্য Personal Protection Equipment যেমন ডাস্ট মাস্ক, গ্লাভস, ইয়ার প্লাগ ইত্যাদি ব্যবহার নিশ্চিত করতে হবে।

১২ . প্রতিষ্ঠানটির অবকাঠামোর পরিবর্তন/পরিবর্ধন কিংবা উৎপাদন প্রক্রিয়ার পরিবর্তন/বৃদ্ধির ক্ষেত্রে পরিবেশ অধিদপ্তরের অনুমতি গ্রহণ করতে হবে।

১৩ . এ ছাড়পত্র দ্বারা নির্মাণ কাজ ও যন্ত্রপাতি স্থাপনের জন্য বিদ্যুৎ সংযোগ পাওয়া যাবে কিন্তু গ্যাস সংযোগের ক্ষেত্রে প্রযোজ্য হবে না।

১৪ . এ ছাড়পত্র ভূমির মালিকানা স্বত্ব নির্ধারণ করে না।

১৫ . অবকাঠামো নির্মাণ ও অন্যান্য কার্যক্রম সমাপ্ত করে পরিবেশগত ছাড়পত্র গ্রহণের জন্য পুনরায় আবেদন দাখিল করতে হবে।

১৬ . পরিবেশগত ছাড়পত্র গ্রহণ ব্যতিরেকে কারখানাটি পরীক্ষামূলক/বাণিজ্যিক উৎপাদনে যেতে পারবে না।

১৭ . এ পর্যায়ে প্রাপ্ত ও পরিবেশিত তথ্যের ভিত্তিতে এ ছাড়পত্র প্রদান করা হলো। পরবর্তীতে কোনো তথ্য অসম্পূর্ণ, ত্রুটিপূর্ণ বা অসত্য কিংবা গোপন করা হয়েছে মর্মে প্রমাণিত হলে এ ছাড়পত্র বাতিল বলে গণ্য হবে। এছাড়া কারখানার বিরুদ্ধে কোন ধরনের অভিযোগ পাওয়া গেলে এবং তদন্তে অভিযোগের সত্যতা পাওয়া গেলে এ ছাড়পত্র বাতিল করা হবে।

১৮ . ছাড়পত্রের মূলকপি/নবায়নপত্র প্রতিষ্ঠনে সংরক্ষণ করতে হবে। পরিবেশ অধিদপ্তরের এনফোর্সমেন্ট টীম বা কোন কর্মকর্তা পরিদর্শনে গেলে তাদেরকে ছাড়পত্র প্রদর্শন ও কারখানার কার্যক্রম পরিদর্শনে সর্বাত্মক সহযোগিতা করতে হবে।

১৯ . এই ছাড়পত্র জারির তারিখ হতে পরবর্তী ১ (এক) বছরের জন্য বহাল থাকবে এবং মেয়াদ শেষ হবার অন্ততঃ ৩০ (ত্রিশ) দিন পূর্বে নবায়নের জন্য আবেদন করতে হবে।

২০ . বাংলাদেশ পরিবেশ সংরক্ষণ আইন, ১৯৯৫ এবং তদধীন প্রণীত বিধিমালা এ প্রদত্ত ক্ষমতাবলে উপরিল্লিখিত শর্তসমূহ Enforce করা হবে।

Annexure - 2

Layout Plan of the Project site

Proposed Route AP-01
Angle- 57°46'55"RT
Distance = 481.76m
X = 732563.816
Y = 2651847.665
Mouza :Khas Char Bagunda

ISHWARDI GRID 132KV

New TT-01
Angle- 26°40'09"RT
Distance = 49.51m
X = 719509.0000
Y = 2652074.9919
Mouza :Bhabanipur

New AP-01
Angle- 52°59'06"RT
Distance = 489.74m
X = 719068.9104
Y = 2652289.8667
Mouza :Bhabanipur

Existing Ground Level (EGL)	= 12.455m	(0.00m)	
Switch Yard Gr. Floor Top	= 16.00m	(+3.545m)	(11'-8")
Main Substation Gr. Floor Top	= 17.00m	(+4.545m)	(14'-11")
Block Substation Gr. Floor Top	= 16.00m	(+3.545m)	(11'-8")
Internal Road Level	= 12.65m	(+0.150m)	(00'-6")
Boundary Road Top Level	= 14.00m	(+1.545m)	(5'-1")
PV Panel Lower Part Height	= 15.485m	(+3.030m)	(9'-11")
PV Panel Upper Part Height	= 16.50m	(+4.045m)	(13'-3")
PV SPC Pile Top Height	= 15.855m	(+3.40m)	(11'-2")
PV Inv. SPC Pile Top Height	= 16.355m	(+3.90m)	(12'-9")

Total land as per digital survey =377 Acre
31 Nos. Block (150 MW DC/148 MW AC/P.F=0.9)
Evacuation 100MW AC (132 KV)

PV Panel Area	= 258.304 Acre
River Embankment With Boundary Road Area	= 26.35 Acre
Internal Road Area	= 10.5 Acre
Service Road, (Shadow Clearance, Cable Trench, Drain, Street Light)	= 22.5 Acre
Main Control Room Area	= 2.294 Acre
Switch Yard Area 132KV	= 3.064 Acre
Block Sub-station for 31 Nos.	= 8.63 Acre
Office Area Building	= 2.14 Acre
Safe Distance Maintain from River	= 15 Acre
Agrovoltaic / Green Zone Pocket Area	= 24.183 Acre
Total Required Project Land Area	= 372.597 Acre
Play Ground, officers Club & Mosque Etc	= 4.403 Acre
Total Land	= 377.00 Acre

1.	Total Table	= 4728 Nos.
2.	Total Inverter	= 744 Nos (@200kw)
3.	Total Table Pile	= 47280 Nos.
4.	Total Inverter Pile	= 744 Nos.
5.	Panel tilt Angle	= 18°
6.	Face	= South
7.	Pitch to Pitch	= 6.513m
8.	Block Sub-Station	= 31 Nos.
9.	Total DC Capacity	= 150 MW
10.	Total AC Capacity (Inv. Cap)	= 148 MW
11.	Power Factor	= 0.9
12.	PV Panel Row to Row	= 1100m
13.	PV Panel Colm. to Colm.	= 2150m

132 KV TL
Damage Brick Field
Fencing Line
SP Area
Flood Light Ht. 9.14m
Banana Garden
GUCHHA GRAM
21.5 km
Flood Light Ht. 8.15m
LABOUR SHED
SOLID WASTE DUMPING YARD
OFFICE
LGED Road
Project Access Road
STP
SEPTIC TANK
Main Substation Height EL =17.00m (+4.545m)
MAIN ENTRANCE
MAIN CONTROL ROOM
PLATFORM EL. +14.00 M.(PWD)
Stack Yard (1 Lac sft.)
LPS
ELEVATED ROAD/DIKE
RAIN WATER HARVEST TANK
GRAVEYARD
MOSQUE
PARK
OFFICERS CLUB
GUEST HOUSE
SWIMMING POOL
PLAY GROUND
HELIPAD
Ramp
EAST
PADMA RIVER

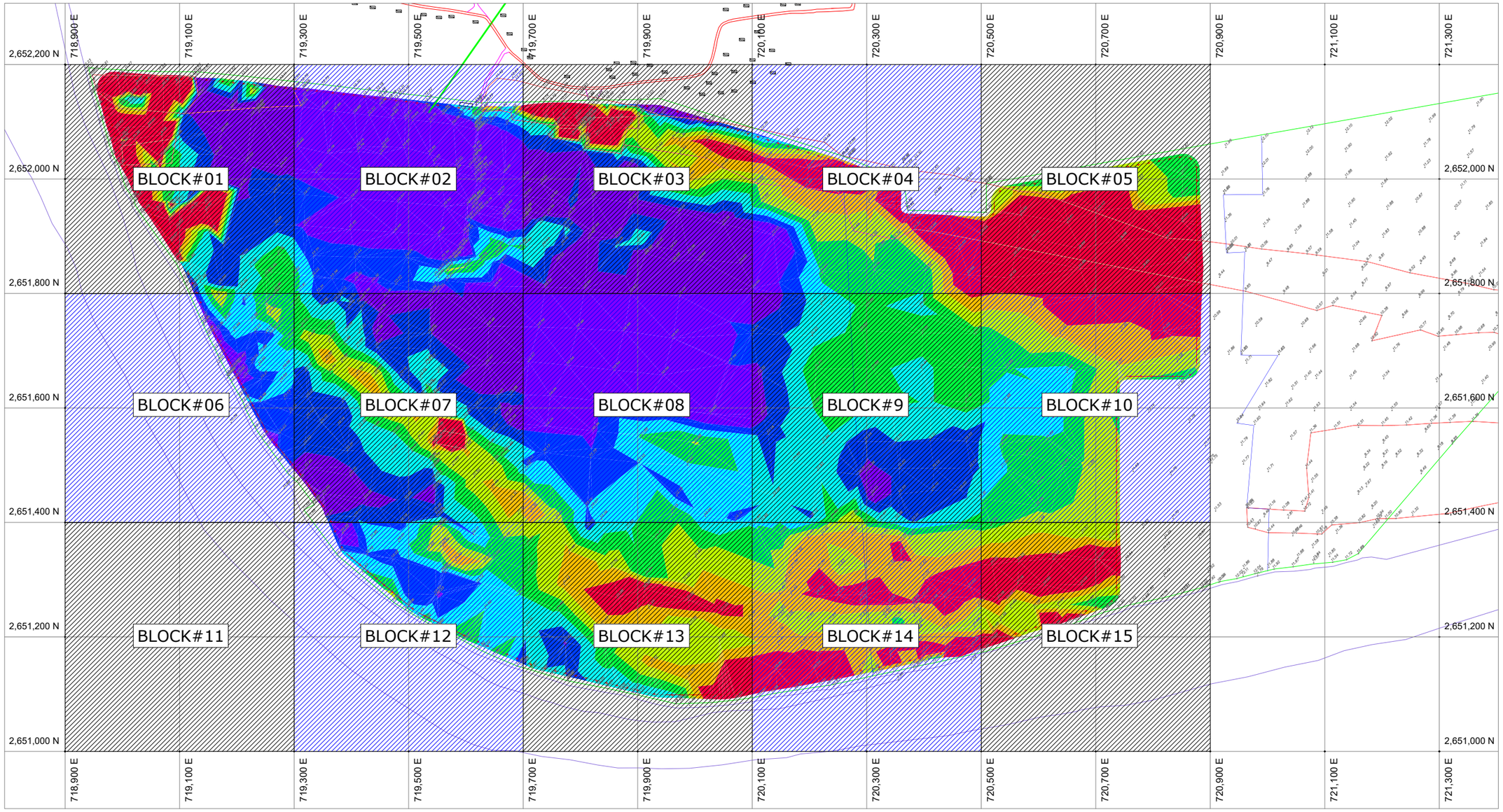
SUBSTATION BUILDING AREA = 0.028 Acre (1219 sft)
SUBSTATION BOUNDARY AREA = 0.250 Acre (10890 sft)
TOTAL = 0.278 Acre (12109 sft)

N
North Pole 90° N
Bangladesh Latitude : 24° N longitude :89.25° E
Latitude
Equator / (0°)
W
E
Prime meridian
Longitude
Latitude
90° S
South Pole
S

						PROJECT : 100MW (AC) SOLAR PARK, BHABANIPUR, HEMAYETPUR,PABNA, BANGLADESH.	OWNER : DYNAMIC SUN ENERGY PRIVATE LIMITED
						EP CONTRACTOR : **PETERSON INNOTEC CO., LTD.** ROOM 2103, 2104 , NO.2 BUILDING , ART & TECHNOLOGY SPACE . No.63, HAIER ROAD, QINGDAO P.R.CHINA TEL: 0086 532 80999562, 80999563 , 80999561 FAX: 0086 532 80999560 P.C. : 266061	EP CONTRACTOR'S DESIGNER : Infratech Energy Co., Ltd. 1032/217 Pahonyothin 18/1 RD. Jatujak District, Bangkok 10900,Thailand www.infratechenergy.com
0	28.09.2022	PRELIMINARY	SUEBPHONG	WANAGORN	POOSIT .3489	DRAWING TITLE : FINAL LAYOUT PLAN	SCALE : 1 : 100
REV	DATE	DESCRIPTION	DRAWN	CHECKED	APPROVED	PROJECT DOCUMENT NO :	PAPER : A1 (m.)
						DRAWING NO : PL- 1	SHEET : 1 / 1

Annexure - 3

Site Elevation Map



LEGEND

- COORDINATE LINE REFERENCE
- PROJECT BOUNDARY/FENCE
- BOUNDARY LINE
- @ X.XXX GROUND LEVEL

Elevation Table

Number	Min. Depth (m.)	Max. Depth (m.)	Color
1	7.487	11.300	
2	11.300	11.500	
3	11.500	11.700	
4	11.700	11.900	
5	11.900	12.100	
6	12.100	12.300	
7	12.300	13.162	

REV	DATE	DESCRIPTION	DRAWN	CHECKED	APPROVED
0	Aug / 23 / 2022	PRELIMINARY	SUEBPHONG	WANAGORN	POOSIT สถิ.3489

PROJECT :
100MW (AC) SOLAR PARK,
BHABANIPUR, PABNA.

OWNER :
DYNAMIC SUN ENERGY
PRIVATE LIMITED

CONTRACTOR :

EPC :

DESIGN :
Infratech Energy Co., Ltd.
1032/217 Pahonyothin
18/1 RD. Jatujak District,
Bangkok 10900,Thailand
www.infratechenergy.com

DRAWING TITLE :
KEY PLAN FOR PRE-DEVELOPMENT

PROJECT DOCUMENT NO :

DRAWING NO :
2D – 1

SCALE : 1 : 7,500

PAPER : A3 (m.)

SHEET :
1 / 16

Annexure - 4

Flood Study & Mitigation Report

FINAL

REPORT ON

FLOOD STUDY AND MITIGATION

100 MWac Bhabanipur, Pabna SOLAR PV POWER PLANT PROJECT, BANGLADESH

Submitted to

DYNAMIC SUN ENERGY PRIVATE LIMITED

August 26, 2022

บริษัท อินฟราเทค เอ็นเนอร์ยี่ จำกัด
Infratech Energy Co.,Ltd.
1032/217 Phaholyothin 18/1 Rd. Jomphon, Jatujak Baugkok. 10900
Tel. 02-272-2474-5 Fax. 02 272-2475 www.infratechenergy.com

DOCUMENT ISSUE RECORD

PROJECT : Dynamic Sun 100 MW solar farm

LOCATION : Pabna, Bangladesh

PROJECT# : 26/08/2022

	Name	Date	Signature
Author	Prasop S. (Bsc. 2nd class honor)	2022-08-25	
Document Check	Sawarot S.(Bsc. 2nd class honor, Msc.)	2022-08-25	
Authorisation	Poosit S.(Msc.)	2022-08-26	

บริษัท อินโฟรเทค เอ็นเนอร์ยี่ จำกัด
Infratech Energy Co.,Ltd.

EXECUTIVE SUMMARY

A flood study for a Dynamic Sun 100 MW solar farm has been carried out and results of the study are concluded below.

The average ground level for this site is EL.12.0 m. PWD

1.Overtopping of Padma River for 25,50 and 100 years ARI considering the effect of climate change and future land development;

Maximum water elevation for 100 year ARI from flood study is EL.15.04 m. PWD

Animation of 2D flood at project site from overtopping of Padma river can be downloaded from;
https://drive.google.com/file/d/1rtWuib_cbto9j7zo2aWuUEUV1SIcI4RY/view?usp=sharing

2. Flood from local rain for 100 years ARI considering the effect of climate change and future land development;

Maximum water elevation for 100 year ARI from flood study is EL.12.03 m. PWD

Animation of 2D flood at project site from local rain can be downloaded from;
https://drive.google.com/file/d/18WatyPGdE5d5eFQq02_-YFhVxtOo7XaY/view?usp=sharing

3. The flood mitigation for this project is suggested by elevate the PV module above the flood level as below.

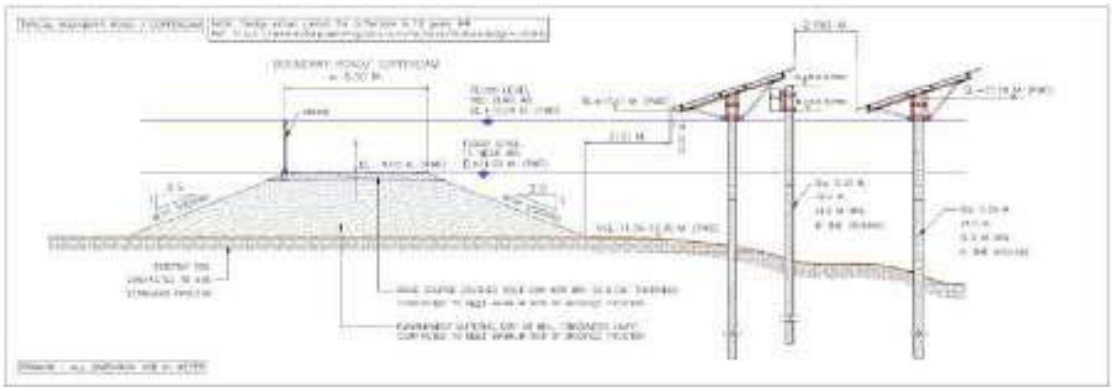


TABLE OF CONTENTS

LIST OF PLATES

LIST OF FIGURES

LIST OF ANNEXES

1.0 INTRODUCTION AND BACKGROUND OF THE PROJECT

Infratech Energy Co., Ltd. has been engaged by Dynamic Sun Energy Pvt Ltd to conduct the flood study for the construction of a 100 MWac solar PV power plant project located within the Bhabanipur, Pabna, Bangladesh.

The site location is at latitude 23.963421°, longitude 89.163830°

The project site is shown in Plate 1-1.

Plate 1-1: Project location

The site is approximately 144 km West of the capital Dhaka and takes 5 hours to reach by car.

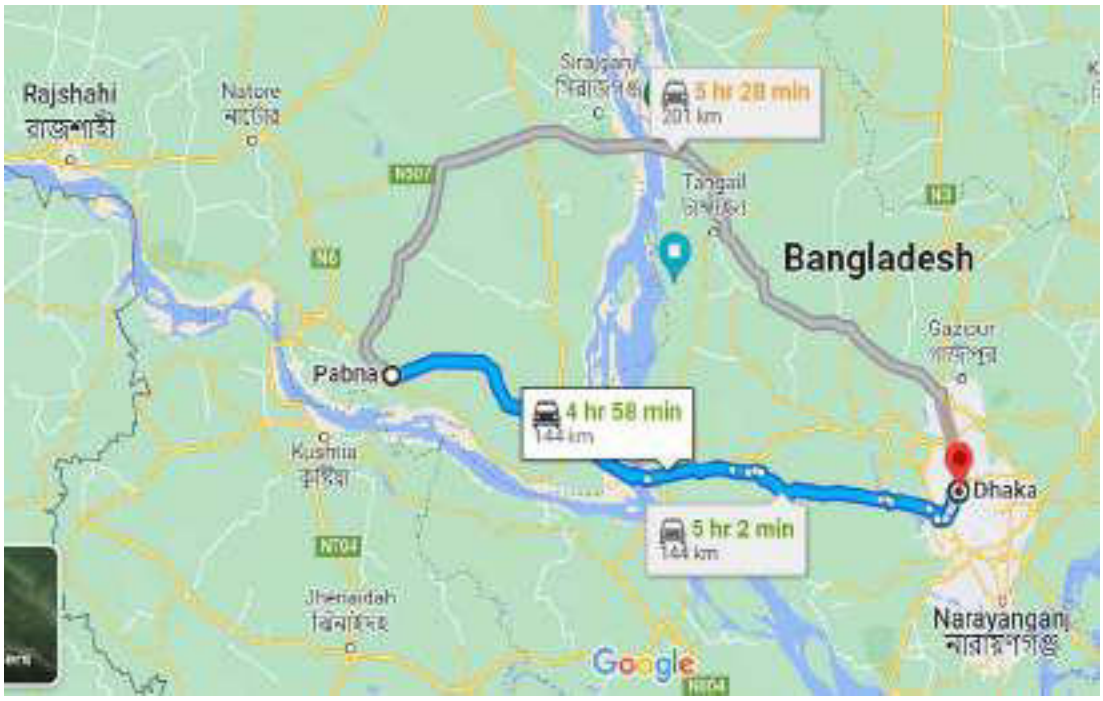


Plate 1-2: Site Vicinity

2.0 OBJECTIVE AND SCOPE OF WORK

The assessment methodology was designed to address potential flood risk from rainfall between 25,50 and 100 years of Appearance Recurrence Interval (ARI) to make the proposed SPPP area flood-free.

The main objectives of the hydrological study of the proposed SPPP are to:

- Flood analysis and calculation of highest flood level due to flood risk from river and high-intensity short-duration rainfall for designing the solar power plant.
- Flood and inundation mitigation

Scope of work shall include.

2.1 Collection of relevant information for the subject property and surrounding area. This included site area maps and identification of land use.

2.2 Collection of hydrological data;
2.2.1 Water level in the nearby river, rainfall, and hydrographic network from BWDB
2.2.2 Available information on the existing natural drainage system in the area.
2.2.3 Some brief overview of historic flood events in the area.
2.2.4. collecting data on existing site discharge and drainage points

2.3 A visit of the site, including a visual survey of the entire drainage area as identified from the maps and data collected. Discussions with the farmers and local population to understand the historical flood levels in the area;

2.4 A review of readily available records and documents on the hydrology of the area, to assist in determining surface water drainage patterns for the subject property and adjacent areas;

2.5 Estimation of design parameters, including storm intensity based on the rainfall data collected for this area. In absence of site-specific information, standard engineering assumptions and factors of safety are applied to available information on this issue;

2.6 Estimation of the peak water level and overtopping of the nearby river for the return period of 20,50 and 100 years including the effect of climate change by local practice in Bangladesh.

2.7 Flood Risk Analysis of the site, including the flood levels likely to be reached for various scenarios and the impact of these flood levels at the site.

2.8 Erosion study of the project site and ;

2.8 Recommendations for flood mitigation.

3.0 SITE INFORMATION

3.1 Site conditions

The proposed SPPP area is flat terrain with undulations.

The project area is predominantly used for agricultural purposes by local inhabitants for banana farms.

The site is situated in the Ganga-Padma River basin.

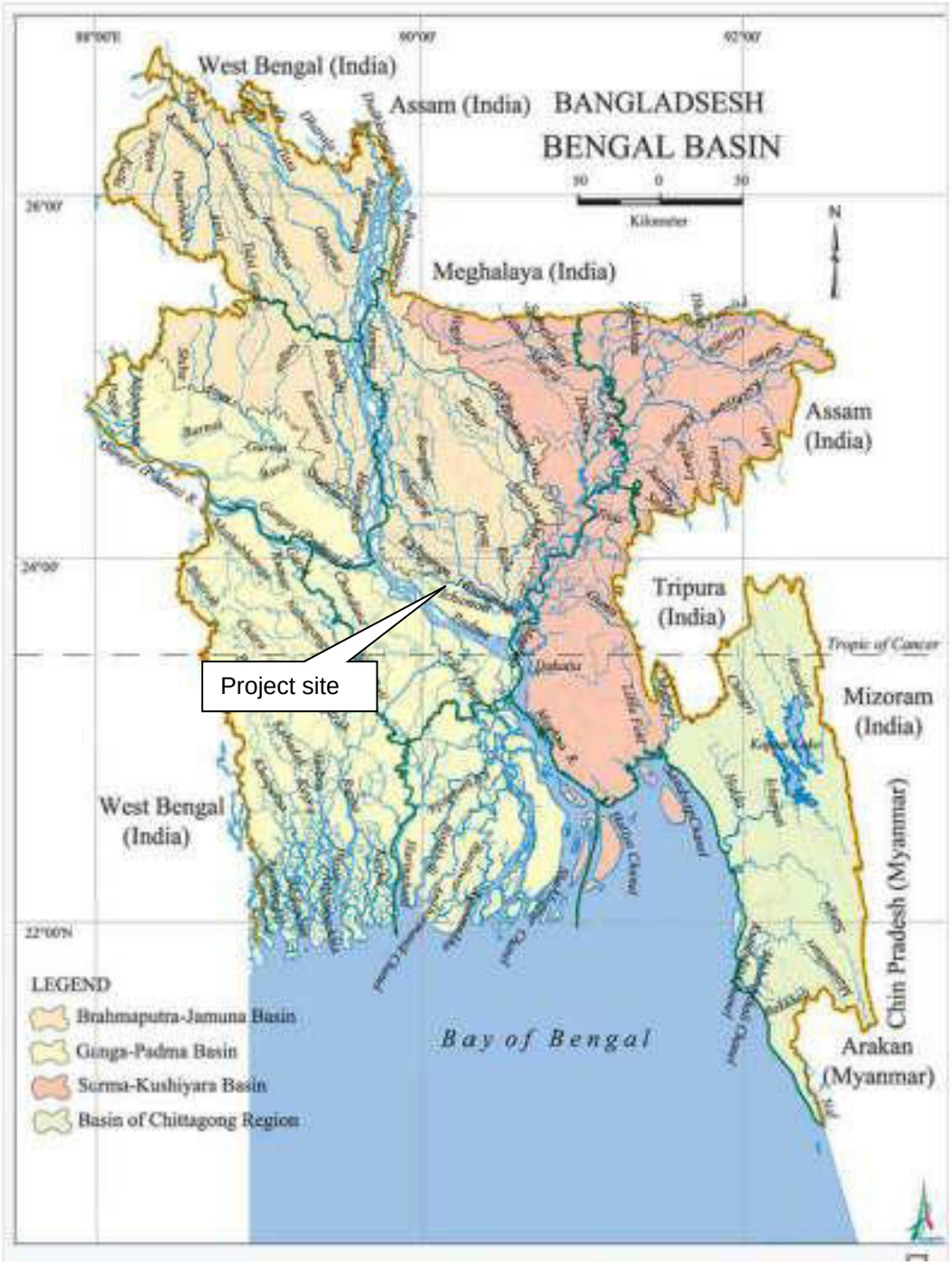


Plate 3-1: River Basin in Bangladesh

Project site is located on the left bank of the Padma River.

Plate 3-2: Nearby River (Padma River)

The Padma or Podda is a major river in Bangladesh. It is the main distributary of the Ganges, flowing generally southeast for 120 kilometers (75 mi) to its confluence with the Meghna River near the Bay of Bengal.

During August, the period of peak flow, the discharge of the river system reaches over 2,500,000 m3 / sec. in the year 1998.

3.2 Rainfall

The mean annual rainfall during monsoon is between 2000-2500 mm./year

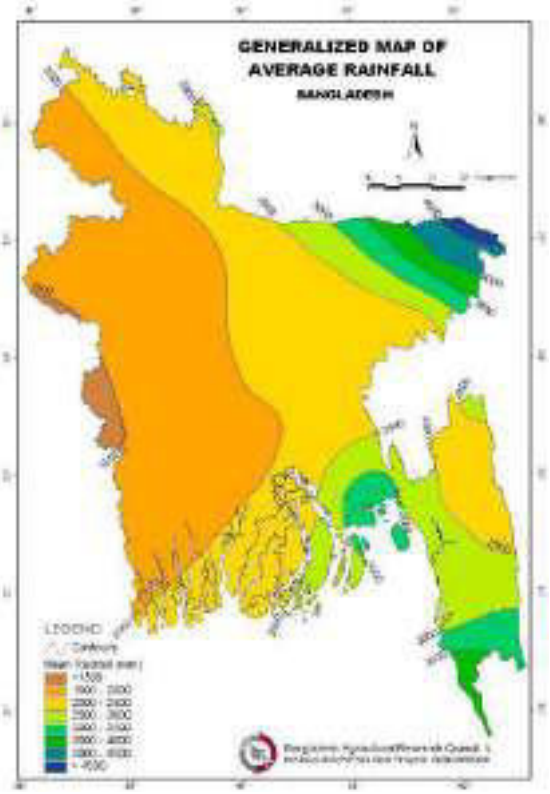


Plate 3-3: Average Rainfall

3.3 Climate

The proposed project area is located in a typical monsoon climate for three main reasons such as.

- Summer: The summer starts in February and ends in May. The summer season is very hot. The temperature varies from 25 degrees centigrade (during nighttime) to 42 degrees Celsius (during daytime). The wind speed during this season is high and usually blows from east to west and south to north direction.
-
- Monsoon: The summer starts in June and ends in September. The monsoon season is also very hot. The temperature varies from 25 - 38 degrees centigrade. During this period about 80% of rainfall occurs. Rest 20% occurs during the rest of the year. The annual rainfall for the Mymensingh rainfall station is 2800mm (Figure 2.4). The wind speed during this season is not so high and usually blows from east to west and south to north direction.

- Winter: The summer starts in October and ends in January. The winter season is cold. The temperature varies from 10 degrees centigrade (during nighttime) and 25 degrees centigrade (during daytime). The wind speed during this season is not high and usually blows from north to east and west to east direction.

3.4 Site elevation

The average site elevation from the topographic map of the project site is EL.12.0 m. PWD (see ***Figure 1.)***

A picture of the site and nearby branch of the Padma River is shown below.

Plate 3-4: Site Pictures

3.5 Discharge points of the project

The internal flow and discharge point of the project from 3D modeling is shown below.

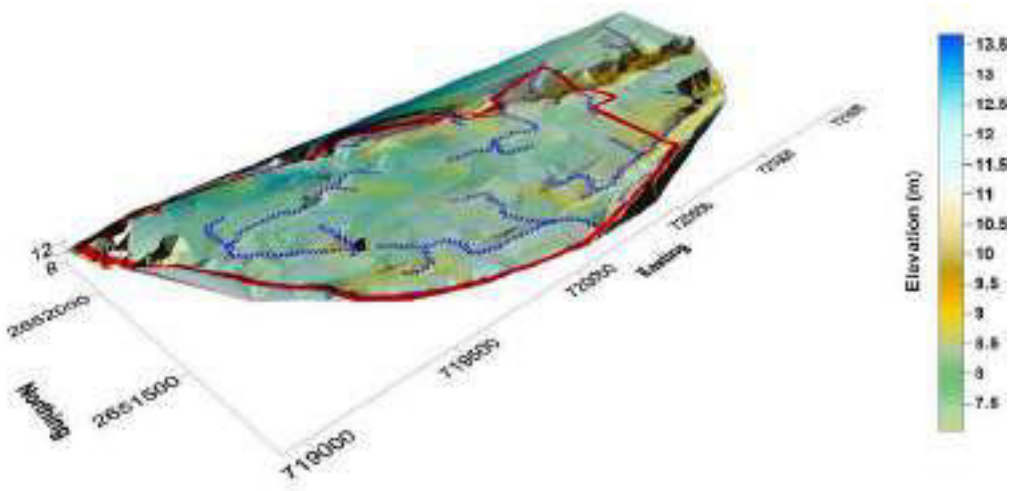


Plate 3-5: Internal flow and discharge point from DEM (Topographic survey)

3.6 Peak floods in the past

Peak flood in the past from the overtopping of the Padma main river has been observed.
The flood duration is between 2-3 months.
The water level in the year 1988 from the local resource is EL.14.87 m.(unconfirmed)

Data from the river gauge at Harding bridge in 1988 shows the water level is EL.15.19 (See ***Figure 2***)

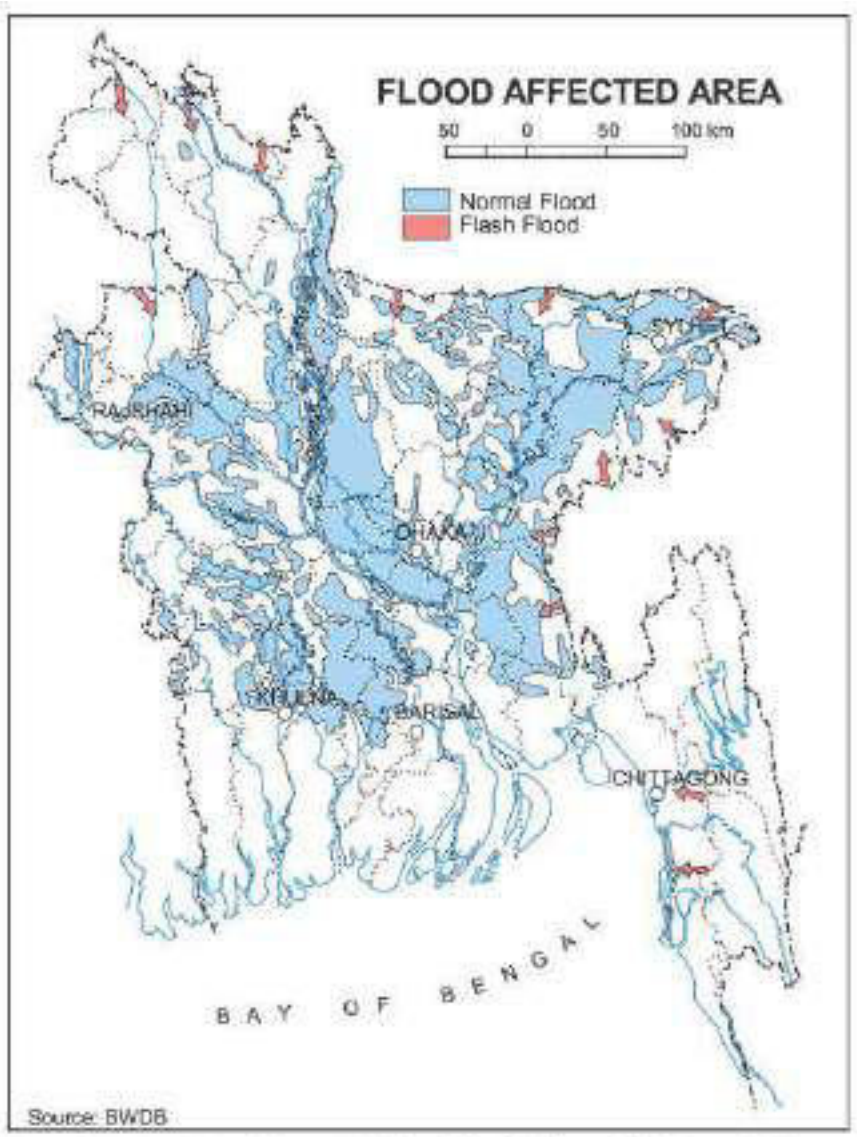
As the project site is on the downstream side, we expect the flood level on-site in the year 2008 to be lower than EL.15.19

4.0 TYPE OF FLOOD AND CAUSE OF FLOOD IN BANGLADESH

Bangladesh generally experiences four types of floods: flash floods, riverine floods, rainfall-induced floods, and storm surge floods, nevertheless, vulnerability to these four types varies according to different regions in the country.

4.1 Flash floods.

A flash flood is characterized by a very sharp rise of the water of rivers and subsequence over bank spillage with high velocity. It is also marked by a relatively rapid recession of water from the floodplains. A flash flood is characterized by a very sharp rise of the water of rivers and subsequence over bank spillage with high velocity. It is also marked by a relatively rapid recession of water from the floodplains.
The extent of flash floods is in the northern and eastern parts of Bangladesh.



Map Showing The Normal And Flash Flood Affected Areas Throughout Bangladesh

Plate 4-1: Flash flood in Bangladesh

In Bangladesh, a flash flood occurs after a heavy downpour in the neighboring hills and mountains. These floods often maul the standing crops at the ripening stage and cause severe damage to physical infrastructures along riverbanks.

4.2 Riverine floods (Long term flood)

Riverine floods from the major rivers generally rise and fall slowly over 10 to 20 days or more. Spilling by the major rivers and their tributaries and distributaries can cause extensive damage to lives and properties. Most of the flood plains in Bangladesh are subject to riverine floods during monsoon including this project.

4.3 rainfall-induced floods

Rainfall-induced floods are caused by high intense local precipitation of long duration in monsoon. In Bangladesh, mainly embanked areas are characterized by this flood. However, in each monsoon, rainfall-induced localized floods are observed in a number of locations in Dhaka city, the capital of the country from insufficient drainage network capacity.

4.4 Storm surge floods

Storm surge floods occur in the coastal areas of Bangladesh which consists of large estuaries, extensive tidal flats, and low-lying islands.

5.0 METHODOLOGY

From the site vicinity in chapter 3, flash floods and storm surges flood are not expected for this project.

5.1 Flood analysis from riverine

In Bangladesh prediction of water level is the main interest of flood management.

Annual maximum water levels of the hydrological gauge station at the nearest river will be used to analyze to derive the Highest Flood Level (HFL) of different return periods (20,25,50 and 100 years).

There are three different methods for the computation of HFL for different return periods. They are.

- Gumbel's Method.
- Log Pearsons Type - 3; and
- Normal Log.

The computations for high flood level (HFL) have been done by using Gumble's Method which is most commonly practiced in Bangladesh.

The computation shall include.

5.1.1 Impact of climate change and future land use to be also considered for the flood analysis for return periods 20,25,50 and 100 years.

5.1.2. Effect of the soil and groundwater on the flood

All information on the river water level at the nearest station and possible from the connected river (if available) will be collected together with information on river station at different locations in the same river are to be collected and compare for the same degree of change.

Once the HFL of the nearest river is known, the extension of flood to the project site will be accomplished with the aid of computer software Geo-HEC RAS and civil 3D in conjunction with site topographic survey and DEM.

5.2 rainfall-induced floods

High intense local precipitation of long duration in monsoon can cause short-term floods within the project site from insufficient discharge capacity.

The scope of the study shall include a collection of historical rainfall, the effect of climate change, and effect of future land use, and information of surrounded artificial rivers for the planning of internal drainage design and flood mitigation.

Information on rainfall data is to be verified for accuracy before use.

Rainfall data from at least three nearby stations are to be statistical analysis to check data homogeneity and consistency (double mass curve and probability distribution).

The future rainfall forecast will be for the return period of 20,25,50 and 100 years ARI.

The study shall include the effect of soil and groundwater in the site area on rainfall induced floods.

Flood mitigation and conceptual design of internal drainage will be included in the study.

6.0 FLOOD ANALYSIS

6.1 Flood analysis from riverine

Data records of the minimum and maximum water level together with discharge from river gauges at Harding bridge station from the year 1972 to 2021 are used for the estimation of water level in Padma River for 100 years ARI with the effect of climate change by the Gumbel method and Log Pearson Type III method

As the distance from Harding bridge to the project site is approximately 21.84 km., it is necessary to find a correlation between the water level at Harding bridge to the nearest river gauge to the project site.

The river gauge at Talbaria station (14.3 km. downstream) is used for calibration of water level and river profile slope.

Assume the slope of the river bed between Talbaria station and to project site (distance 6.84 km) is the same as the river bed from Harding bridge to Talbaria,

Details analysis in ***Annex A*** is concluded below.

Plate 6-1: River gauge station at Harding bridge and Talbaria station

Gumbel	Hardinge Bridge station to Talbaria station	14300	m	14.3	km
	Slope	0.000035	m/m		
	Tr	WL(Max) Hardinge Bridge	(Slope x L)	WL(Max) Talbaria	
	WL 2YR	13.869	0.501	13.368	
	WL 5YR	14.380	0.501	13.880	
	WL 10YR	14.719	0.501	14.219	
	WL 25YR	15.147	0.501	14.647	
	WL 50YR	15.465	0.501	14.964	
	WL 100YR	15.780	0.501	15.280	

Plate 6-2: Correlation between water level at Harding bridge station and Talbaria station by the Gumbel method.

Gumbel	Talbaria station to Project site	6840	m	6.84	km
	Slope	0.000035	m/m		
	Tr	WL(Max)_Talbaria	(Slope x L)	WL(Max)_Site	
	WL 2YR	13.368	0.239	13.129	
	WL 5YR	13.880	0.239	13.640	
	WL 10YR	14.219	0.239	13.979	
	WL 25YR	14.647	0.239	14.407	
	WL 50YR	14.964	0.239	14.725	
	WL 100YR	15.280	0.239	15.040	

Plate 6-3: Correlation between water level at Talbaria station and water level in front of the project site by the Gumbel method.

Log Pearson Type III	Hardinge Bridge station to Talbaria station	14300	m	14.3	km
	Slope	0.000035	m/m		
	Tr	WL(Max)_Hardinge Bridge	(Slope x L)	WL(Max)_Talbaria	
	WL 2YR	13.942	0.501	13.441	
	WL 5YR	14.389	0.501	13.889	
	WL 10YR	14.628	0.501	14.128	
	WL 25YR	14.887	0.501	14.387	
	WL 50YR	15.056	0.501	14.556	
	WL 100YR	15.210	0.501	14.709	

Plate 6-4: Correlation between water level at Harding bridge station and Talbaria station by the Log Pearson Type III method

Log Pearson Type III	Talbaria station to Project site	6840	m	6.84	km
	Slope	0.000035	m/m		
	Tr	WL(Max)_Talbaria	(Slope x L)	WL(Max)_Site	
	WL 2YR	13.441	0.239	13.202	
	WL 5YR	13.889	0.239	13.649	
	WL 10YR	14.128	0.239	13.888	
	WL 25YR	14.387	0.239	14.147	
	WL 50YR	14.556	0.239	14.317	
	WL 100YR	14.709	0.239	14.470	

Plate 6-5: Correlation between water level at Talbaria station and water level in front of the project site by the Log Pearson Type III method

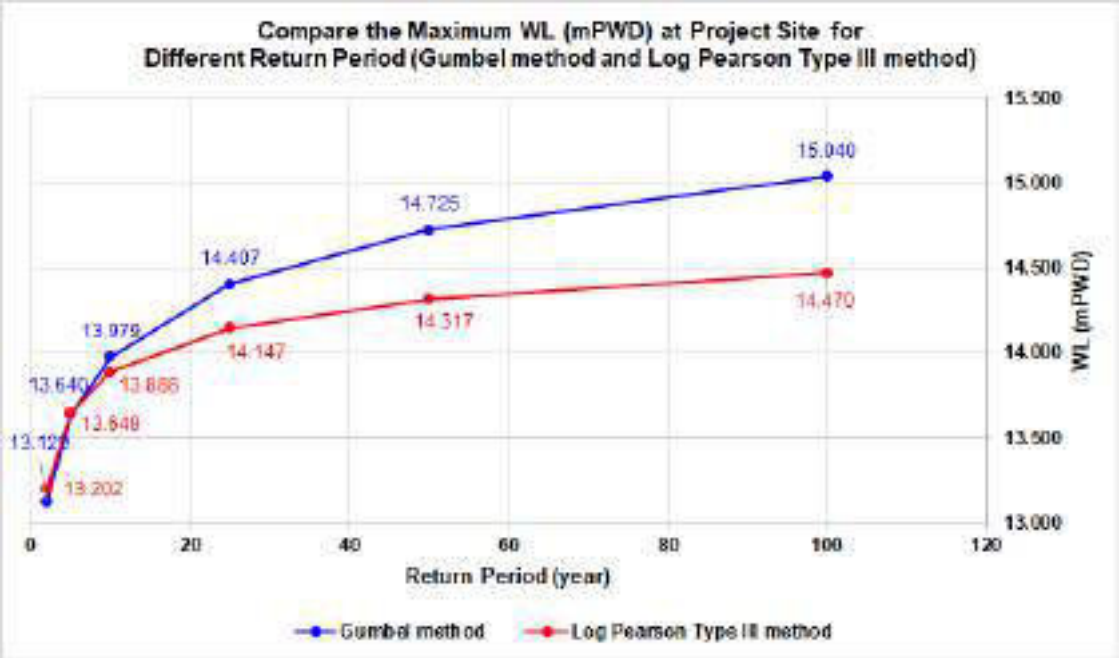


Plate 6-6: Compare the Maximum WL (mPWD) at Project Site for Different Return Period (Gumbel method and Log Pearson Type III method)

From the calculation analysis of maximum water level by Gumbel method and Log Pearson type III. The maximum water level calculated by Gumbel method is higher than Log Pearson type III, so selected by Gumbel method

The results of the maximum water level calculated by Gumbel method is shown in ***Plate 6-7*** below;

Tr	Maximum WL (mPWD) at Project Site (Gumbel Distribution)
2	13.129
5	13.640
10	13.979
25	14.407
50	14.725
100	15.040

Plate 6-7: Maximum water level at the project site by the Gumbel method

Water level for 100 years ARI with the effect of climate change by the Gumbel method is calculated to EL.15.04 m. PWD.

From the average site elevation at EL.12.0 m. PWD, average flood depth is 3.0 m. (see ***Figure 3***)

To explore the extended flood from the overtopping of Padma main river to the project side, the computer software Geo-HecRas is used for flood simulation. (see ***Annex B***).
Animation of 2D flood at project site from overtopping of Padma river can be downloaded from;

https://drive.google.com/file/d/1rtWuib_cbto9j7zo2aWuUEUV1SIcI4RY/view?usp=sharing

Plate 6-8: Extended flood from overtopping of Padma River

Flood depth on-site from 100 years ARI with the effect of climate change is shown in ***Figure 3***

6.2 Rainfall-induced flood

Rainfall data from 3 rainfall stations covering the project site (see ***Figure 4***) from Open Weather(https://home.openweathermap.org/) are used for the study of the rainfall-induced flood.

For the pre-development stage, the rainfall-induced flood may occur in the low ground areas which can be mitigated by backfilling low spot areas.
In other areas, water from rainfall will flow to the discharge point as shown in plate 3-5.

Maximum inundation extents under 100-year ARI local rainfall event for the site location, the computer software Geo-HecRas is used for flood simulation. (see ***Annex C***).

The ponding up of rainwater within the site is up to EL.**12.03** for 100 years ARI.

Plate 6-9: Maximum inundation flood depth extents under 100-year ARI local rainfall event within the site

Maximum water level at Cross section S-01 is shown in ***Plate 6-10*** below;

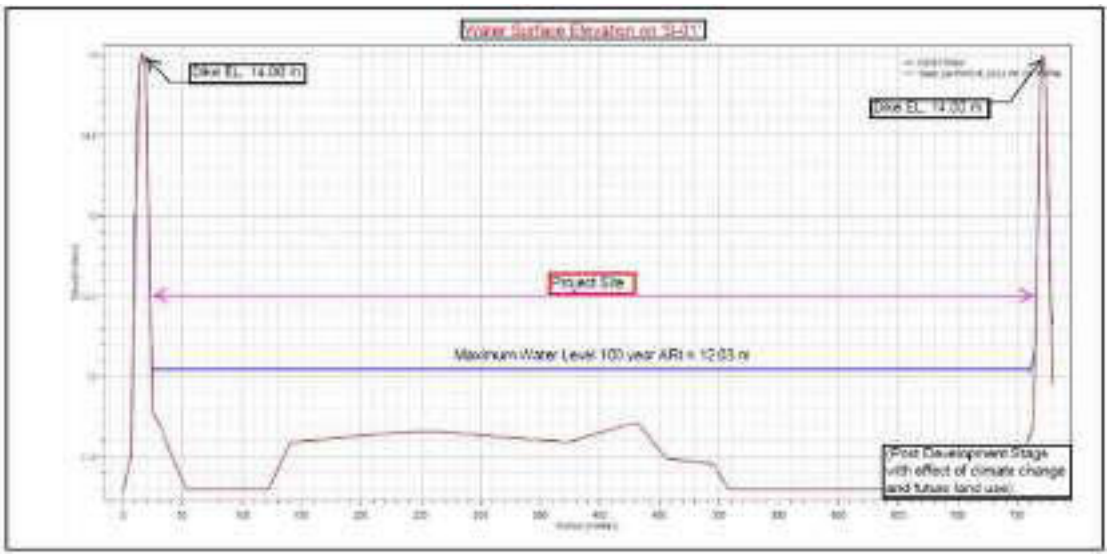


Plate 6-10: Flood depth 100 years ARI from local rain
(Post Development Stage with effect of climate change and future land use)

Animation of 2D flood at project site can be downloaded from;

https://drive.google.com/file/d/18WatyPGdE5d5eFQq02_-YFhVxtOo7XaY/view?usp=sharing

The flow rate at the project site from local rain is shown in ***Annex D***.
The amount of flow rate is used for internal drainage design in the post-development stage.

7.0 FLOOD MITIGATION

The flood mitigation for this project is suggested below.

- Flood dike height to 100-year ARI with freeboard 0.50 m. to protect PV module from flooding. (Dry site)

  OR

- Elevate PV module height to 100-year ARI with freeboard 0.50 m. and allow flooding within site.

7.1 Flood dike (Earth dike) height to 100-year ARI with freeboard 0.5 m.

As the existing soil is sandy soil with high water conductivity and requires a minimum side slope of 1:2(V: H) for an earth dike, we do not suggest an earth dike for flood protection for the following reasons.

7.1.1 Elevation of flood dike at EL.15.54 m. PWD required a large amount of soil to form a dike.

7.1.2 Footprint (toe of dike) will interfere with PV module area and reduce the usable area for PV arrays.

7.1.3 For a long period of flooding (2-3 months), a large volume of seepage water passing through the dike body and foundation will require water pumps to dry the site.

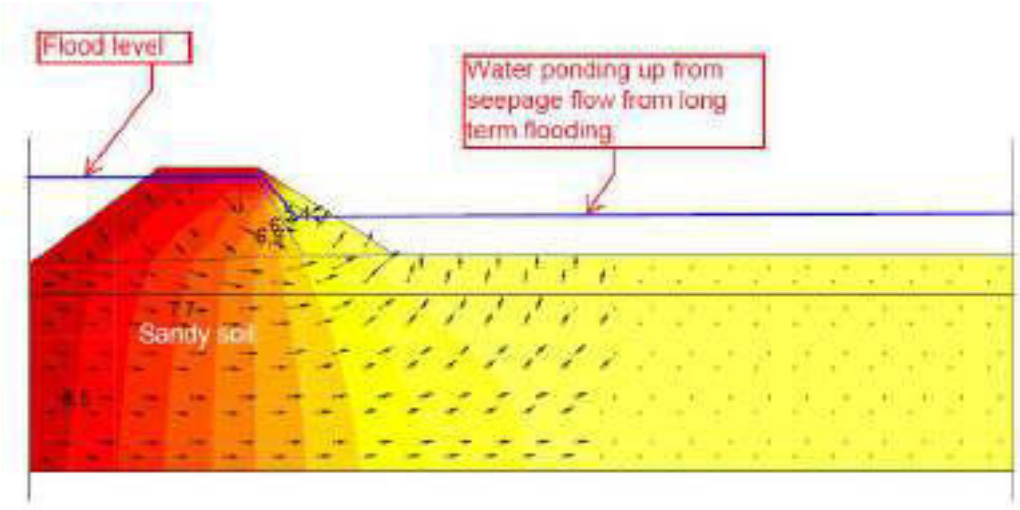


Plate 7-1: Seepage flow through earth dike

7.2 Elevate PV module height.

This option is preferred for a solar farm in a flood plain area for the following reasons.

7.2.1 Cost and timesaving of earthwork construction.

7.2.2 Gain more usable are for PV module arrays.

7.2.3 No water pump is required.

A typical drawing for this type of flood protection is shown below.

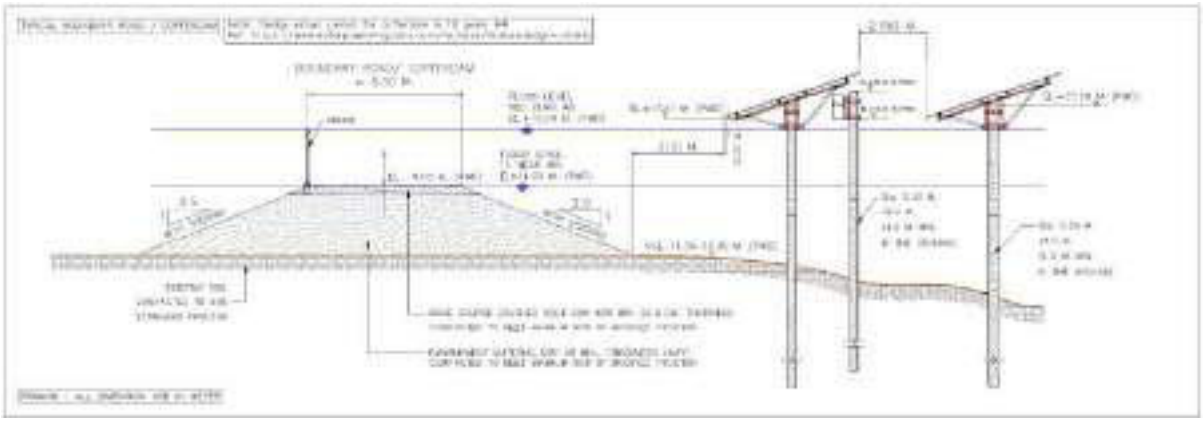


Plate 7-2: Typical flood protection by elevated PV module

The boundary road can be used for flood protection(cofferdam) from the overtopping of the Padma river during plant construction.

The elevation of the boundary road is suggested to meet the flood level at 10-year ARI for cofferdam design (EL.14.00 m.) ,*Ref:https://www.waterpowermagazine.com/features/featuredesign-criteria*

The ponding up of rainwater from local rain within the site (see ***Annex C***) is shown below.

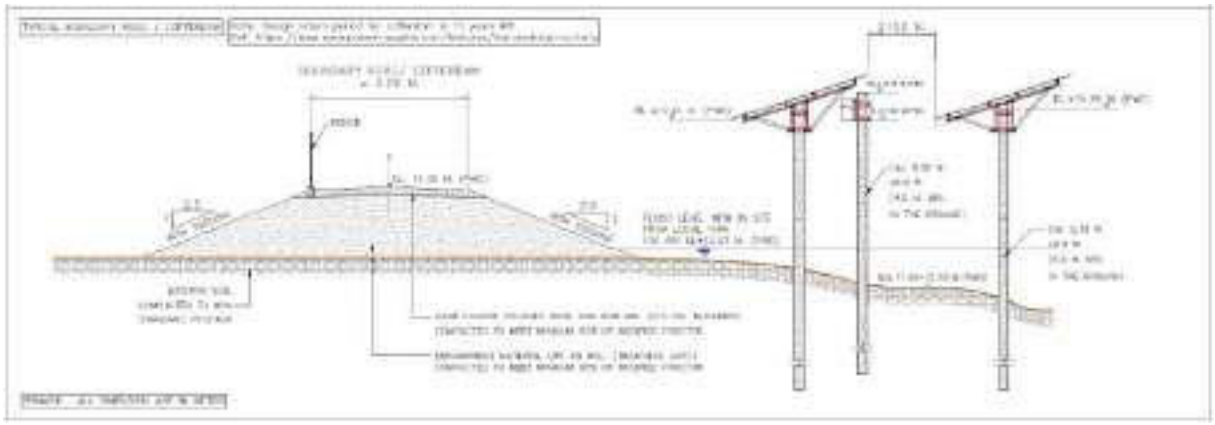


Plate 7-3: Flood level within site from internal rain (100 years ARI)

8.0 EROSION OF PROJECT SITE

Gradient of the Padma River is less than 1:1000 (see plate 6-2 and 6-3), flow velocity is mild.

From the site visit, no erosion on the river bank in front of the project site has been observed from the flat slope bear river bank in front of the project site.
Erosion control is not required.

Plate 8-1: Flat slope of riverbank in front of project site (No bank erosion)