ADB

Addendum to Environmental Impact Assessment

PUBLIC

July 2024

India: Assam Power Sector Investment Program - Tranche 3

120 MW Lower Kopili Hydroelectric Project

Prepared by Assam Power Generation Corporation Limited (APGCL), Government of Assam for the Asian Development Bank (ADB). This is an addendum to environmental impact assessment originally posted in June 2018 available on https://www.adb.org/projects/documents/ind-47101-004-eia-0 and Interim Addendum to EIA was posted on February 2024 available on https://www.adb.org/projects/documents/ind-47101-004-eia-1.

Asian Development Bank

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Project Number: 47101-004
June 2024

SFG Log: 6130

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CURRENCY EQUIVALENTS

(As of 23 May 2024)

Currency unit	–	Indian rupee (₹)
₹1.00	=	$0.012
$1.00	=	₹83.29

ABBREVIATIONS

AAQ	-	ambient air quality
AAQM	-	ambient air quality monitoring
ADB	-	Asian Development Bank
ADC	-	Autonomous District Council
APGCL	-	Assam Power Generation Corporation Limited
APH	-	auxiliary powerhouse
APSIP	-	Assam Power Sector Investment Program
ASPCB	-	Assam State Pollution Control Board
BDL	-	below detectable limit
BIS	-	Bureau of Indian Standards
BGL	-	below ground level
BOD	-	biochemical oxygen demand
CA	-	compensatory afforestation
CEA	-	Central Electricity Authority
CGWA	-	Central Ground Water Authority
CITES	-	Convention on International Trade in Endangered Species
CO	-	carbon monoxide
COD	-	chemical oxygen demand
CP-1	-	Contract Package 1 (Bldg & Infra)
CP-2	-	Contract Package 2 (Roads, Civil & HM)
CP3	-	Contract Package 3 (EM Works)
CP4	-	Contract Package 4 (Transmission Line)
CPCB	-	Central Pollution Control Board
CRTDP	-	Combined Resettlement and Tribal Development Plan
CRVA	-	Climate Risk and Vulnerability Assessment
CSC	-	Construction Supervision Consultant
CSMRS	-	Central Soil and Material Research Station
CWC	-	Central Water Commission
DFO	-	Divisional Forest Officer
DG	-	diesel generating set
DO	-	dissolved oxygen
DPR	-	detailed project report
d/s	-	downstream
EA	-	executing agency
EAC	-	Expert Appraisal Committee
EARF	-	environmental assessment and review framework
EC	-	environment clearance
e-flow	-	environmental flow
EHS	-	environment, health and safety
EIA	-	environmental impact assessment
EMoP	-	environmental monitoring plan
EMP	-	environmental management plan

EPC	-	engineering, procurement and construction
ESCAP	-	United Nations Economic and Social Commission for Asia and Pacific
FRL	-	full reservoir level
GHG	-	greenhouse gas
GIS	-	geographical information system
GoA	-	Government of Assam
GoI	-	Government of India
GSI	-	Geological Survey of India
HEP	-	hydroelectric project
HFL	-	highest flood level
HRT	-	head race tunnel
IA	-	implementing agency
IMD	-	Indian Meteorological Department
IRC	-	Indian Road Congress
IUCN	-	International Union for Conservation of Nature
IVI	-	important value index
IWPA	-	Indian Wildlife Protection Act, 1972
LHS	-	left hand side
LKHEP	-	Lower Kopili Hydroelectric Project
LPG	-	liquefied petroleum gas
LT	-	low tension
Max	-	maximum
MBBR	-	Moving bed biofilm reactor
MDDL	-	minimum draw down level
MFF	-	multitranche financing facility
Min	-	minimum
MOC	-	Memorandum of Changes
MoEF&CC	-	Ministry of Environment, Forest and Climate Change MoP
	-	Ministry of Power
MPH	-	main power house
MSL	-	mean sea level
MW	-	megawatt
NAAQS	-	National Ambient Air Quality Standards
N, S, E, W,	-	wind directions (north, south, east, west or combination
NEEPCO	-	Northeastern Electric Power Corporation Limited
NGO	-	non-governmental organization
NGT	-	India's National Green Tribunal
NH	-	national highway
NOC	-	No Objection Certificate
NO_x	-	oxides of nitrogen
NP	-	National Park
NPK	-	nitrogen, phosphates, and potassium
NPL	-	National Physical Laboratory, U.K.
NBWL	-	National Board for Wildlife of India
OSHA	-	Occupational Safety and Health Administration
PCC	-	Portland Cement Concrete
PD	-	Project Director
PFR	-	periodic financing request
PM	-	particulate matter
PIA	-	project influence area

PIU	-	Project Implementation Unit
PLF	-	Plant Load Factor
$PM_{2.5}$ or PM_{10}	-	Particulate matter of 2.5 micron or 10-micron size
PMSC	-	Project Management Supervision Consultant
PMU	-	Project Management Unit
PPE	-	personal protective equipment
PPT	-	parts per trillion
PUC	-	Pollution Under Control
PWD	-	Public Works Department
RCC	-	reinforced cement concrete
REA	-	Rapid Environmental Assessment
RHS	-	right hand side
RoW	-	right of way
RSPM	-	respiratory suspended particulate matter
SEIAA	-	State Environmental Impact Assessment Authority SESC
	-	Social and Environmental Safeguards Cell
SH	-	state highway
SEMP	-	site-specific environmental management plan
SO_2	-	sulphur dioxide
SoI	-	Survey of India
SPCB	-	State Pollution Control Board
SPL	-	sound pressure level
SPM	-	suspended particulate matter
SPS	-	ADB Safeguard Policy Statement, 2009
S/S	-	substation
ST	-	scheduled tribes
STP	-	sewage treatment plant
TA	-	technical assistance
T&D	-	transmission and distribution
TDS	-	total dissolved solids
TL	-	transmission line
ToR	-	terms of reference
TRC	-	tail race channel
TSS	-	total suspended solids
WLS	-	Wildlife Sanctuary
WWF	-	World Wildlife Fund
ZSI	-	Zoological Survey of India

WEIGHTS AND MEASURES

dB(A)	–	A-weighted decibel
ha	–	hectare
km	–	kilometre
km^2	–	square kilometer
kV	-	kilovolt (1000 volts)
kW	-	kilowatt (1000 watts)
kWh	-	kilowatt-hour
KWA	–	kilowatt ampere
Leq	–	equivalent continuous noise level
µg	–	microgram
m	–	meter

MW	–	megawatt

NOTES

(i) The fiscal year (FY) of the Government of India and its agencies begins on 1 April and ends on March 31. “FY” before a calendar year denotes the year in which the fiscal year ends, e.g., FY2023 begins on 1 April 2022 and ends on 31 March 2023.

(ii) In this report, "$" refers to US dollars.

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EXECUTIVE SUMMARY

The EIA for the Lower Kopili Hydro Electric Project (120 MW) was prepared during 2014-2015 and additional studies were done in 2017-2018. EIA was disclosed in 2018 on ADB's website and in 2019 on MoEF&CC's site. Environment Clearance was accorded on 4th September 2019. EC amendment was accorded on 3rd January 2024.

The interim addendum to EIA was prepared to reflect the changes in initial project scope and identify additional/residual environmental impacts, if any, based on field due diligence and devised mitigation measures as required. Interim EIA addendum was disclosed in February 2024.

The updated Addendum to EIA includes downstream and backwater impact assessment factoring in peaking power (10-daily flow data) as per draft reservoir operations manual and is based on primary survey data and modelling of the river morphology, hydrology and ecology. This addendum also includes final dam break analysis, emergency response plan for downstream areas; design provisions for treatment of acidic water runoff collected from weep holes in tank with automatic pH meter, dozing apparatus etc. prior to pumping out runoff to the river; recommendations for bird divertor installations on 220 KV, 33 KV and 400 KV transmission lines; information on newly found rheophytes, habitat suitability in reservoir area and downstream locations along with commitment to formulate and implement the offset management plan demonstrating how ADB's Safeguard Policy Statement 2009 critical habitat requirements will be met as would be applicable prior to dam impounding; updated environment mitigation and monitoring plan along with commitments of activities to be implemented prior to impounding of the reservoir.

To monitor the hourly flow data automatic Water Level /Velocity instruments are being installed in the upstream of the reservoir, based on which the dam operations plan and its associated impacts, additional if any would be refined as would be appropriate prior to impounding of reservoir. The study of the migratory aquatic species as stipulated by MoEF&CC in the EC amendment letter dated 03 January 2024 would take around a year to capture all season data. Once completed this will be incorporated appropriately in the safeguard documents and disclosed along with findings of detailed rheophytes survey in Kopili river (and elsewhere in Assam in relation to offset potential) and in-situ/ offset management plan as would be applicable. Unless the commitments as agreed are met the hydro power plant will operate on base flow and not as peaking power plant to prevent potential impacts of diurnal variation in water levels and flow.

The environmental assessment for roads that are proposed to be elevated viz. Longku Nala stretch of NH-627 (design not yet available from PWD and construction yet to commence), village roads likely to be submerged between Borolongku to Lorelangsu and road from NH-627 to Tortelangso will be included into the safeguards documents as would be appropriate and submitted to ADB for clearance and disclosure prior to impoundment of reservoir.

Dam design (including geological conditions) and safety during construction is being reviewed and monitored by the Dam Safety Experts continually and will also ensure that all pre impounding requirements are adequately addressed prior to impounding of the reservoir.

Community awareness raising and mock drills for disaster management prior to reservoir inundation will be carried out in collaboration with the District Disaster Management Authority (DDMA) and Assam State Disaster Management Authority (ASDMA). Awareness for rejuvenation of the existing sources of ground water in the downstream villages will be carried out by Central Ground Water Authority (CGWA) as part of their general program.

APGCL commits to ensure that submergence area will be cleared along with requisite permissions (in such manner that sediment generation due to loosening of soil and methane emission due to composting of terrestrial plants under water is minimum) in phases in consultation with forest department before impounding.

APGCL commits to ensure the implementation of slope protection measures of reservoir rim (both right and left bank), right bank slope at the downstream of main dam will be undertaken prior to impounding of reservoir in timely manner so that adequate time is available for the slope to stabilize. Achievements of all above commitments will be reported to ADB as part of pre impoundment report.

This updated addendum to EIA report is to be read along with the EIA disclosed in 2018 and interim addendum to EIA disclosed in Feb 2024.

1. Introduction

1. This Addendum is prepared as part of the Environmental Impact Assessment (EIA) of the Lower Kopili Hydroelectric Project (LKHEP or the project) being executed and implemented by Assam Power Generation Corporation Limited (APGCL) and funded under tranche 3 of an Asian Development Bank (ADB) loan through a Multi-tranche Financing Facility (MFF) for the Assam Power Sector Investment Program (APSIP). Tranche 3 of the MFF included one subproject i.e., construction of the 120 MW LKHEP in the State of Assam. Following ADB's Safeguard Policy Statement (SPS) 2009 requirements the project was classified as Category A for environment, hence an EIA was carried out by APGCL per ADB's SPS 2009 requirements.

2. The EIA report prepared by APGCL was disclosed on ADB's website in June 2018. It assessed the impact of the LKHEP and was based on feasibility design of DPR 2015, environmental baseline data collected in the year 2014 - 2015 as part of the EIA required by Ministry of Environment, Forest and Climate Change, GOI dated October 2016 and prepared by an APGCL appointed consultant (WAPCOS Ltd.) [1] Supplementary assessment studies were also carried out in 2017 by a consultant (ES Safeguards Compliance Services Private Limited, India) appointed by APGCL and the studies were part of the June 2018 EIA. Subsequently the tranche 3 loan for LKHEP was approved by ADB on 7 December 2020 with a condition that, prior to the commencement of civil works, an update to the June 2018 EIA report be prepared by APGCL to reflect up to date baseline data (including flora and fauna surveys following previous methodologies) and the EPC contractor's detailed design. APGCL also received environmental clearance from the Ministry of Environment, Forest, and Climate Change (MoEF&CC) of Government of India on 4 September 2019. Updated environmental baseline and pre-construction stage data has been collated by APGCL during 2020-2021. There have also been some adjustments in the layout of project components from June 2018 EIA report as part of detailed design by the EPC contractor, which was approved by Central Electricity Authority, GOI in November 2022. Thereafter, the interim Addendum was prepared to update the impact assessment in relation to these changes during implementation as a corrective action in accordance with ADB's Safeguard Policy Statement 2009, the project EARF, and tranche 3 Project Administration Manual.

3. Based on the EIA report 2019, after the approval of the Expert Appraisal Committee of MoEF&CC, Environment Clearance (EC) was accorded by MoEF&CC, GOI in the year 2019. As per EC stipulation, downstream impact assessment was to be carried out again after 5 years of commission of the Hydro Power Plant. It was found that hourly flow data was not available for the 2 upstream projects. Flow data is also not collected for river Kopili at Kneronighat gauze station of CWC. The required frequency of flow data, river morphology, etc. were not available for stretch of Kopili river with CWC and upstream dams. Hence, additional in-depth studies were carried out under JFPR grant on few of the above aspects to update the down stream impact assessment and back water

[1] There are thus two EIA reports for the project, the national EIA report disclosed at APGCL and MoEFCC websites and the June 2018 EIA report as disclosed on the ADB website

assessment and the collection of hourly data on water flow is expected to be completed before impounding of reservoir. APGCL further engaged experts to complete the study on impact of reservoir operations on the river ecology. The study on downstream impacts of peaking power got delayed because two upstream HEPs were not working after the disasters that occurred in the upper dam. A penstock (pipe) carrying water from the Kopili hydroelectric project to the main power station bursted, leading to massive flooding on 07 October 2019 and the incident led to the closure of 200 MW Kopili HEP run by NEEPCO. Again on 26.03.22 another incident occurred where valve house bursted, and consequently 75 MW Khandong Powerhouse of the Kopili Project was shut down. Both the plants were under repairing and maintenance (Figure 26) until after September 2023. Meanwhile though data on river morphology etc. could be collected and modelled, however hourly flow data truly representing the condition with upper dams being in operation could not be collected (complete data is expected to be available by July 2025). At present a draft reservoir operations plan has been prepared based on 10-daily flow data and used for the downstream impact assessment. Once the hourly flow data is available, reservoir operation plan will be updated, downstream impacts factoring peaking power will be updated and an optimum reservoir operations plan would be finalised. APGCL commits to complete all the above tasks prior to impounding of reservoir. Impacts on recently identified rheophilic species as stated in the report is preliminary due to lack of enough species level literary and survey data. Based on the preliminary findings, provision for offset management has been provided in the report. Once detailed survey is conducted in the next flowering season and impacts concluded, relevant mitigation measures either in the form of offset or in-situ management plan will be prepared and implemented prior to impounding of the reservoir. APGCL also commits to operate the plant in base flow and not as peaking power plant unless, the management measures are implemented.

4. This updated Addendum to EIA report contains Downstream and backwater assessment based on 10-daily flow of river water and updated dam break analysis and emergency action plan including resilience plan for pilot villages. The project remains in Category A for the environment as per ADB's SPS classification.

5. This Addendum is to be read in conjunction with the June 2018 EIA report[2] and Interim EIA addendum.[3]

1.1. Background of the Project

6. The LKHEP project is being funded by ADB under tranche 3 of the APSIP MFF which was approved on 7 December 2020 and became effective on 10 March 2021. APGCL is the executing and implementing agency for it.

7. The project is situated in the West Karbi Anglong and Dima Hasao (also known as North Cachar Hills) Autonomous District Council (ADC) areas of Central Assam. The

[2] Assam Power Sector Investment Program – Tranche 3: 120 MW Lower Kopili Hydroelectric Project Draft Environmental Impact Assessment | Asian Development Bank (adb.org)
[3] https://www.adb.org/projects/documents/ind-47101-004-eia-1

Project location (dam site) is defined by 25°39’57.39” N latitude and 92°46’53.62” E longitude. Project location maps are shown in Map 1, Map 2. Since the June 2018 EIA there have been no changes in the overall project location, approved project footprint, rationale, and justification of the project.

Map 1: Location of Project within Assam State

Map 2 : Administrative study area of Kopili river basin

8. The LKHEP is sited downstream of the existing Kopili HEP comprising the Khandong and Umrong dams at 30 km upstream of the LKHEP dam. The project envisages

utilization of the regulated discharge from the existing Kopili HEP and the discharge from the 788 km^2 intermediate catchment by creation of a reservoir and utilizing a gross head of about 114 m. The project is a run-of-river cum storage scheme (used for peaking power) on the Kopili river at Longku. The live storage in the reservoir will last for only a few days if the power generation runs at full installed capacity. It is therefore intended to run the main powerhouse (MPH) at full potential (for base load) in the monsoon season and operate it as a peaking power station in the non-monsoon/dry season for at least 3 hours a day (with reservoir storage occurring for 21 hours/day, with no tailrace discharge from the MPH). The MPH will receive water diverted at the dam at Longku on the Kopili river. The installed capacity of the MPH is 110 MW comprising of 2 units of 55 MW each. An Auxiliary Power House (APH) having a capacity of 10 MW (2x2.5 MW + 1x5 MW) is also planned at the toe of the dam for utilizing the mandatory releases for ecological purposes. The APH would operate throughout the day as here the water will be released constantly from the bottom of the dam to maintain the e-flow downstream of LKHEP dam at Longku. Automatic regulation valve (e.g. needle type control valve), and an ultrasonic flowmeter will be installed to monitor and maintain the E-flow. Even when the units at the Auxiliary Power House are not operational, E-flow will be preserved through a 1.5-meter diameter steel pipe. With a finalized length of 46.013 kilometers, the 220 kV transmission route will carry the 110 MW generated at the Main Power House to Sankardev Nagar substation. The 10 MW power generated from the Auxiliary Power House will be transmitted to Umrangso substation via the existing 22-kilometer construction power line (33 kV) laid by APGCL.

9. Water stored in the reservoir will be taken out for power generation through two separate intake structures, one for the MPH and the other for the APH. The MPH intake is on the right bank of the reservoir and would be controlled with 2 vertical gates. The APH intake also has 2 vertical gates. The MPH of 110 MW is designed to have an average net head of 108 m. It is estimated to produce 415.78 GWh of electricity per year under average hydrological conditions. The APH is estimated to have a net head of 47.3 m, to produce 53.80 GWh of electricity per year. Accordingly, the two power houses of LKHEP are expected to jointly produce 469.58 GWh per year, reflecting an annual capacity factor of 44.67%. Power generation capacity was also 120 MW in earlier EIAs by MoEF&CC and ADB. There have been no changes in the power generation capacity or operational regime in the final design since the June 2018 EIA.

1.2. Scope of the Addendum

10. This Addendum has been prepared to address the extent to which the assessment in the June 2018 EIA report remains valid, and any changes to the predicted impacts. Its scope considers:

(i) Detailed downstream and backwater impact assessment based on 10-daily water flow data and draft reservoir operation plan including conditions stipulated by MoEF&CC in the EC amendment letter dated 3rd Jan, 2024. For the assessment of aquatic migratory species study covering all the seasons are required. However, this report only contains data and related analysis for the period of February to May 2024. This addendum includes primary data and assessment on river ecology (aquatic and rheophilic species), impact on downstream wildlife sanctuary, tourist place etc.

(ii) design provisions as agreed for treatment of acidic water runoff collected from weep holes in tank with automatic pH meter, dozing apparatus etc. before the water is pumped out to the river;

(iii) Recommendations for bird divertor installations on 220 KV, 33 KV and 400 KV transmission lines,

(i) downstream impact assessment on ground water hydrology; and

(iv) Updated Dam break analysis.

(v) Emergency Action Plan - Emergency preparedness and evacuation plan for the community for Operations period;

(vi) Disaster resilience plan for pilot villages in the downstream

1.3. Outline of the updated Addendum

11. This Addendum includes sections on:

1. Introduction: Presents the project background, extent of the Addendum and the structure of the report.
2. Downstream Impact Assessment including backwater impact – Covers Topography and Hydrology, draft Reservoir Operation Plan, Impact on ground water, Aquatic ecology, Water quality, Flora and fauna.

3. Impact on Pabitora WLS
4. Impact on Panimur / Koka Water falls
5. Dam Break Analysis and impact on the downstream areas
6. Emergency action Plan
7. Update on Dam Investigation
8. Treatment of acidic water runoff
9. Updated Environment Management Plan (Additional measures)
10. Updated Environment Monitoring Plan (Additional measures)
11. Conclusions and Recommendations: Covers key findings and recommendations.

2. Down stream and Backwater Impact Assessment

12. Hydropower projects can disrupt flows and alter the magnitude, frequency, duration, and timing of flow regimes and their sediments. The four main ways that a hydro project can affect a river ecosystem that are:

a. partially or wholly dewatered river reach
b. Altered flow regime
c. Changes in longitudinal and lateral connectivity
d. Inter basin transfers.[4]
e. Resultant impact on river and riparian ecology
f. Downstream groundwater hydrology etc.

13. Not all hydropower projects have the same level of impact on their host river system, as many factors influence the potential severity. These factors relate to the location, design, and operating pattern of the hydropower project, and the associated degree of connectivity lost along the river, baseline river condition etc.

2.1. Topography and hydrology

2.1.1. River cross section survey

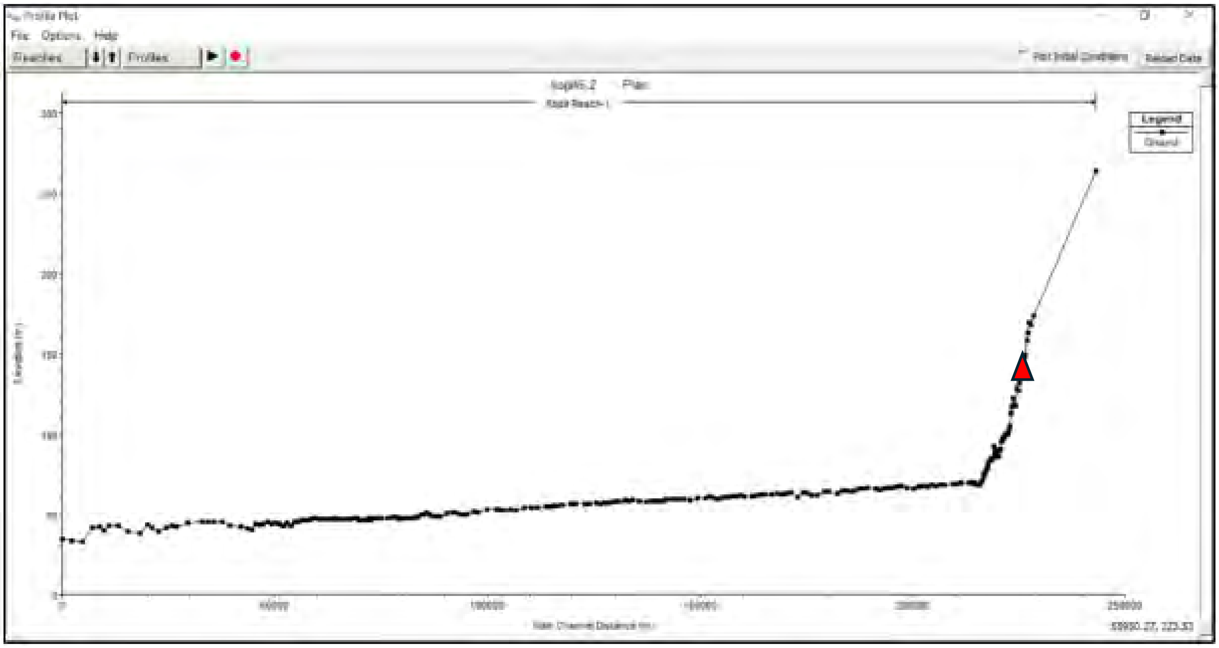
14. The river cross-section survey of Kopili River and its major tributaries were carried out by M/s RMSI under JFPR grant in 2023. The cross-section interval was about 250 m for a stretch of 14 km starting from LKHEP to the confluence point of the Mynriang river (56 cross sections). Following this, team has surveyed a further 216 km stretch of the Kopili river at variable intervals, starting from the confluence point of the Mynriang river to its confluence with Brahmaputra River (191 cross sections). In addition to the above, the team has also surveyed one cross-section at the NEEPCO Power plant site. The bed slope from upstream of the Lower Kopili proposed reservoir to the confluence with Mynriang is steep, drastically changing downstream. Downstream of Borpani, the riverbed exhibits significant undulation, possibly indicating large micro-scale bedforms in this stretch. The last 50-60 km reach is protected by embankments, influencing the high flow and morphology. In this reach, backwater effect from Brahmaputra, especially during high flows, may lead to sediment deposition in the Lower Kopili reaches.

[4] GOOD PRACTICE HANDBOOK Environmental Flows for Hydropower Projects Guidance for the Private Sector in Emerging Markets. The World Bank Group (WBG). Feb 2018 Source: https://www.ifc.org/content/dam/ifc/doc/mgrt-pub/gph-eflows-for-hydropower-projects-updated-compressed.pdf

Map 3: Location plan of surveyed cross-sections of Kopili river

15. The longitudinal profile of a river depicts change in elevation of the channel bed over the entire length of the river from its origin to its mouth. The longitudinal profile of Kopili river is shown in Figure 1.

Figure 1: Longitudinal Profile of Kopili River showing LKHEP



2.1.2. Major basins and their catchment areas

16. There are 9 major river basins with 53 sub basins in the Kopili river catchment (Map-4). Catchment area of each basin is mentioned in the table 1. Contribution of each tributary in the downstream are mentioned in Table 2.

Table 1: Major basins and their catchment areas

Sl. No.	Major Basin Name	Area (sq. km)
1	Kalang	516.0
2	Sonai	1215.0
3	Umiam	1417.8
4	Diganu	1783.8
5	Barpani	2386.1
6	Kopili	3286.3
7	Diyung	3884.2
8	Jamuna	4821.3
9	Intermittent basins	1250.0
Total		20,560.5

Map-4: Major basins under river Kopili

Table 2 : Adopted flow at all the river confluence downstream of LKHEP
(Used for DBA)

River	Distance from LKHEP (km)	Average Flow Considered (cumec)
Amreg River	14.4	21.49
Jamuna River	27.1	19.25
Diyang River	94.7	93.35
Kolong River	139.2	101.54
Borpani River	142.3	57.45
Umium River	166.6	32.98
Digaru River	222.3	36.82

2.1.3. Dam Operation Hydrograph

17. The dam operation hydrograph is prepared as per the draft reservoir operation plan to be adopted for Lower Kopili HEP. In this regard, it is relevant to clarify that two types of reservoir operation plan can be prepared depending on the availability of type of inflow data. If long-term monthly or ten-daily inflow data are available, reservoir operation plan will be of a long-range or seasonal control. Similarly, if long-term daily/hourly inflow data are available, reservoir operation plan will be of a short-range or day-to-day control.

18. At present, long-term daily/hourly inflow data of Kopili river at dam of Lower Kopili HEP is not available. Therefore, reservoir operation plan is developed on the basis of available long term (18 years) inflow data from the year 1998-99 to 2015-16. The following data are used for the preparation of the present report:

(i) Approved 10-Daily Flow Series data of Kopili river of 18 years (Year 1998-99 to Year 2015-16)

(ii) Approved monthly ecological release data as per MoEF

(iii) Area-Elevation-Reservoir Capacity Curve of Lower Kopili Dam

(iv) Reservoir Operation Plan (Draft) of Lower Kopili Dam

(v) IS 7323 (1994): Operation of Reservoirs – Guidelines

19. The proposed reservoir of Lower Kopili Dam will serve only one purpose i.e power generation, therefore it is defined as a single purpose reservoir. In reality, Lower Kopili reservoir will be operated in an integrated manner along with existing Khandong dam and Umrangsu dam located at upstream of Lower Kopili dam for optimum utilisation of Kopili river system.

20. In the preparation of reservoir operation plans for an integrated operation of system of reservoirs, principles applicable to separate units are first applied to the individual reservoirs.

21. Accordingly, in the present study, dam operation hydrograph is prepared as per reservoir operation plan of Lower Kopili dam solely. A rule curve is developed for LKHEP reservoir showing the limiting elevations above which the reservoir is not to be operated throughout the year (Table 3). An integrated Reservoir operation system will be developed before the operation of the LKHEP.

Table 3: Dam Operation Hydrograph

Month	Period	Days	Ecological Release (m^3/s)	Spill from Dam(m^3/s)		Total Release from Dam(m^3/s)	
				Max	Min	Max	Min
Jun	I	10	33.97	135.52	0.00	169.49	33.97
	II	10	33.97	154.94	0.00	188.91	33.97
	III	10	33.97	337.34	0.00	371.31	33.97
Jul	I	10	33.97	191.81	0.00	225.78	33.97
	II	10	33.97	139.07	0.00	173.04	33.97
	III	11	33.97	222.26	0.00	256.23	33.97
Aug	I	10	33.97	275.73	0.00	309.70	33.97
	II	10	33.97	134.52	0.00	168.49	33.97
	III	11	33.97	65.23	0.00	99.20	33.97
Sep	I	10	33.97	175.04	0.00	209.01	33.97
	II	10	33.97	27.94	0.00	61.91	33.97

Month	Period	Days	Ecological Release (m^3/s)	Spill from Dam(m^3/s)		Total Release from Dam(m^3/s)	
				Max	Min	Max	Min
	III	10	33.97	29.20	0.00	63.17	33.97
Oct	I	10	16.835	84.19	0.00	101.02	16.84
	II	10	16.835	55.26	0.00	72.10	16.84
	III	11	16.835	44.10	0.00	60.94	16.84
Nov	I	10	16.835	2.90	0.00	19.74	16.84
	II	10	16.835	0.00	0.00	16.84	16.84
	III	10	16.835	0.00	0.00	16.84	16.84
Dec	I	10	5.345	0.00	0.00	5.35	5.35
	II	10	5.345	0.00	0.00	5.35	5.35
	III	11	5.345	0.00	0.00	5.35	5.35
Jan	I	10	5.345	0.00	0.00	5.35	5.35
	II	10	5.345	0.00	0.00	5.35	5.35
	III	11	5.345	0.00	0.00	5.35	5.35
Feb	I	10	5.345	0.00	0.00	5.35	5.35
	II	10	5.345	0.00	0.00	5.35	5.35
	III	8	5.345	0.00	0.00	5.35	5.35
Mar	I	10	5.345	0.00	0.00	5.35	5.35
	II	10	5.345	0.00	0.00	5.35	5.35
	III	11	5.345	0.00	0.00	5.35	5.35
Apr	I	10	16.835	0.00	0.00	16.84	16.84
	II	10	16.835	0.00	0.00	16.84	16.84
	III	10	16.835	1.36	0.00	18.19	16.84
May	I	10	16.835	0.00	0.00	16.84	16.84
	II	10	16.835	0.00	0.00	16.84	16.84
	III	11	16.835	36.55	0.00	53.39	16.84

2.1.4. Change in the water level due to LKHEP Reservoir operation.

22. Based on this Dam operation Hydrograph pre and post LKHEP low and high flow events in the downstream up to the confluence of the river Brahmaputra (228 Km) has been analysed in the Table 4. Water levels were also compared to know the changes with the project and without the project scenario.

23. Influence of water level has been observed up to around 95 Km downstream from the LKHEP Dam (Figure 2). After that point there is no significant change in the water level. Low flow events after LKHEP varied between 0.03 m to 0.45 m in different sections of the river. Similarly, during monsoon, the water level will increase by 0.03 m to 1.5 m. Major changes are observed in the Dam to the confluence of the Amring River only. So downstream of LKHEP has been considered upto 95 Km. Influence of Brahmaputra water level can be seen upto around 139.2 km downstream from the dam (near the confluence of Kolong river).

Table 4: Water Level in the downstream pre and post LKHEP

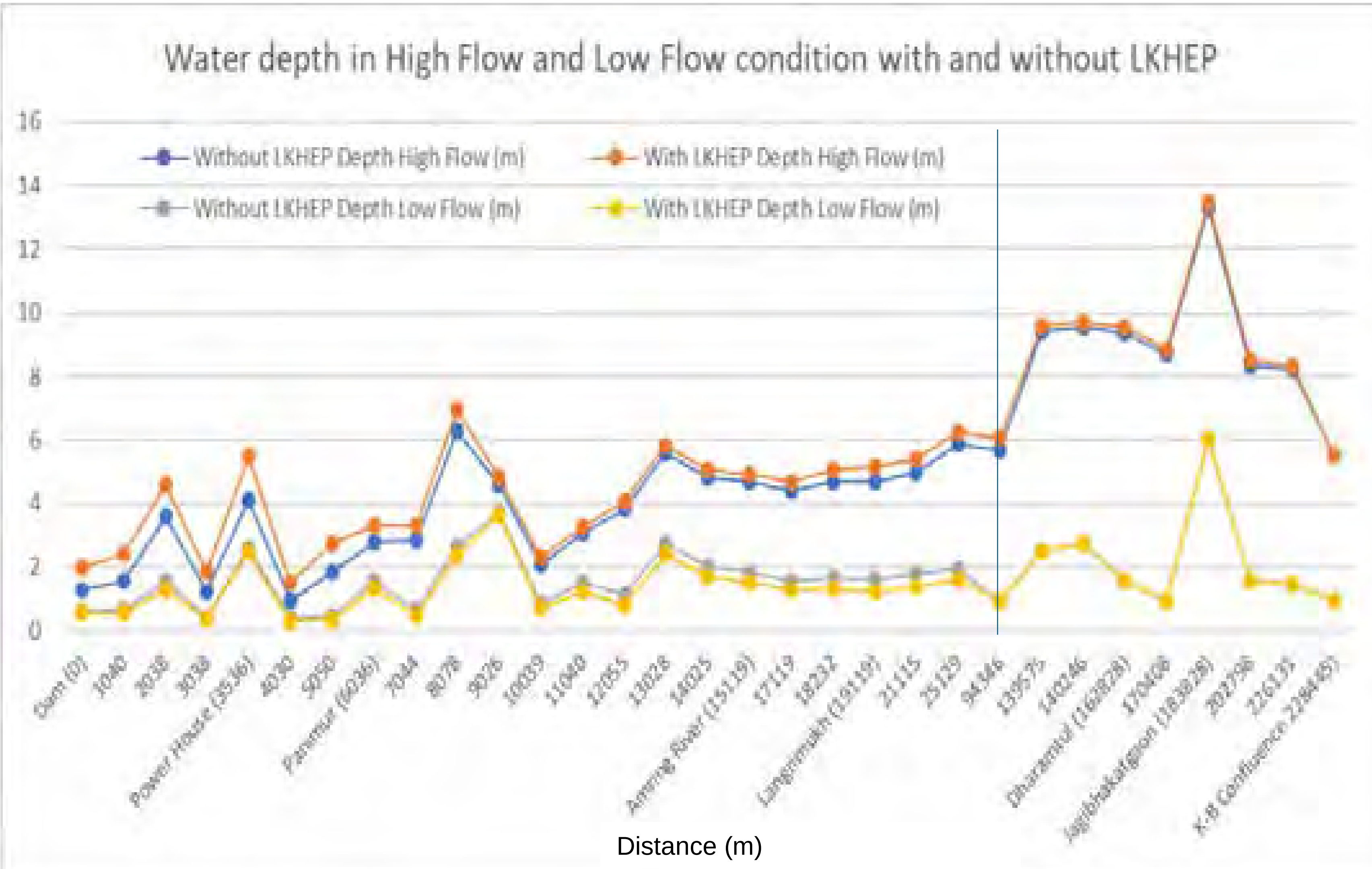
		Before LKHEP				After LKHEP						Difference	
Distance from LKHEP (m)	Bed Level (m)	Min WSE (m)	Max WSE (m)	Depth Low Flow (m)	Depth High Flow (m)	Max WSE (m)	Min WSE (m)	Depth Low Flow (m)	Depth High Flow (m)	CWC Station	Location	Decrease in Low Flow (m)	Increase in High Flow (m)
0	173.33	173.94	174.61	0.61	1.28	175.33	173.89	0.56	2		LKHEP Dam	0.05	0.72
539	167.55	171.47	172.87	3.92	5.32	173.89	171.29	3.74	6.34			0.18	1.02
800	168.65	171.47	172.87	2.82	4.22	173.89	171.29	2.64	5.24			0.18	1.02
1040	169.23	169.91	170.79	0.68	1.56	171.63	169.82	0.59	2.4			0.09	0.84
1329	163.06	163.77	165.16	0.71	2.10	166.53	163.68	0.62	3.47			0.09	1.37
1540	158.31	158.61	159.20	0.30	0.89	159.97	158.61	0.3	1.66			0.00	0.77
2038	148.83	150.39	152.41	1.56	3.58	153.44	150.14	1.31	4.61			0.25	1.03
2286	147.27	147.95	149.11	0.68	1.84	149.92	147.84	0.57	2.65			0.11	0.81
2539	140.09	140.96	142.29	0.87	2.20	143.44	140.84	0.75	3.35			0.12	1.15
2800	136.4	138.75	139.91	2.35	3.51	140.58	138.57	2.17	4.18			0.18	0.67
3038	137.61	138.06	138.86	0.45	1.25	139.46	137.98	0.37	1.85			0.08	0.60
3282	132.07	132.71	134.13	0.64	2.06	135.47	132.61	0.54	3.4			0.10	1.34
3536	127.5	130.12	131.64	2.62	4.14	132.99	129.97	2.47	5.49			0.15	1.35
3796	126.9	130.12	131.54	3.22	4.64	132.58	129.97	3.07	5.68			0.15	1.04
4030	128.83	129.20	129.81	0.37	0.98	130.36	129.14	0.31	1.53			0.06	0.55
4259	117.86	123.08	124.35	5.22	6.49	125.85	122.98	5.12	7.99			0.10	1.50
4550	118.17	123.08	124.04	4.91	5.87	124.55	122.98	4.81	6.38			0.10	0.51
4787	122.48	123.08	124.04	0.60	1.56	124.55	122.98	0.5	2.07			0.10	0.51
5050	117.27	117.74	119.14	0.47	1.87	120.01	117.63	0.36	2.74			0.11	0.87
5286	113.04	113.72	114.80	0.68	1.76	115.4	113.55	0.51	2.36			0.17	0.60
5543	104.89	106.22	108.77	1.33	3.88	109.75	105.91	1.02	4.86			0.31	0.98

		Before LKHEP				After LKHEP						Difference	
Distance from LKHEP (m)	Bed Level (m)	Min WSE (m)	Max WSE (m)	Depth Low Flow (m)	Depth High Flow (m)	Max WSE (m)	Min WSE (m)	Depth Low Flow (m)	Depth High Flow (m)	CWC Station	Location	Decrease in Low Flow (m)	Increase in High Flow (m)
5789	102.89	103.39	104.77	0.50	1.88	105.36	103.26	0.37	2.47		Main Power House	0.13	0.59
6036	99.83	101.39	102.61	1.56	2.78	103.15	101.18	1.35	3.32			0.21	0.54
6315	100.38	101.35	102.52	0.97	2.14	103.13	101.14	0.76	2.75			0.21	0.61
6550	99.46	100.25	101.90	0.79	2.44	102.44	100.08	0.62	2.98			0.17	0.54
6793	97.86	99.23	101.31	1.37	3.45	101.92	99.07	1.21	4.06			0.16	0.61
7044	98.09	98.76	100.92	0.67	2.83	101.39	98.57	0.48	3.3			0.19	0.47
7285	96.43	98.20	100.50	1.77	4.07	100.77	97.85	1.42	4.34			0.35	0.27
7546	95.6	96.25	98.38	0.65	2.78	99.14	96.07	0.47	3.54			0.18	0.76
7803	90.58	92.84	96.41	2.26	5.83	97.08	92.55	1.97	6.5			0.29	0.67
8078	90.17	92.82	96.48	2.65	6.31	97.14	92.54	2.37	6.97			0.28	0.66
8282	85.87	92.80	95.92	6.93	10.05	96.48	92.53	6.66	10.61			0.27	0.56
8548	90.19	92.80	95.92	2.61	5.73	96.48	92.53	2.34	6.29			0.27	0.56
8818	86.18	92.52	93.34	6.34	7.16	93.59	92.42	6.24	7.41			0.10	0.25
9026	88.76	92.52	93.34	3.76	4.58	93.59	92.42	3.66	4.83			0.10	0.25
9256	92.15	92.48	93.33	0.33	1.18	93.61	92.45	0.3	1.46			0.03	0.28
9556	84.74	85.68	87.15	0.94	2.41	87.51	85.47	0.73	2.77		Panimur	0.21	0.36
9783	84.26	85.13	86.44	0.87	2.18	86.7	84.98	0.72	2.44			0.15	0.26
10039	84.23	85.08	86.34	0.85	2.11	86.57	84.93	0.7	2.34			0.15	0.23
10268	83.59	84.45	85.84	0.86	2.25	86.08	84.21	0.62	2.49			0.24	0.24
10532	81.96	82.66	83.92	0.70	1.96	84.14	82.49	0.53	2.18			0.17	0.22
10795	78.76	80.09	82.65	1.33	3.89	82.88	79.71	0.95	4.12			0.38	0.23
11040	76.89	78.40	79.95	1.51	3.06	80.14	78.12	1.23	3.25			0.28	0.19
11293	76.5	77.17	78.76	0.67	2.26	79	77	0.5	2.5			0.17	0.24

		Before LKHEP				After LKHEP						Difference	
Distance from LKHEP (m)	Bed Level (m)	Min WSE (m)	Max WSE (m)	Depth Low Flow (m)	Depth High Flow (m)	Max WSE (m)	Min WSE (m)	Depth Low Flow (m)	Depth High Flow (m)	CWC Station	Location	Decrease in Low Flow (m)	Increase in High Flow (m)
11554	74.09	76.13	77.65	2.04	3.56	77.69	75.88	1.79	3.6			0.25	0.04
11778	75	75.58	77.21	0.58	2.21	77.39	75.41	0.41	2.39			0.17	0.18
12055	71.21	72.35	75.07	1.14	3.86	75.3	72.02	0.81	4.09			0.33	0.23
12288	69.94	71.29	74.05	1.35	4.11	74.27	70.96	1.02	4.33			0.33	0.22
12541	68.22	71.24	74.08	3.02	5.86	74.3	70.91	2.69	6.08			0.33	0.22
12777	68.71	71.24	74.08	2.53	5.37	74.3	70.91	2.2	5.59			0.33	0.22
13028	68.47	71.24	74.08	2.77	5.61	74.3	70.91	2.44	5.83			0.33	0.22
13274	68.2	71.24	74.06	3.04	5.86	74.28	70.91	2.71	6.08			0.33	0.22
13529	68.58	71.24	74.05	2.66	5.47	74.27	70.91	2.33	5.69			0.33	0.22
13774	68.71	71.23	74.02	2.52	5.31	74.24	70.91	2.2	5.53			0.32	0.22
14025	69.17	71.23	74.00	2.06	4.83	74.23	70.9	1.73	5.06			0.33	0.23
14300	69.82	71.22	73.99	1.40	4.17	74.21	70.9	1.08	4.39			0.32	0.22
15119	69.26	71.11	73.96	1.85	4.70	74.2	70.78	1.52	4.94		Amring River	0.33	0.24
17119	69.37	70.95	73.79	1.58	4.42	74.07	70.65	1.28	4.7			0.30	0.28
18232	68.85	70.53	73.55	1.68	4.70	73.92	70.2	1.35	5.07			0.33	0.37
19119	68.73	70.36	73.44	1.63	4.71	73.87	69.98	1.25	5.14	Langrim ukh		0.38	0.43
21115	68.4	70.22	73.35	1.82	4.95	73.79	69.79	1.39	5.39			0.43	0.44
21937	67.96	69.92	73.29	1.96	5.33	73.71	69.52	1.56	5.75			0.40	0.42
23155	67.9	69.81	73.26	1.91	5.36	73.68	69.42	1.52	5.78			0.39	0.42
24119	67.98	69.66	73.23	1.68	5.25	73.63	69.25	1.27	5.65			0.41	0.40
25129	67.31	69.24	73.18	1.93	5.87	73.56	68.93	1.62	6.25			0.31	0.38
26137	67.46	69.19	73.16	1.73	5.70	73.54	68.91	1.45	6.08			0.28	0.38

		Before LKHEP				After LKHEP						Difference	
Distance from LKHEP (m)	Bed Level (m)	Min WSE (m)	Max WSE (m)	Depth Low Flow (m)	Depth High Flow (m)	Max WSE (m)	Min WSE (m)	Depth Low Flow (m)	Depth High Flow (m)	CWC Station	Location	Decrease in Low Flow (m)	Increase in High Flow (m)
27119	66.82	69.03	73.12	2.21	6.30	73.47	68.84	2.02	6.65		Diyung River	0.19	0.35
94346	58.96	59.94	64.62	0.98	5.66	65	59.91	0.95	6.04		Jamuna River	0.03	0.38
95369	58.17	59.59	64.39	1.42	6.22	64.77	59.56	1.39	6.6			0.03	0.38
139575	49.08	51.61	58.50	2.53	9.42	58.7	51.61	2.53	9.62		Kolong River	0.00	0.20
140246	48.86	51.60	58.40	2.74	9.54	58.58	51.6	2.74	9.72			0.00	0.18
143311	50.15	50.99	58.14	0.84	7.99	58.3	50.99	0.84	8.15		Barpani River	0.00	0.16
143577	49.94	50.94	58.09	1.00	8.15	58.25	50.94	1	8.31			0.00	0.16
162828	47.01	48.57	56.39	1.56	9.38	56.55	48.57	1.56	9.54	Dharamtul		0.00	0.16
170268	47.09	48.07	55.74	0.98	8.65	55.91	48.07	0.98	8.82		Umiam River (168.6 km)	0.00	0.17
170408	47.03	48.01	55.72	0.98	8.69	55.89	48.01	0.98	8.86			0.00	0.17
183828	40.82	46.84	54.13	6.02	13.31	54.29	46.84	6.02	13.47	Jagibhakatgaon		0.00	0.16
202798	43.17	44.72	51.52	1.55	8.35	51.67	44.72	1.55	8.5			0.00	0.15
226131	33.49	34.99	41.74	1.50	8.25	41.8	34.99	1.5	8.31		Digaru River (222.6 km)	0.00	0.06
228445	32.73	33.68	38.26	0.95	5.53	38.29	33.68	0.95	5.56		K-B Confluence	0.00	0.03

Figure 2: Pre and Post LKHEP water depth (M) in low and high Flow Events



(Note : Chainages are in meter)

2.2. Reservoir operations Plan

24. The proposed Lower Kopili Hydroelectric Project (LKHEP) is the second stage development of Kopili River Catchment Area in east of Karbi Anglong district of Assam near Longku. The first stage which is upstream of the proposed LKHEP, consists of (3 x 25 MW) Khandong HEP and (4 x 50 MW) Kopili HEP schemes. Both the projects are being operated and maintained by M/s NEEPCO. The LKHEP scheme has been contemplated to run at full potential in monsoon season and operate as a peaking station in non-monsoon season. The installed capacity of the project is envisaged as 120 MW comprising of the Main Powerhouse with 2 units of 55 MW each and an Auxiliary Powerhouse with an installed capacity of 10 MW located at the dam toe.

25. The proposed reservoir of Lower Kopili Dam will serve only one purpose i.e. power generation, therefore it is defined as a single purpose reservoir. In reality, Lower Kopili reservoir will be operated in an integrated manner along with existing Khandong dam and Umrangsu dam located at upstream of Lower Kopili dam for optimum utilisation of Kopili river system.

26. A rule curve is developed for LKHEP reservoir showing the monthly variation of limiting elevations within which the reservoir is to be operated throughout the year. A rule curve is generally based on detailed sequential analysis of various critical combinations of hydrological conditions and water demands. Reservoir operation rule based on historical inflow data is equivalent to presuppose that historical inflow pattern will be repeated in the future. The rule curve is selected such a way that average annual energy should be more than target annual energy of 451.71 MU.

27. An iterative procedure is used for establishing operation rules of Lower Kopili reservoir that attain the following goals.

- o Maximization of Power Generation of Main Powerhouse
- o Minimization of overflow/spilling of water from reservoir
- o Release of Environmental flow as per MoEF&CC stipulation

28. The Kopili River catchment, having lower altitudes, does not receive snowfall. Heavy rainfall starts from the month of April due to thunderstorm activity, which is followed by the south-west monsoon. The base-flow contribution sustains the flow in the river during non-monsoon months. Considering the inflow pattern, rule curve is divided into two distinct periods namely (i) filling period (April to July) and (ii) depletion period (October to Mid-March).

29. In general, one of key functions of hydropower storages is to minimise spill during high flow (monsoon) periods and to operate at the highest possible reservoir level during other seasons. Therefore, rule curve is prepared considering two conflicting criteria i.e. (i) Maximization of Energy & (ii) Minimization of spill from reservoir.

30. Average annual flow for 18 years (1998-99 to 2015-16) of Kopili river at proposed dam site of LKHEP is estimated as 2533 MCM. The rule curve is selected such a way

that average annual spill should be less than 10% of 2533 MCM. It is pertinent here to clarify that the inflow at the proposed Lower Kopili dam is influenced by operational rules and releases from the Kopili Power Plant and Umrong Dam, particularly in the lean season. At present, long-term daily/hourly inflow data of Kopili river at dam of Lower Kopili HEP is not available. Therefore, reservoir operation plan is developed on the basis of available long term (18 years) 10 daily inflow data from the year 1998-99 to 2015-16. Summary of the flow pattern of Kopili river is shown in Table 5.

Table 5: Flow Pattern of Kopili River at Lower Kopili Dam Site

S. No.	Flow Characteristics	Unit	Values
1	Average Annual Flow	MCM	2533
2	Maximum Annual Flow	MCM	2991
3	Minimum Annual Flow	MCM	2184
4	Average monsoon Flow (June-Oct.)	MCM	1726
5	Average non-monsoon Flow (Nov.-May)	MCM	807
6	Maximum 10-daily discharge (June III 2023-2024)	m3/s	495.68
7	Maximum 10-daily Non-Monsoon (Nov.-May) discharge	m3/s	184.28
8	Minimum 10-daily discharge (April II 1998-1999)	m3/s	6.13
9	Minimum 10-daily Monsoon (June-Oct.) discharge	m3/s	22.25

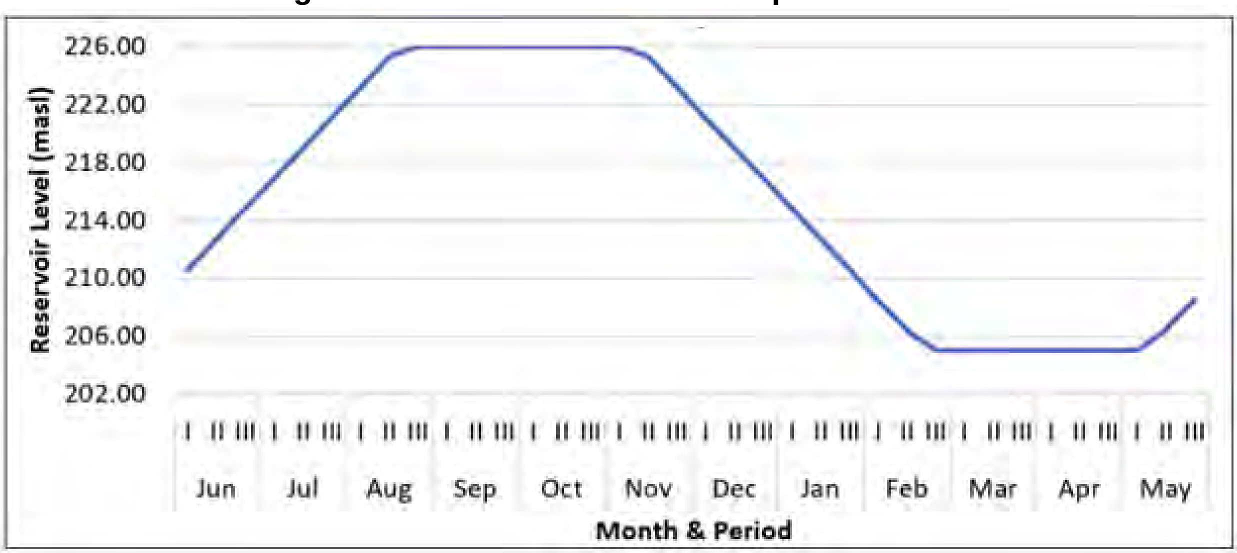
31. Month Wise Target Reservoir Level as per Rule Curve is shown in the table 6. Rule Curve of Lower Kopili Reservoir is presented in Figure 3.

Table 6: Month Wise Target Reservoir Level

Month	Period	Starting Reservoir Level (masl)	End Reservoir Level (masl)
June	I	209.20	211.30
	II	211.30	213.40
	III	213.40	215.50
July	I	215.50	217.60
	II	217.60	219.70
	III	219.70	221.80
August	I	221.80	223.90
	II	223.90	226.00
	III	226.00	226.00
September	I	226.00	226.00
	II	226.00	226.00
	III	226.00	226.00
October	I	226.00	226.00
	II	226.00	226.00
	III	226.00	226.00
November	I	226.00	226.00

	II	226.00	223.90
	III	223.90	221.80
December	I	221.80	219.70
	II	219.70	217.60
	III	217.60	215.50
January	I	215.50	213.40
	II	213.40	211.30
	III	211.30	209.20
February	I	209.20	207.10
	II	207.10	205.00
	III	205.00	205.00
March	I	205.00	205.00
	II	205.00	205.00
	III	205.00	205.00
April	I	205.00	205.00
	II	205.00	205.00
	III	205.00	205.00
May	I	205.00	205.00
	II	205.00	207.10
	III	207.10	209.20

Figure 3: Rule Curve of Lower Kopili Reservoir



2.3. Impact on Ground Water in the downstream

32. Surface water generated by rainfall is the main source of water in the Kopili basin. Ground water is also available and used in the plain areas of the basin. According to the central Ground Water Authority (CGWA), there is abundance of ground water resources in Assam and Meghalaya, with a large potential to utilize for domestic use as well as for irrigation.

2.3.1. Pre-and Post-dam discharge Scenarios

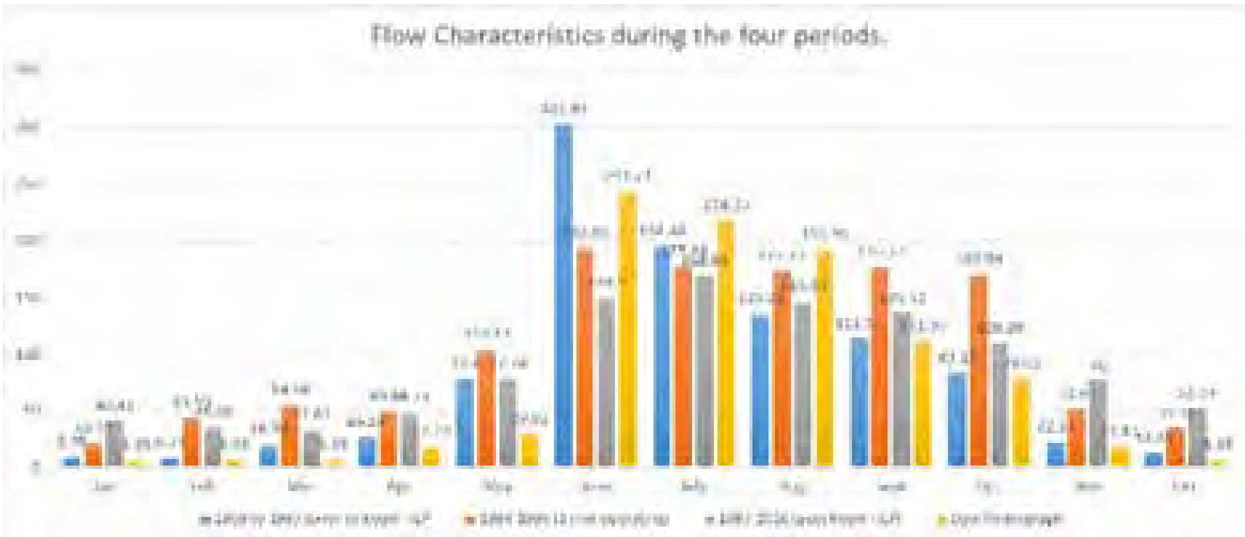
33. As mentioned above, to assess the impact of the Kopili dam on river flow and to establish before and after dam discharge scenario, the period from 1959 to 1983 was considered as pre-dam era while period from 1999 to 2016 was considered post-dam era. It is clearly observed that mean of monthly mean discharge was increased from 84.55 m3/s to 89.49 m3/s in post dam era. As far as mean of monthly maximum is concerned, it has reduced significantly from 486.20 m3/s to 192.68 m3/s in post dam period while mean of monthly minimum was increased significantly in post dam period from 20.72 m3/s to 55.53 m3/s.

34. The following table 7 and figure 4 depicts mean monthly flow during the 4 periods. Period I - 1959 to 1983 (prior to Kopili HEP); Period II- 1984-1996 (1 unit operating); Period III- 1997-2023 (post Kopili HEP) and Period IV- Post LKHEP.

Table 7: Summary of Mean Monthly Flows m3/s at LKHEP during the four periods

Years		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
1959 to 1983 (prior to Kopili HEP		8.95	8.33	18.96	26.54	77.6	301.87	194.48	135.29	112.57	83.11	22.27	12.35	83.82
1984-1996 (1 unit operating)		20.35	43.59	54.56	49.03	103.13	192.95	177.34	172.73	176.37	169.94	51.84	34.31	103.85
1997-2023 (post Kopili HEP)		40.41	35.06	32.81	46.73	77.78	148.9	168.84	145.39	135.53	109.39	76.0	52.04	89.05
Dam Hydrograph of LKHEP during operation	Max	5.35	5.35	5.35	17.29	29.02	243.24	218.35	192.46	111.36	78.02	17.81	5.35	77.41
	Min	5.35	5.35	5.35	16.84	16.84	33.97	33.97	33.97	33.97	16.84	16.84	5.35	18.72

Figure 4 : Change in flow characteristics at LKHEP Dam site pre and post KHEP and LKHEP

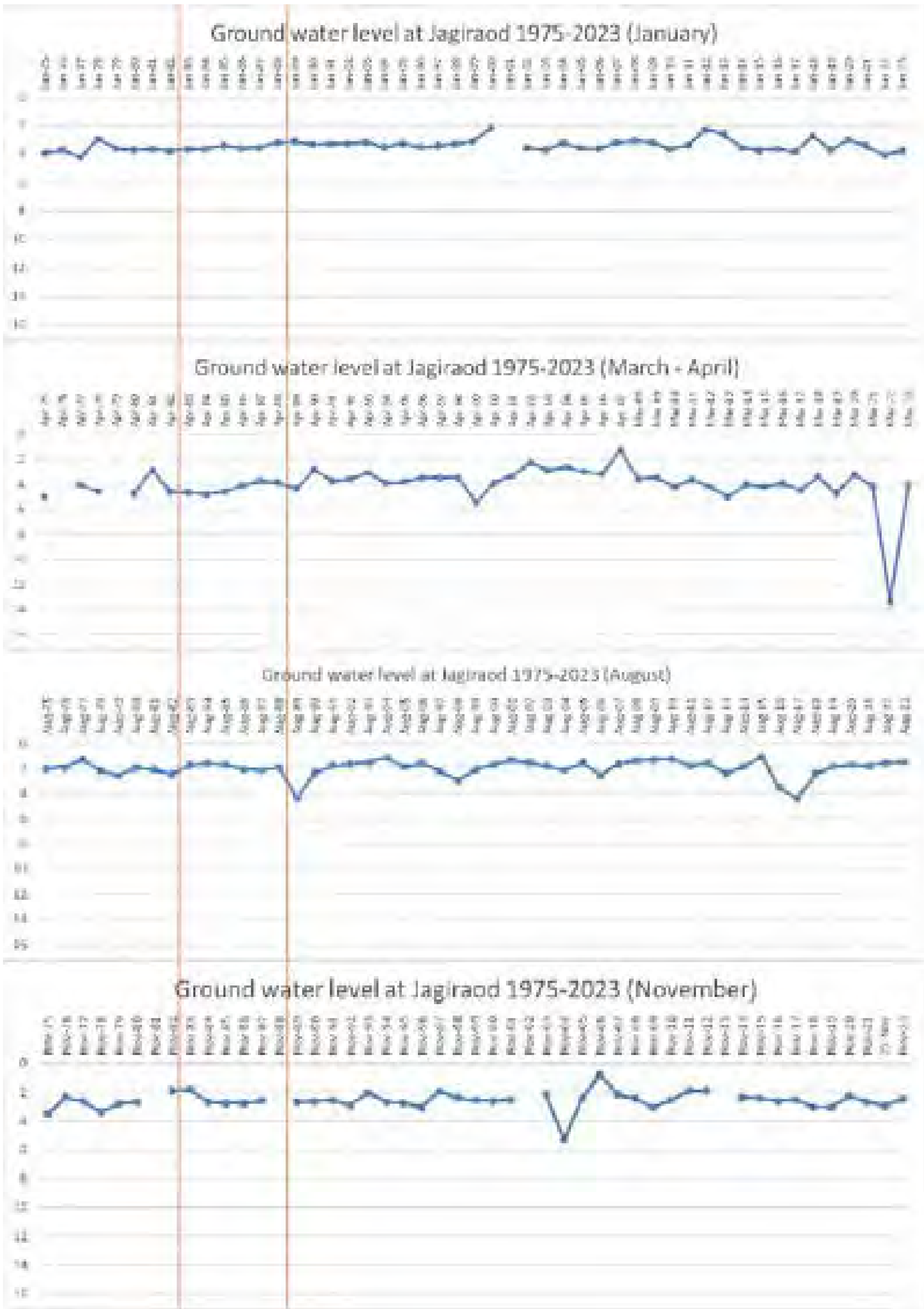


2.3.2. Impact on ground water level in the down stream

35. To know the impact of the reservoirs on the ground water level in the downstream, water level parameters of the 10 monitoring wells maintained by CGWA were analysed for all the seasons (Figure 5). There was no significant change in the ground water level over the years. As Jagiroad station has longest series of data set, hence the results of that station for each season are presented in the Figure 6 and variation of water level throughout the year are shown in Figure 7.

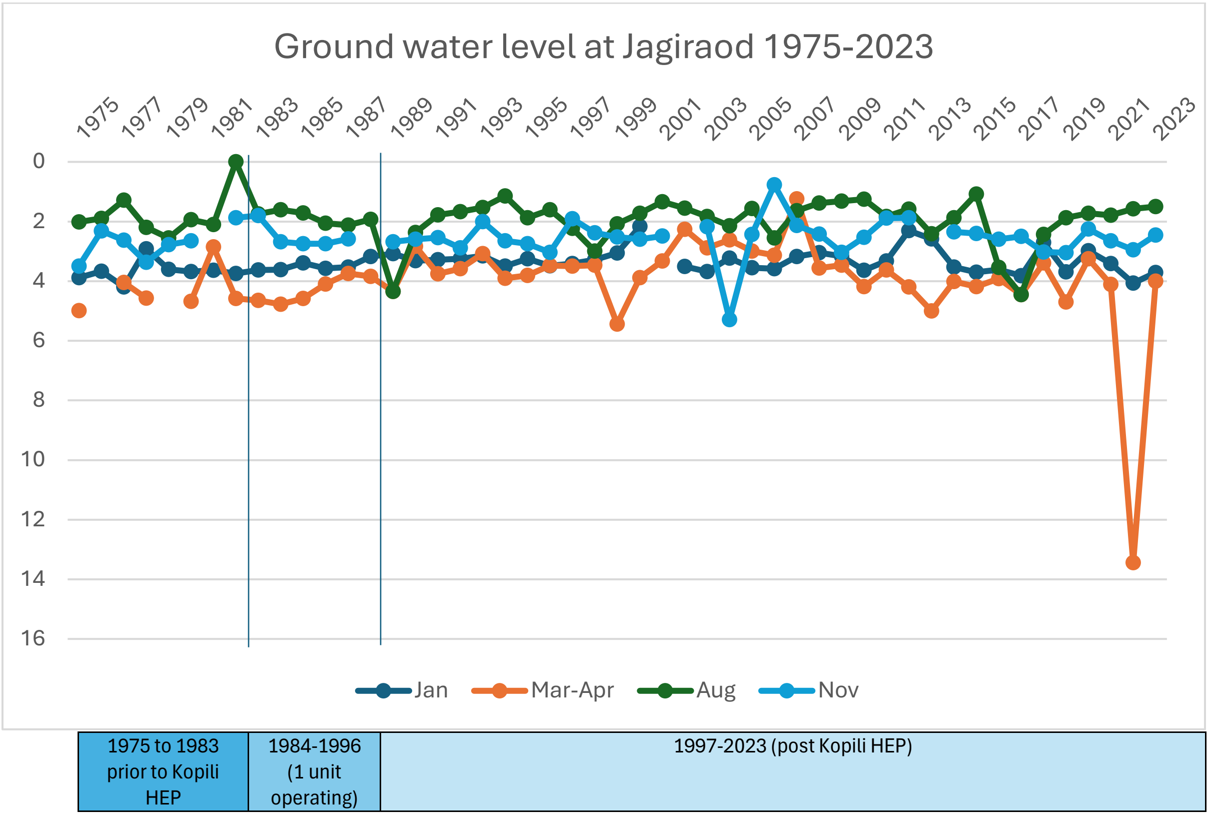
Figure 5: Ground water Monitoring stations maintained by CGWA near Kopili River

Figure 6: Ground water level at Jagiroad (1973-2023)



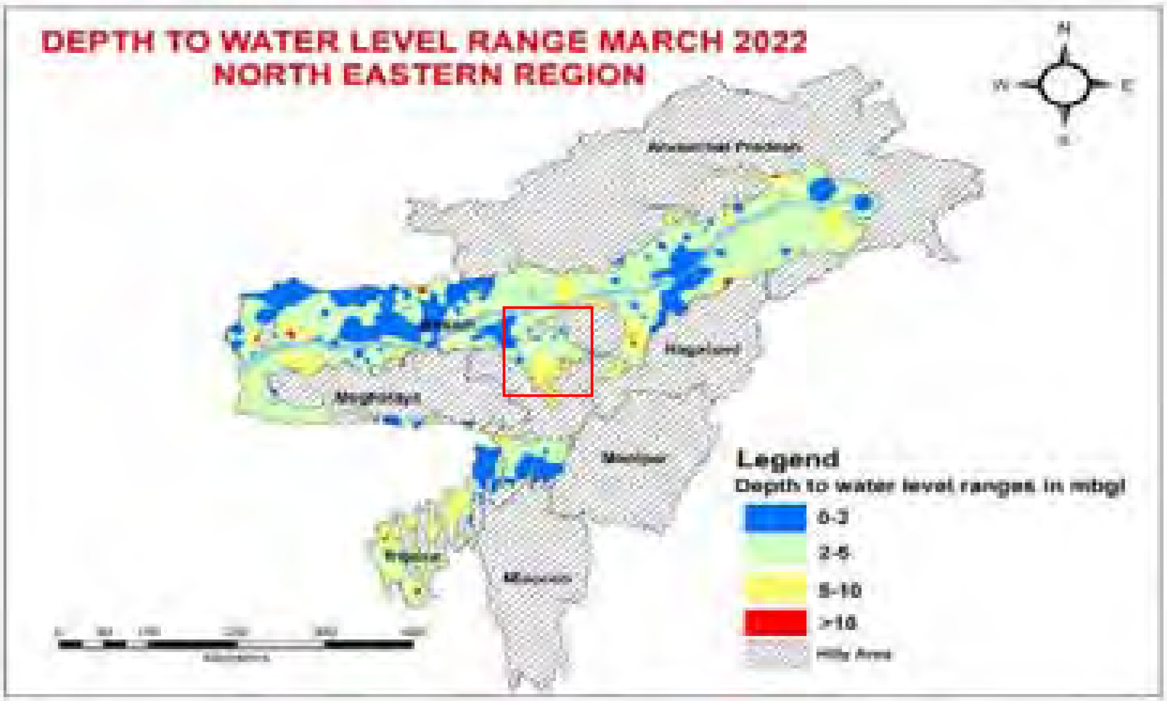
1975 to 1983 prior to Kopili HEP	1984-1996 (1 unit operating)	1997-2023 (post Kopili HEP)

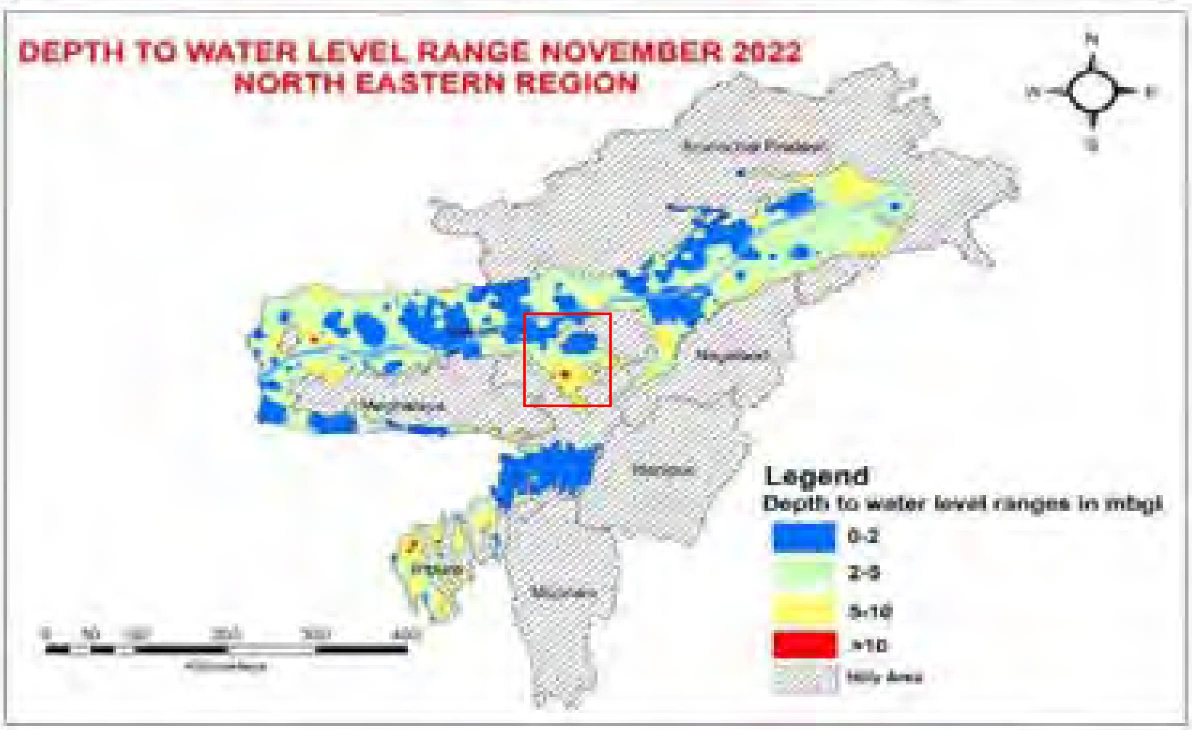
Figure 7: Seasonal Variation of Ground water at Jagiraod CGWA well



36. Ground water level pre monsoon, post monsoon period and district contour Maps of Assam and the respective downstream districts prepared by CGWA are given below Map 5 to Map 11. In the downstream of LKHEP there are 6 districts namely Dima Hasao, West Karbi Anglong, Hojai, Nagaon, Marigaon, Kamrup (Metro) (Map 2).

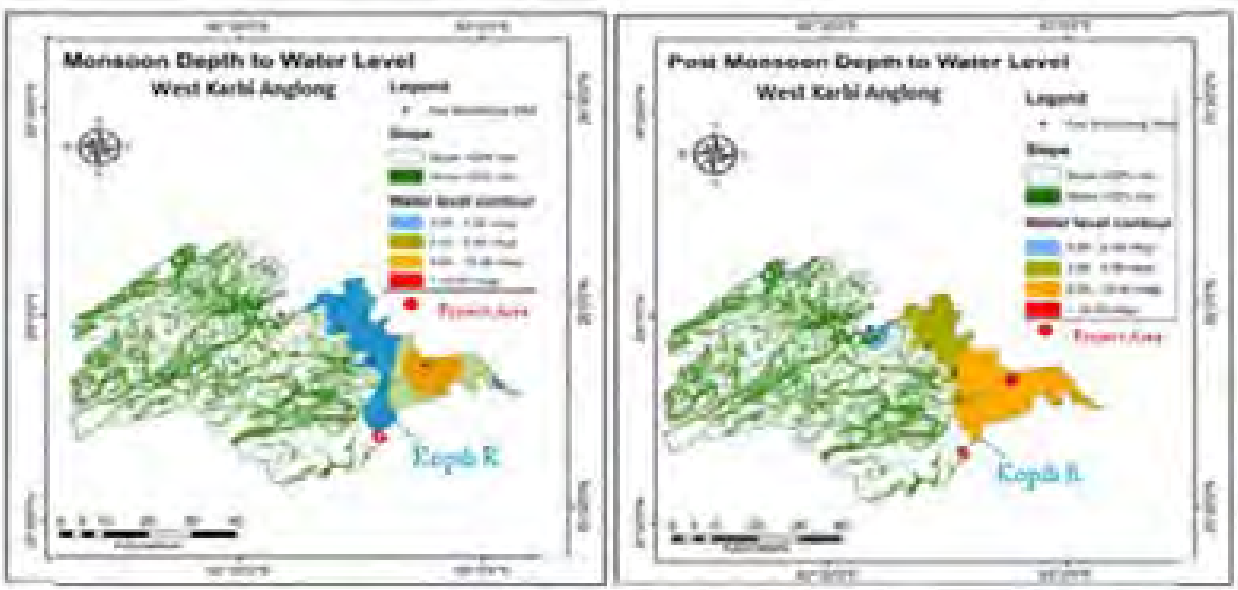
Map 5: Water level map of Assam[5]





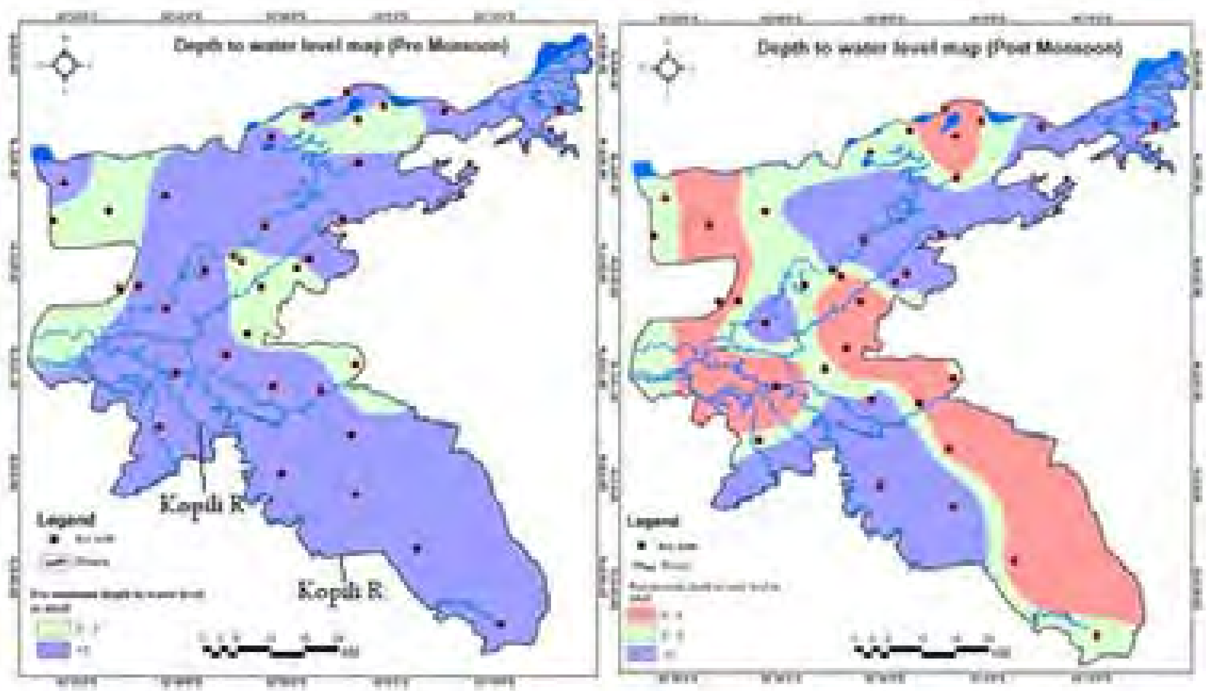
[5] Source : DYNAMIC GROUND WATER RESOURCES OF ASSAM (As on March, 2023) Prepared by IRRIGATION DEPARTMENT GOVERNMENT OF ASSAM GUWAHATI & CENTRAL GROUND WATER BOARD NORTH EASTERN REGION, GUWAHATI GUWAHATI December 2023

Map 6: Ground water Scenario of West Karbi Anglong

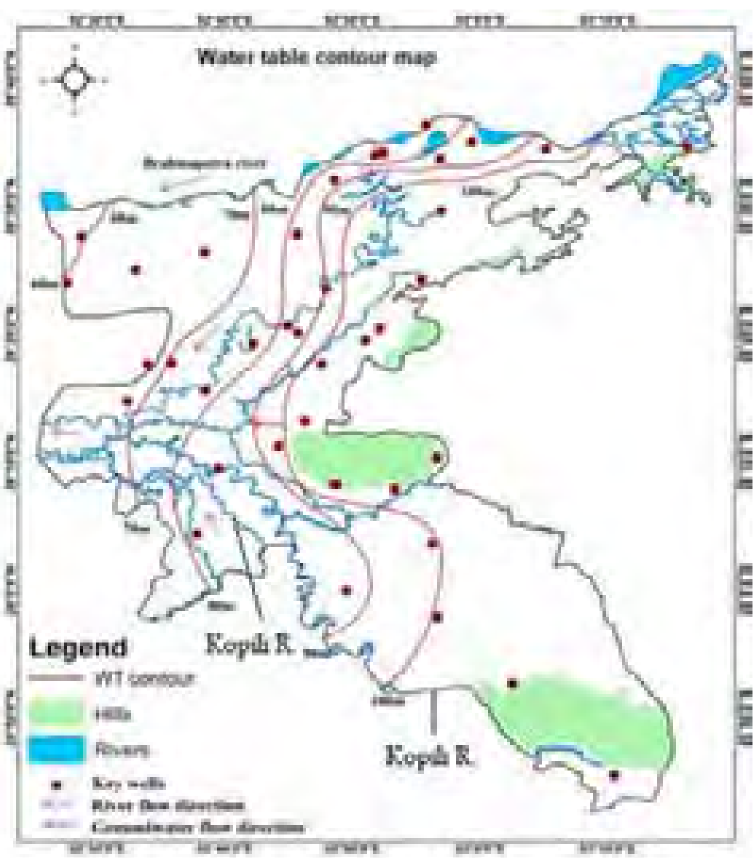


Map 7: Water table contour map of West Karbi Anglong

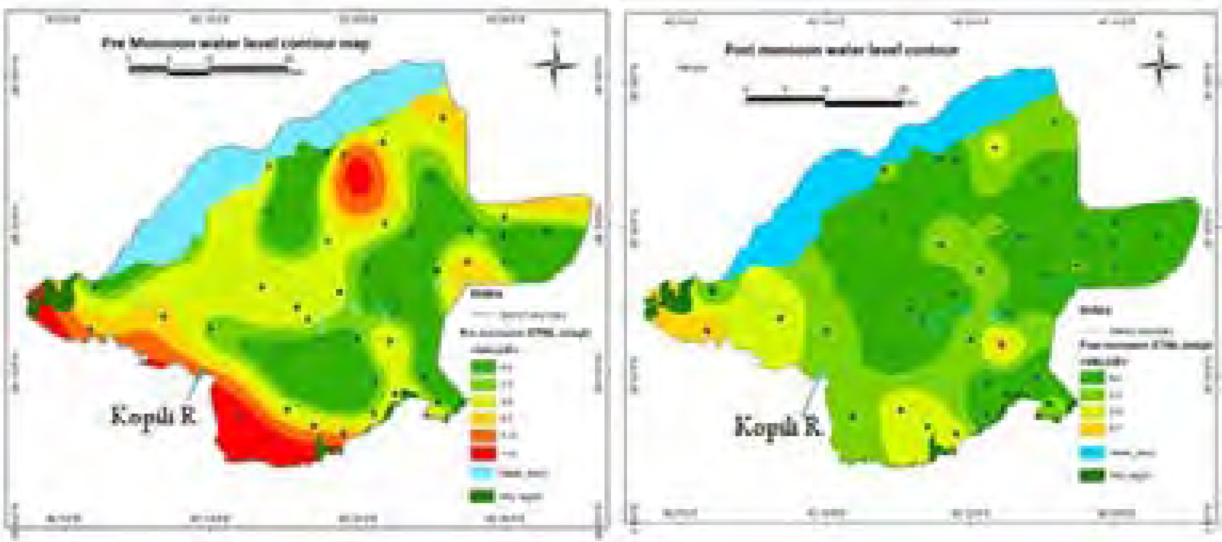
Map 8: Ground water Scenario of Nagaon District



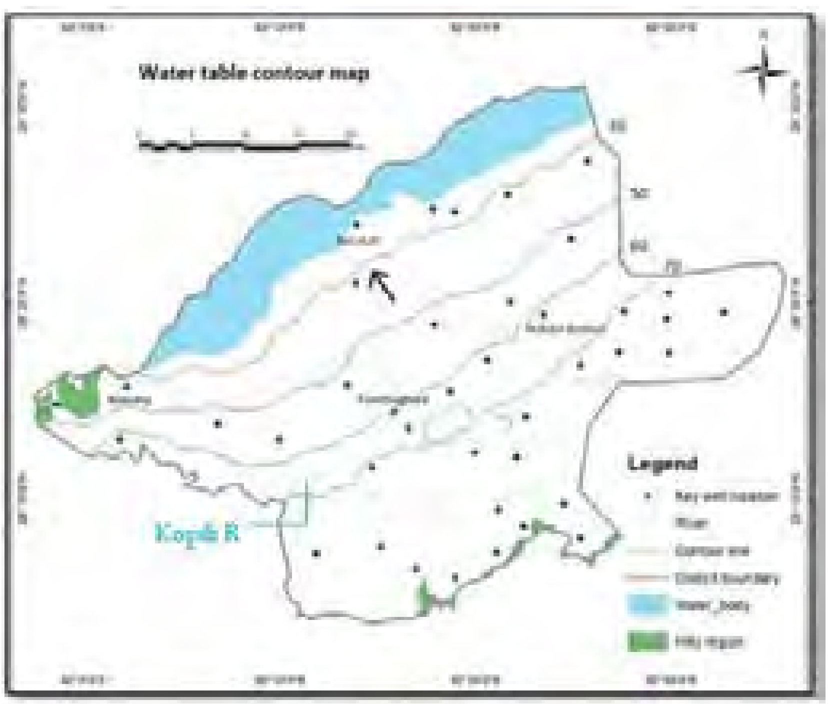
Map 9: Water table contour map of Nagaon District



Map 10: Ground water Scenario of Morigaon District



Map 11: Water table contour map of Morigaon District



(Note : Contour represented in meters above mean sea level)

37. There is no change in ground water level downstream from the Kopili HEP observed based on the long term historical data and it is also expected that similar trend might prevail after operation of Lower Kopili Hydro Electric Project at Longku, Dima Hasao. .

Extraction of ground water in the down stream districts are shown in the table 8.The recharge from rainfall during monsoon season has not been computed using water level fluctuation method (WLFM) as Ground Water Monitoring Wells (GWMW) in the districts are very few[6].

38. Further, sampling through interview were carried out in selected villages in the downstream. The results indicate that few wells were dried up over time and the water can be found in much deeper levels in few villages and in others the ground water level has raised. These results may not be conclusive as several other factors might be involved like irrigation, excessive use of water (demand) due to increase in the population apart from water flow of Kopili river. In most of the villages the level of ground water has gone down in last 10-15 years (Table 9). In few cases (viz. Langrimukh) there is no change as there are other streams near the bore well. During the survey it was observed that water level has been reduced in the shallow wells till the confluence of Brahmaputra River. Important to note that in the villages the wells are not maintained periodically for recharge as was also confirmed by CGWB during consultation. As a general practice CGWA conducts awareness campaign at the grass root level about co-operative management of the aquifer in an equitable manner by community efforts, water conservation, finding indigenous solutions for meeting the water demands under their annual programme etc. Management provision for recharging the ground water table to be initiated by respective district and state authorities using various water harvesting techniques, like using the dried well as recharging pits, etc.

[6] AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES, North Eastern Region, Guwahati, Central Ground Water Board Department of Water Resources, River, Development and Ganga Rejuvenation, Ministry of Jal Shakti, Government of India. 2022

Table 8: Extraction of ground water in the down stream districts of LKHEP[7]

Sl. No	Name of District	Monsoon season recharge from rainfall	Monsoon season recharge from other sources	Non-monsoon season recharge from rainfall	Non-monsoon season recharge from other sources	Total annual ground water recharge	Total Natural Discharges	Annual Extractable Ground water Resource	Annual extraction - Irrigation	Annual extraction - Industrial	Annual Extraction - Domestic	Total Annual Extraction	Annual GW Allocation for domestic use (2025)	Net GW availability for future	Stage of GW extraction (%)	Area Type Category:
1	Dima Hasao	43723.75	113.78	19071.65	17.3	62926.48	6292.65	56633.83	339.36	1.19	230.83	571.38	243.95	56049.33	1.01	Safe
2	Kamrup	9751.93	650.71	4887.87	188.75	15479.26	1547.92	11384.44	1537.2	121.46	348.8	2007.46	352.35	9373.43	17.63	Safe
3	Kamrup Metro	3681.43	107.61	1537.67	24.84	5351.55	535.15	4713.7	0	121.46	3382.43	3503.89	3415.44	1176.8	74.33	Safe
4	Karbi Anglong	102594	2415.12	26988.7	4326.15	136324	13632.4	120038	1066.8	2.4	1909.09	2978.29	2051.09	116917.7	2.48	Safe
5	Morigaon	40981.25	2934.09	8474.76	3108.6	55498.7	2774.94	51854.53	10829.28	4.98	2237.35	13071.61	2470.28	38549.99	25.21	Safe
6	Nagaon	85908.46	9996.23	21452.74	9941.94	127299.4	12729.94	108901.9	27157.2	43.36	4227.78	31428.33	4637.48	77063.82	28.86	Safe

[7] Source : https://data.opencity.in/dataset/9a2cc6d0-3abe-4e3c-b0d6-9ce294c22588/resource/a00849b5-c2cf-4687-8a3b-519fc9344cde/download/assam_gw.csv

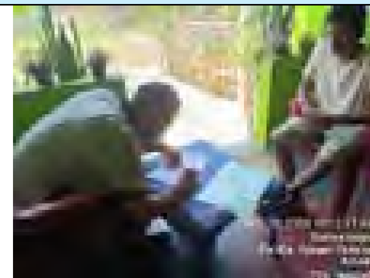
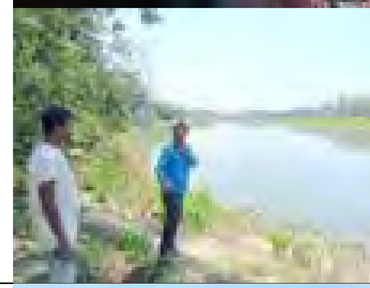
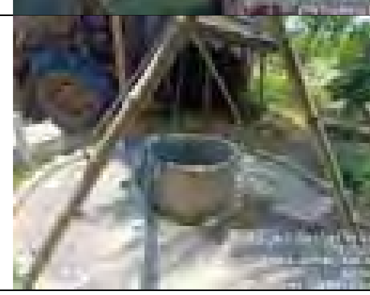
Table 9 : Summary of the consultation with the villagers in the downstream districts

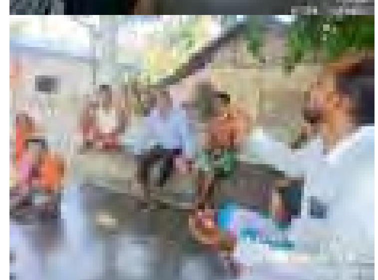
	Name of the Village	Distance of well from Kopili (m)	District	Ground water Status	Photographs
1	Phanglangso (23 Km from LKHEP Dam)	150 m	Dima Hasao	• Two wells of 18 m were dried up • Earlier water were found at 40 m in bore wells now it can be found at 60 m level	  
1.1	Phanglangso (23 Km from LKHEP Dam)	150 m	Dima Hasao	• Community mainly use groundwater for drinking purpose. There are about 5 farmers using bore well for irrigation and some farmers pump water from river. During summer the ground water level go low in	• Outcome of the Consultation during preparation of VDMP

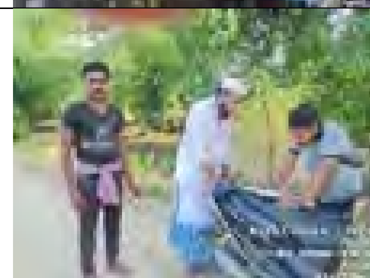
	Name of the Village	Distance of well from Kopili (m)	District	Ground water Status	Photographs
				case the depth is around 18.28 m. Community keep the bore well depth at 27.4 m to get adequate discharge	
2	Boro Longku 1.1 km u/s of LKHEP Dam	1.5 Km	Dima Hasao	• 10 years back water was collected from ring well 6.1 m. • Now they collect water from small streams	
3	Langrimukh 17.1 km d/s of LKHEP Dam	200 m - 300 m	Dima Hasao	• Earlier (10 years back) water was collected from 15.24 m to 18.28 m ring wells • But now water level improved.	
4	Langri II 20.6 Km d/s of LKHEP Dam	600 to 700 m	Dima Hasao	• 15 to 20 years ago ring wells depth was 12.19 m. • Now adays 21.34 m ft also is not enough to get water • In winter it goes further below	 

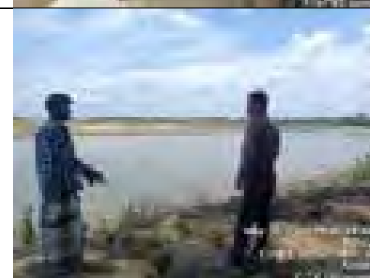
	Name of the Village	Distance of well from Kopili (m)	District	Ground water Status	Photographs
5	Choto Washiling No II 18km d/s of LKHEP Dam	3500 from the well	Dima Hasao	• 0.61 m less water level than last year •	
6	Rajbari II 20.7 km d/s of LKHEP Dam	Adjacent to river	Dima Hasao	• Before 10 years water can be extracted from ring well from 21.34 m depth • Now sufficient water is not available in 24.38 m to 27.43 m.	
7	Borolangfer	400m – 500 m	Dima Hasao	• Earlier (25 to 30 years back) ground water level was not changed during monsoon and winter season. • But now water is scares in both monsoon and winter season.	
8	Longku II 0.85 km u/s of LKHEP Dam	1 Km	Dima Hasao	• Before 15 years the depth of water table was 4.57 m now >7.62 m.	

	Name of the Village	Distance of well from Kopili (m)	District	Ground water Status	Photographs
					
9	Dakhin Kenduguri (54 Km from LKHEP Dam))	150m to 200 m	Hojai	• 8 tubewell • Community use ground water for drinking and not for irrigation. The depth of borewell is around 12.19 m and has good discharge. No change in the water table was observed over the year.	
10	Namtaradubi village (63 Km from LKHEP Dam))	300 m	West Karbi Anglong	• Community use groundwater from domestic purposes and not for agriculture. The ground water level has gone down in the recent past particularly during the month of April-May. The community has to go to a depth of >60.96 m to get adequate discharge	

	Name of the Village	Distance of well from Kopili (m)	District	Ground water Status	Photographs
11	Rajadubi 24.6 km d/s of LKHEP Dam	300 m	Karbi Anglong	• In the last 2 years ground water depletion was observed around 1.54 m – 1.83 m.	 
12	Bagisadubi II 29.5 km d/s of LKHEP Dam	500 m	Karbi Anglong	• 5 to 6 years ago water was available in the ring wells 3.04 m – 6.96 m. Now there is no water in the ring well.	 
13	Kheron Kochari Gaon 33.9 km d/s of LKHEP Dam	700m -800 m	Karbi Anglong	• 12.19 m – 13.71 m ring wells are closed	

	Name of the Village	Distance of well from Kopili (m)	District	Ground water Status	Photographs
					
14	Kheroni Nepali Basti 34.8 km d/s of LKHEP Dam	50m and 100 m	Karbi Anglong	• 48.77 m and some borewells are up to 109.73 m Changes observed in water level of ring well and bore well.	
15	Thaisubali 43.43 km d/s of LKHEP Dam	500m -600 m	Karbi Anglong	• In winter water level goes down 1.5 m to 1.83 m. • Maximum numbers of tubewells are closed.	 
16	Monduli	600-700 m	Hojai	• Water level 15.24 m -21.34 m • Closed handpump is 800 m from river	

	Name of the Village	Distance of well from Kopili (m)	District	Ground water Status	Photographs
					
17	Okintu	700 m	Hojai	• Flood affected area	
18	Framapar	1.5 Km	Hojai	• From 2008 ground water is depleting. • 1,5 m – 1.8 m difference observed. • Flood affected area	 
19	Lonkjan Dorji Sheet 45.57 km d/s of LKHEP Dam	400 m	Hojai	• Flood affected area • No difference observed	

	Name of the Village	Distance of well from Kopili (m)	District	Ground water Status	Photographs
					
20	Jamuna Sit 48.26 km d/s of LKHEP Dam	200 m	Hojai	• Water level is 9.14 m – 12.19 m. • 3-4 years water is not sufficient	
21	Digal Nali 59.76 km d/s LKHEP Dam	800 m	Hojai	• Water level is at 36.57 m. • 3-4 years it is depleting by 6.1 m – 7.62 m	
22	Raikat Chandanpur 61.26 km d/s LKHEP Dam	100 m	Hojai	• From 2008 ground water depletion was observed by 6.1 m – 7.62 m	
23	Hawaipur 55.85 km d/s of LKHEP dam	2360 m	Hojai	• Maximum wells are closed 6.1 m – 7.62 m • Few handpumps are closed and those are 1.5 Km from river.	

	Name of the Village	Distance of well from Kopili (m)	District	Ground water Status	Photographs
					
24	Kakoti Gaon (83 Km from LKHEP Dam))	150 m	Nagaon	• About 20 farmers use ground water for irrigation. The community experience depletion of groundwater and community has to deepen the borewell upto 40.76 m to get good discharge	
25	Thengbhanga village (123 Km from LKHEP Dam))	500 m	Morigaon District	• Community use groundwater for drinking and borewell with depth 36.57 m give good discharge. No reporting of ground water depletion. Community has facilities to take river water for irrigation using pumps	

2.4. Aquatic ecology

39. The project involves construction of a dam and reservoir, which will alter the natural flow of the river water and may impact both the upstream reservoir area and the downstream ecosystem, including human settlements. The hydropower dam is designed to regulate water flow, known as environmental flow (e-flow), to cater to downstream users and aquatic ecosystems. It is well known that biotic communities play a vital role in river water systems concerning both quality and quantity.
To ascertain the magnitude of the impact on biotic and abiotic components during water releases in various seasons and during peaking power generation, thorough assessments are necessary. As per the amendment of the Environment Clearance on 3rd Jan 2024, MoEF&CC has stipulated additional condition for Aquatic study specially, migratory aquatic species concerning occurrence of fishes /habitat impact studies shall be carried out from recognised govt. Institutes and to prepared mitigation measures, with provision of financial budget revised in the EMP. APGCL engaged the College of Fisheries, Raha under Assam Agriculture University to carry out the study. As per the requirement 8 samplings were carried out during the period February to May 2024. Findings are described based on the study carried out during this period only and samples were collected from 8 nos. of sampling stations u/s and d/s of the LKHEP dam up to the confluence of the Diyung river.

40. The following stations (Map 13) are selected for the investigation covering approximately 33 Km pathlength of the river based on a preliminary visit for collection of water samples, sediment, fish, plankton, periphyton, benthos & riparian vegetation samples to collect information on various study parameters.

2.4.1. Aquatic study sampling stations

42. **Sampling stations**

Station 1: Located at 29 Kilo (Latitude $25^{0}35.885^{/}$ N; Longitude $92^{0}44.929^{/}$; Elevation 269m) approximately 11.9 Km upstream of the LKHEP. (Dam to Station 1=11.9 km)
Station 2: Located at approximately 1 Km upstream of the LKHEP (Latitude $25^{0}39.329^{/}$ N; Longitude $92^{0}47.325^{/}$; Elevation 190m) (Station 1 to 2 distance 10 km). (Dam to Station 2=1.60 km)
Station 3: Located just outside LKHEP project diversion tunnel outlet **(**Latitude $25^{0}40.064^{/}$ N; Longitude $92^{0}46.828^{/}$; Elevation 161m) (Station 1 to 3 distance 12 km, Station 2 to 3 distance 2 km).
Station 4: Located at downstream powerhouse of the LKHEP (Latitude $25^{0}41.934^{/}$ N; Longitude $92^{0}48.250^{/}$; Elevation 99m) (Station 1 to 4 distance 17 km, Station 3 to 4 distance 5 km). (Dam to Station 4=5.41 km)

Station 5: Located at 6 km from the tail race of LKHEP (Latitude $25^0 43.389^/$ N; Longitude $92^0 49.366^/$; Elevation 98m) (Station 1 to 5 distance 20 km, Station 4 to 5 distance 3 km), (Dam to Station 5=8.40 km)

Station 6: Located at one kilometer from confluence point of River Amreng & River Kopili (Latitude $25^0 45.070^/$ N; Longitude $92^0 51.295^/$; Elevation 77m) (Station 1 to 6 distance 27 km, Station 5 to 6 distance 7 km). (Dam to Station 6=16 km)

Station 7: Located at the confluence point of River Kopili & River Diyung (Latitude $25^0 40^/ 1$N; Longitude $92^0 47^/ 45$; Elevation 60m) (Station 1 to 7 distance 34km, Station 6 to 7 distance 7 km). (Dam to Station 7=27 km)

Station 8: Reservoir area on Longku Nala (Pond created due to one dyke) (Map 12)

Map 12 : Aquatic study sampling stations

2.4.2. Water quality of Kopili in relation to pH

2.4.2.1. Background

41. It aims to evaluate the ongoing changes in the pH levels of the Kopili River to gauge their potential impact on the development of flora and fauna. This evaluation will help designers, decision makers to understand the need of the future construction requirements like fish ladders/fish pass etc.

2.4.2.2. Methodology

42. It is based on a thorough desktop review and analysis of secondary data available in the EIA reports prepared for this project. This report provides a chronological order of pH testing conducted at the project site and various tributaries, as outlined below. It also includes the pH water quality test being conducted by EMC in March 2023 and contractor from NABL lab since commencement of project with additional to daily pH testing at intake of LKHEP being measured through pH meter from Jan 2023.

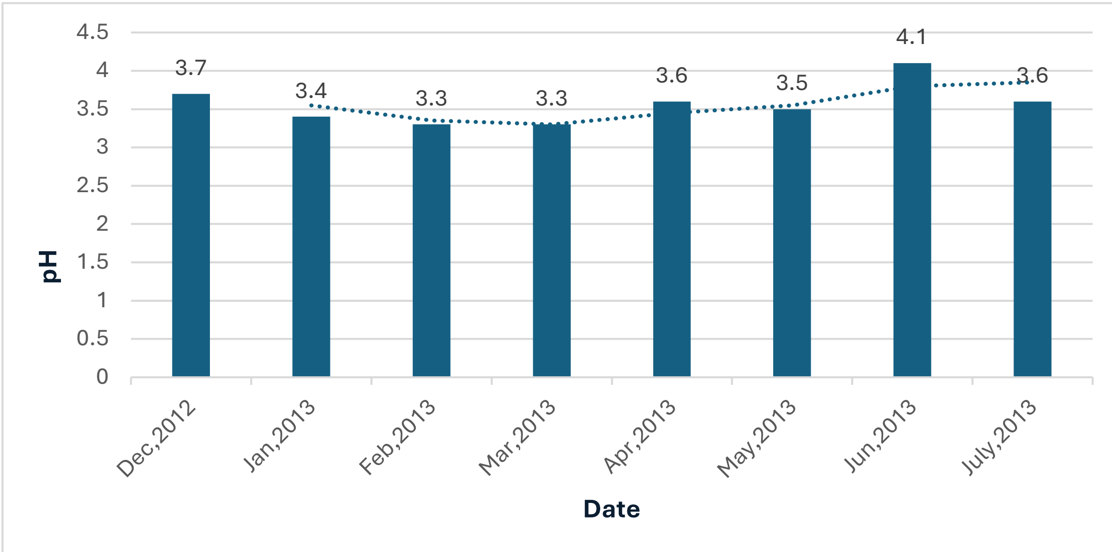
2.4.2.3. Data Collection

43. Below the chronological order of Kopili river sampling and testing under this project has been presented.

Figure 8 : Testing the pH of Kopili River

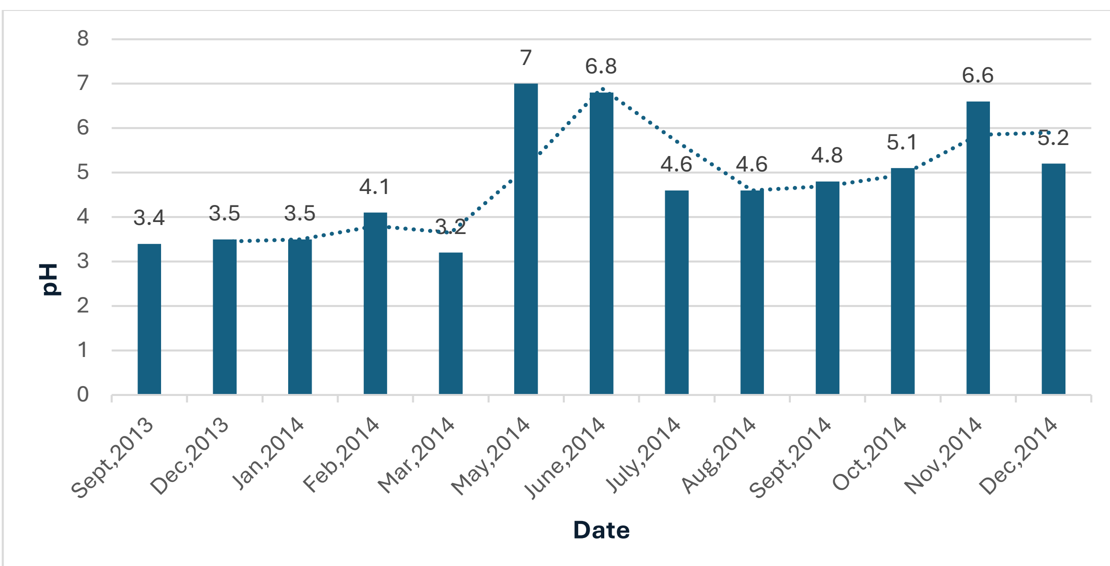
44. In the year 2012-13, pH testing was conducted on Kopili River water in the project area during DPR preparation. The results of these tests are presented below showing acidic nature of water.

Figure 9 : pH value of Kopili river project area in 2012-13 (DPR)



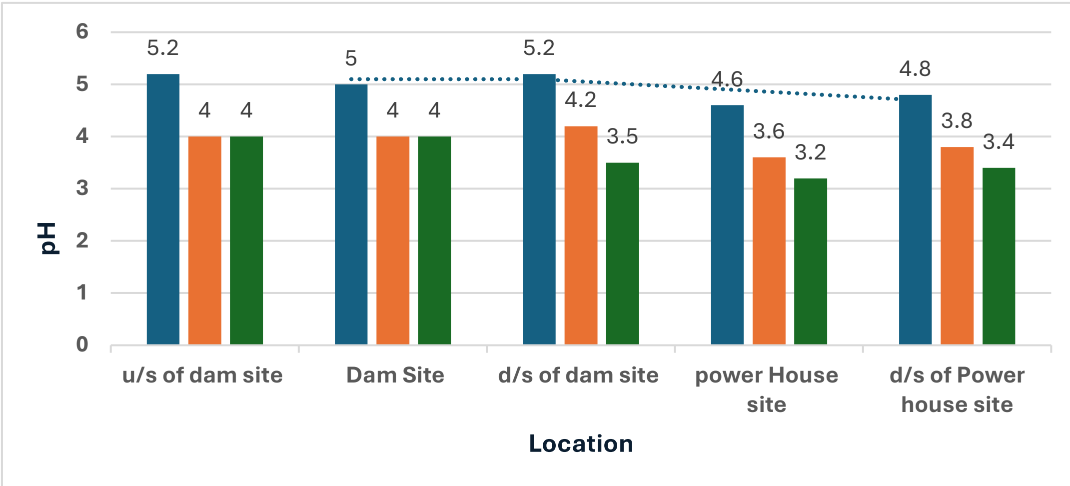
45. In year 2013-14, pH testing was conducted at Dam site of LKHEP during DPR preparation. The results of these tests are presented below, indicating variations in pH at the dam site, with spikes observed during the monsoon season, followed by a subsequent decrease.

Figure 10 : pH value of LKHEP Dam site in 2013-14 (DPR)



46. In 2015, as part of the draft EIA preparation, surface water sampling and water quality analysis were conducted across three seasons: Monsoon (August 2014), Winter (December 2014 to January 2015), and Summer (April 2015) and result of pH is presented below.

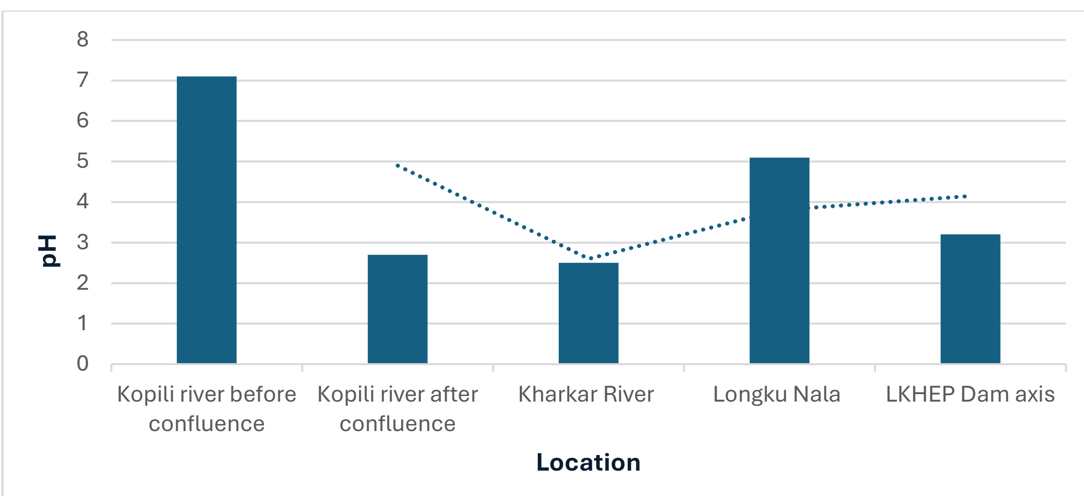
Figure 11 : pH value of Kopili river in 2015 (draft EIA)



47. Water Quality Sampling Results showed pH levels ranging from 3.2 to 5.2 in the project area, indicating high acidity which is not in line with BIS standards and renders the water unsuitable for construction purposes. Additionally, it falls below CPCB's criteria of 6.5 to 8.5 for Class D water, which is essential for wildlife and fisheries propagation in India.

48. In January 2017 (draft EIA, 2018), six additional samples, comprising five surface samples taken from different points along the Kopili River (before and after confluence, Kharkar River, Longku Nala, LKHEP Dam axis) and one groundwater sample, were collected and analyzed at the Civil Engineering Department laboratory of Assam Engineering College, Guwahati.

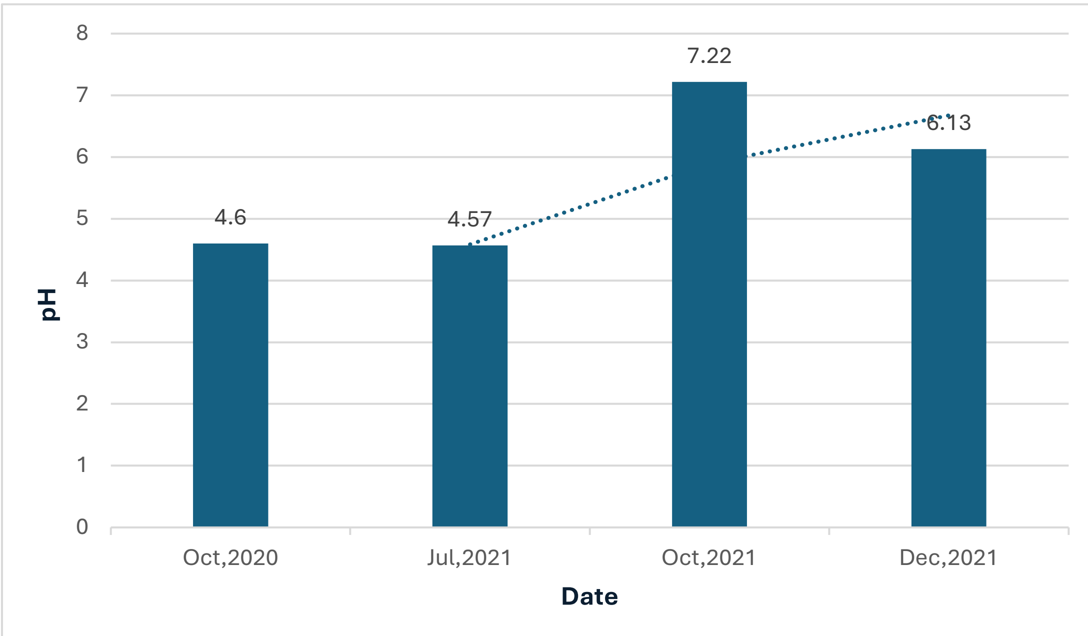
Figure 12 : pH Value of Kopili River 2012-2013 (draft EIA,2018)



49. These findings indicate that the water quality of the Kopili River is influenced by the introduction of low-pH water from the Kharkar River. Notably, sulfide levels were found to be highest in both the Kharkar River and the Upper Kopili.

50. To validate the baseline data for the water quality, a follow up baseline monitoring by NABL lab has again been carried out prior to start of the construction activities and is continued. The compiled data for DAM site testing is presented below.

Figure 13 : pH value of LKHEP Dam site



51. The pH trend observed at the dam site, as documented through testing conducted by the NABL lab, displays fluctuations across the recorded dates. The trend initiates in October 2020 with a pH value of 4.6, signaling acidic conditions prevailing at the site during that period. Subsequent testing in July 2021 reveals a marginal decrease to 4.57. The spike observed in October may be attributed to increased rainfall during that period, which could have influenced the pH levels. Thereafter, the pH levels started decreasing again in December.

52. In April 2023 after discussion with ADB mission, EMC conducted sampling and testing to check the effect of Pyrites on water samples and its pH with ABNS Scientific Services an NABL lab. The results reveal pH values ranging from 2.87 to 4.29 in surface water samples, indicating an acidic nature across four different locations in the Powerhouse areas. Notably, samples from two potential Pyrite Prone Areas (Sample no. 2 and Sample

no. 4) recorded pH values below 3, suggesting the possible presence of Pyrite in these areas.

Table 10: Additional surface water samples

S. No.	Sample code	Location
1	S1 (GW)	From the colony of Contract Package 1 (beside the muck disposal site) **(pH 7.38**)
2	S2 (PH1)	Pyrite Prone Area at Power House near side way area(**pH 2.87**)
3	S3 (PH2)	At Power House just beneath of E-130 near the side way area **(pH- 4.29)**
4	S4 (PH3)	Pyrite Prone Area at Power House near Tail Race Tunnel (TRT)(**pH- 2.93**)
5	S5 (PH5)	At Powerhouse from the pool of Kopili Seepage Water near the TRT **(pH- 4)**

Table 11: pH records during the aquatic ecology study in the Kopili River from Feb 2024 to May, 2024.

Time period in days / Sampling station	1st sampling (0 days, Feb 2024)	2nd sampling (15 days, March 2024)	3rd sampling (30 day, March 2024)	4th Sampling (45 days, April 2024)	5th sampling (60 days, April 2024)	6th sampling (75 days, May 2024)	Location
Station 1	4.56	4.4	4.56	4.3	4.16	4.5	Kopili River upstream of LKHEP
Station 1	4.6	4.43	4.6	4.3	4.19	4.56	Kopili River upstream of LKHEP
Station 1	4.62	4.48	4.62	4.34	4.17	4.5	Kopili River upstream of LKHEP
Station 2	4.8	4.8	4.8	4.57	4.35	4.89	Kopili River upstream of LKHEP
Station 2	4.8	4.8	4.8	4.57	4.37	4.8	Kopili River upstream of LKHEP
Station 2	4.8	4.8	4.8	4.45	4.38	4.9	Kopili River upstream of LKHEP
Station 3	4.8	4.8	4.8	4.68	4.4	3.9	Kopili River Dam site
Station 3	4.7	4.6	4.5	4.6	4.42	4.03	Kopili River Dam site
Station 3	4.8	4.8	4.9	4.6	4.43	4.03	Kopili River Dam site
Station 4	4.7	4.7	4.77	4.6	4.5	4.76	Kopili River downstream of dam near Power House
Station 4	4.73	4.73	4.73	4.73	4.47	4.76	Kopili River downstream of dam near Power House
Station 4	4.72	4.72	4.72	4.63	4.51	4.76	Kopili River downstream of dam near Power House
Station 5	4.8	4.8	4.8	4.7	4.64	4.67	Kopili River downstream at Panimur
Station 5	4.78	4.7	4.78	4.7	4.54	4.6	Kopili River downstream at Panimur

Time period in days / Sampling station	1st sampling (0 days, Feb 2024)	2nd sampling (15 days, March 2024)	3rd sampling (30 day, March 2024)	4th Sampling (45 days, April 2024)	5th sampling (60 days, April 2024)	6th sampling (75 days, May 2024)	Location
Station 5	4.75	4.75	4.75	4.7	4.5	4.67	Kopili River downstream at Panimur
Station 6	4.7	4.7	4.7	5.1	4.9	4.76	Kopili River downstream at Amring confluence
Station 6	4.65	4.65	4.65	5.01	4.88	4.72	Kopili River downstream at Amring confluence
Station 6	4.73	4.73	4.73	5.1	4.86	4.72	Kopili River downstream at Amring confluence
Station 7		7.26	8.56	8.7	8.38	7.5	Kopili River downstream at Doyang confluence
Station 7		7.3	8.9	8.4	8.39	7	Kopili River downstream at Doyang confluence
Station 7		7.28	8.9	8.7	8.1	7.62	Kopili River downstream at Doyang confluence
Station 8			7.36	7.2	7.61	8.07	Langku Nala in submergence
Station 8			7.98	7.21	7.56	8	Langku Nala in submergence
Station 8			7.98	7.3	7.61	8.08	Langku Nala in submergence

2.4.4.4. Water pH monitored during the Aquatic study during Feb to May, 2024.

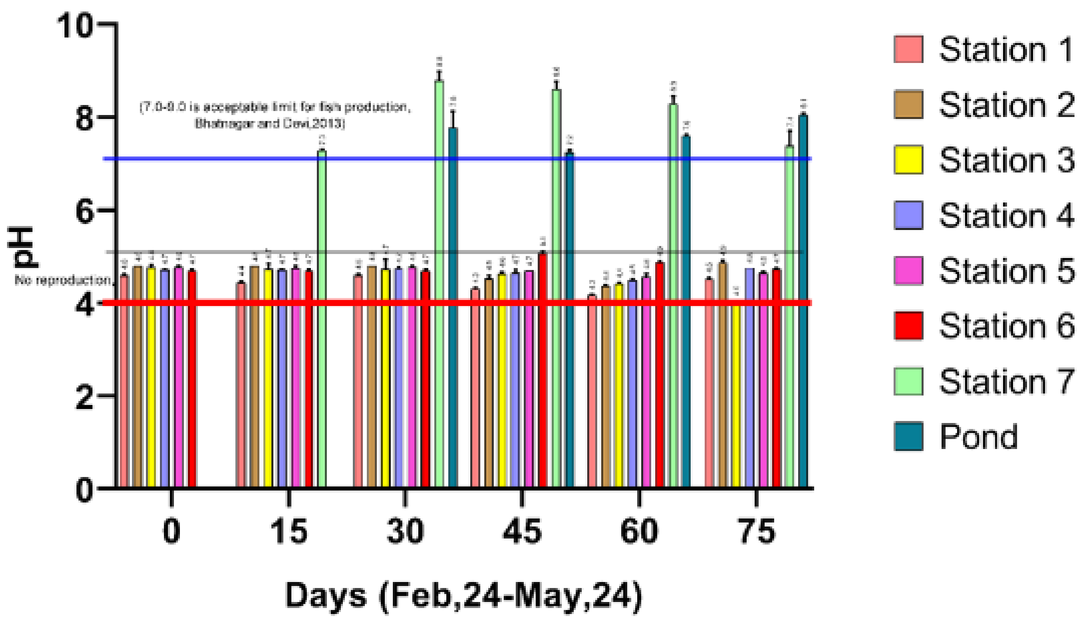
53. The pH values of water samples from various stations over a 75-day period from February to May 2024 exhibited noticeable time variability and differences across stations. At Station 1, the pH values remained relatively stable, ranging from 4.16 to 4.62, with an overall mean of approximately 4.41 and a standard deviation indicating minor fluctuations over time. The initial pH started at 4.56, dropped slightly in mid-March to 4.3, and then stabilized around 4.5 by May. Station 2 showed consistently higher pH levels, ranging from 4.35 to 4.9, with a mean of around 4.63. The pH here remained steady through March and April, with slight variations observed towards the end of the sampling period. Station 3 exhibited wider variability, with pH values from 3.9 to 4.9 and a mean of 4.47. The pH at Station 3 initially remained stable, showed a slight dip in April, and then decreased more significantly by May.

54. Station 4 had relatively higher and stable pH values, ranging from 4.5 to 4.76, averaging 4.66. The pH remained consistent across the sampling period with minor fluctuations. Station 5 showed slight fluctuations, with pH values from 4.5 to 4.8, and a mean of 4.71. The pH levels dropped slightly in March and April but returned to initial levels by May. Station 6 (after the confluence of Amring River) showed more significant time variability, with pH ranging from 4.65 to 5.1, and a mean of 4.79, indicating an increase in pH levels during the later sampling periods, especially noticeable in May. Station 7 (after the confluence of Doyang River) had the highest and most variable pH values, ranging from 7.26 to 8.7, with a mean of 8.07. Initial pH values were high in March, increased slightly in April, and then showed some decrease by May. The catchment area

pond exhibited a narrower range, from 7.2 to 8.08, with a mean of 7.64. Its pH values were relatively stable but showed a slight increase towards the end of the sampling period. The data reveals that while some stations maintained consistent pH levels over time, others, particularly Stations 6 and 7, experienced significant changes, possibly due to environmental or anthropogenic influences. The standard deviations for each station highlight the degree of fluctuation, with Stations 6 and 7 showing higher variability compared to the relatively stable pH levels observed at other stations. This indicates that certain areas are more susceptible to factors that influence pH, emphasizing the importance of continuous monitoring and analysis to understand the underlying causes of these variations.

55. Maintaining an optimal pH range is crucial for the health and productivity of aquatic ecosystems. For most fish and aquatic organisms, a pH between 7.0 and 8.5 is ideal, supporting maximum biological productivity and well-being. When the pH of the water falls between 4.0 and 6.5 or rises between 9.0 and 11.0, fish experience significant stress, which can affect their growth, reproduction, and overall health. Extreme pH levels, specifically those below 4.0 or above 11.0, are typically lethal to fish, leading to almost certain death due to the inability of their physiological systems to cope with such harsh conditions (Bhatnagar & Devi 2013)[8]. Before dam operation the pH of the river crossed 6.5 in certain months. But after initiating the dam operation from July 2023 onwards the pH of the river Kopili has not been increased to such a level (above 6.5) up to the confluence of the Diyung River (Figure 19), which can support aquatic species till the data collected in 10th May 2024.So pH in the station no 1-6 are not suitable for the survival of the fishes.

Figure 14 : Kopili River water pH



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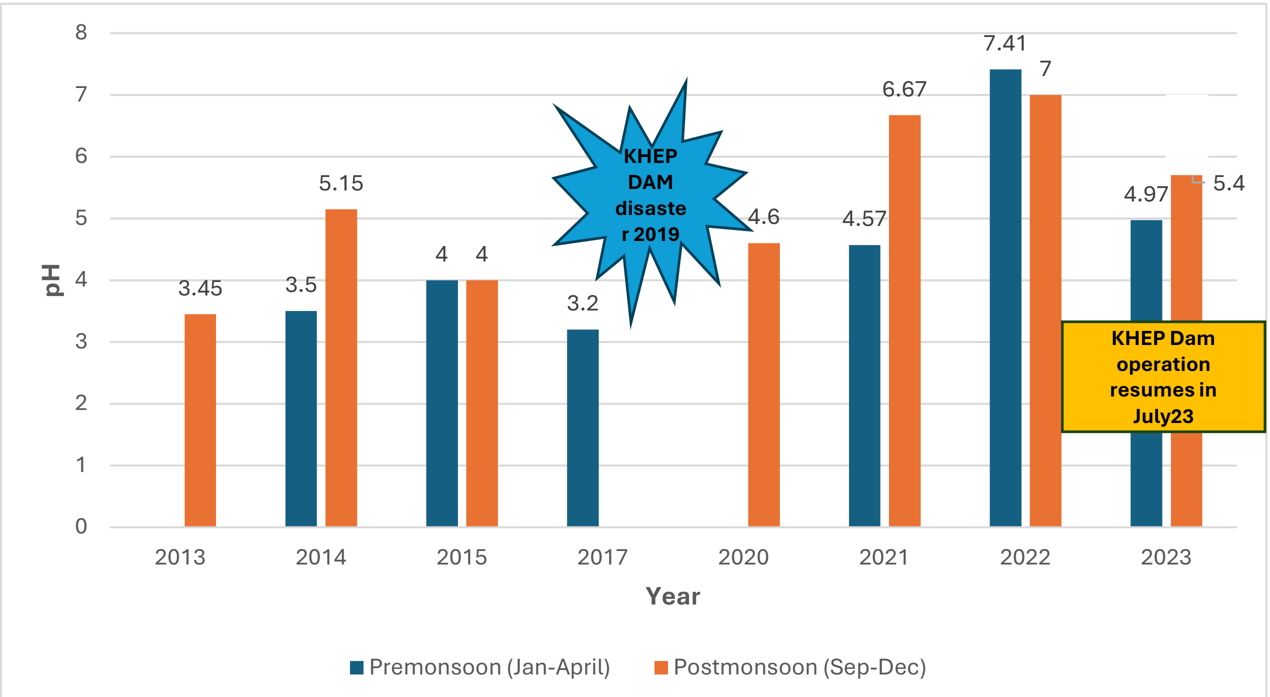
[8] Bhatnagar, A., & Devi, P. (2013). "Water quality guidelines for the management of pond fish culture." International Journal of Environmental Sciences, 3(6), 1980-2009.

2.4.4.5. Conclusion

56. Upon compiling the pH test reports for both pre-monsoon (January to April) and post-monsoon (September to December) periods at the dam site, a notable trend emerges, shedding light on the water quality dynamics over the years.

Figure 15: Trend of pH at LKHEP Dam Site



57. The pH levels during the pre-monsoon season fluctuated, with values ranging from acidic to neutral. There is no clear upward or downward trend over the years. In contrast, the post-monsoon pH levels remained relatively stable, with most values falling within the neutral range. There is a slight increase in pH levels observed in recent years, suggesting potential improvements in water quality during this season.

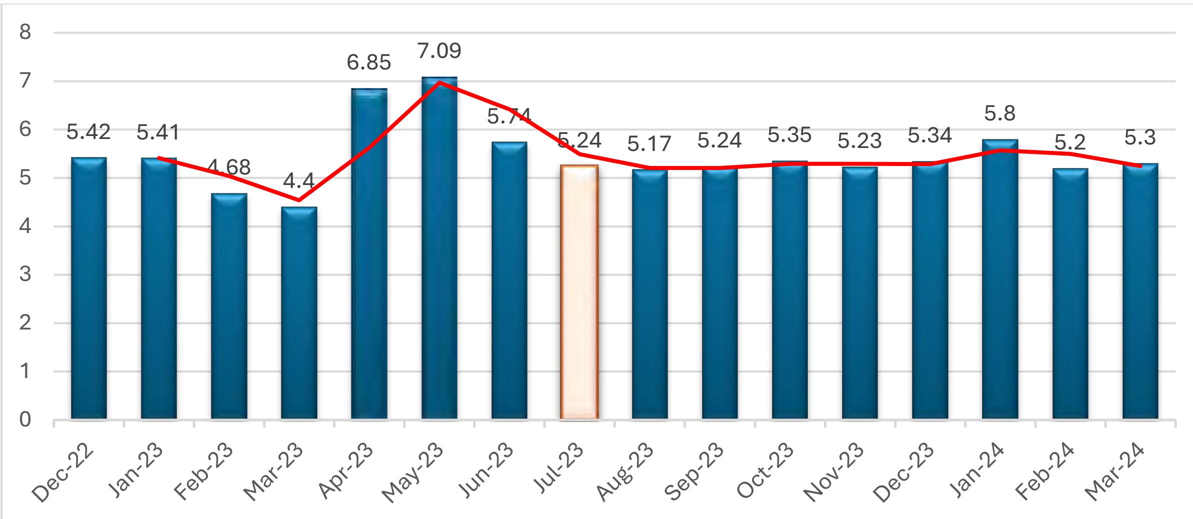
58. Despite the KHEP dam disaster in 2019, there has been no significant deviation in pH trends observed post-disaster, even after the operation of the dam started in July 2023. This suggests a limited impact on water pH despite the occurrence of the disaster.

59. Despite these variations, an analysis of the entire report spanning from 2013 to date reveals an overall improvement in the Kopili river's pH.

60. However, the pH of the water at the dam site is being rigorously monitored by the CP2 contractor on a daily basis through pH meter. The analysis of this data for year 2023

yields the following results. It's noteworthy that the NEEPCO plant resumes operations in July 2023.

Figure 16: Median pH Value in river Kopili



61. The pH trend in the river Kopili exhibits significant fluctuations over the recorded months, beginning in December 2022 and continuing to the present date. Data collection is observed from May to June 2022, followed by a gap during the monsoon season. pH measurements resume from December 2022 onwards. The trend starts with a pH level of 7.8 in May 2022, decreasing to 7.5 by June 2022. A substantial decline is noted in December 2022, dropping to 5.42, followed by decreases to 5.41 in January 2023 and 4.68 in February 2023. March 2023 records the lowest pH value of 4.4. Positive shifts occur in April 2023 (6.85) and May 2023 (7.09). However, fluctuations persist, with June 2023 at 5.74. Subsequent months show values ranging from 5.17 to 5.35, indicating a somewhat stabilized pH trend. During the aquatic species studies by The College of Fisheries Raha, the pH at Dam site varies between 3.9 to 4.9 during February to May, 2024. Also after initiating the dam operation from July 2023 onwards the pH of the river Kopili has not been increased to such a level (above 6.5) up to the confluence of the Diyung River as of 10th May 2024, and hence is not favourable for aquatic species .

2.4.3. Physico-Chemical Water Quality

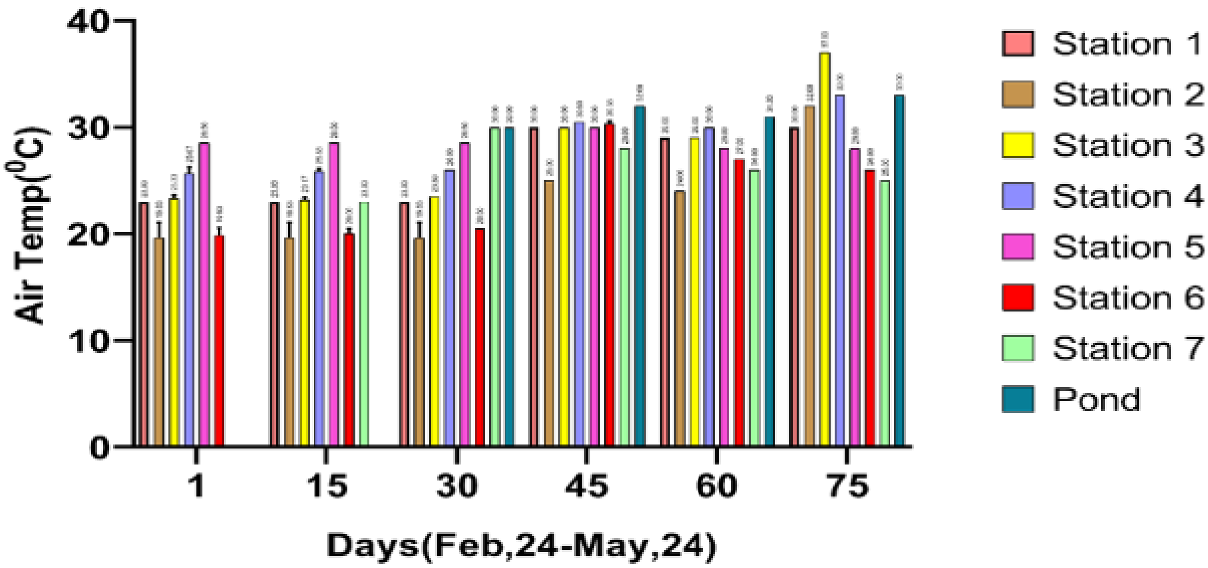
A. Physical Parameters

2.4.3.1. Air Temperature

62. Atmospheric temperature of the study area displayed notable variation during the period of investigation. The mean temperature for Station 1 was 26.83°±3.43°C, indicating moderate variability. The mean temperature for Station 2 is 23.33± 4.89°C, reflecting notable variability. The mean temperature for Station 3 was 30.25± 5.54°C. The mean temperature for Station 4 is 29.75± 2.88°C. The mean temperature for Station 5 is 28.42±

0.22°C, indicating high stability. The mean temperature for Station 6 was 24.83± 4.30°C. The mean temperature for the pond is 31.83± 1.17°C. These observations indicate varying degrees of temperature stability and increase across different stations, reflecting diverse local environmental conditions in Kopili.

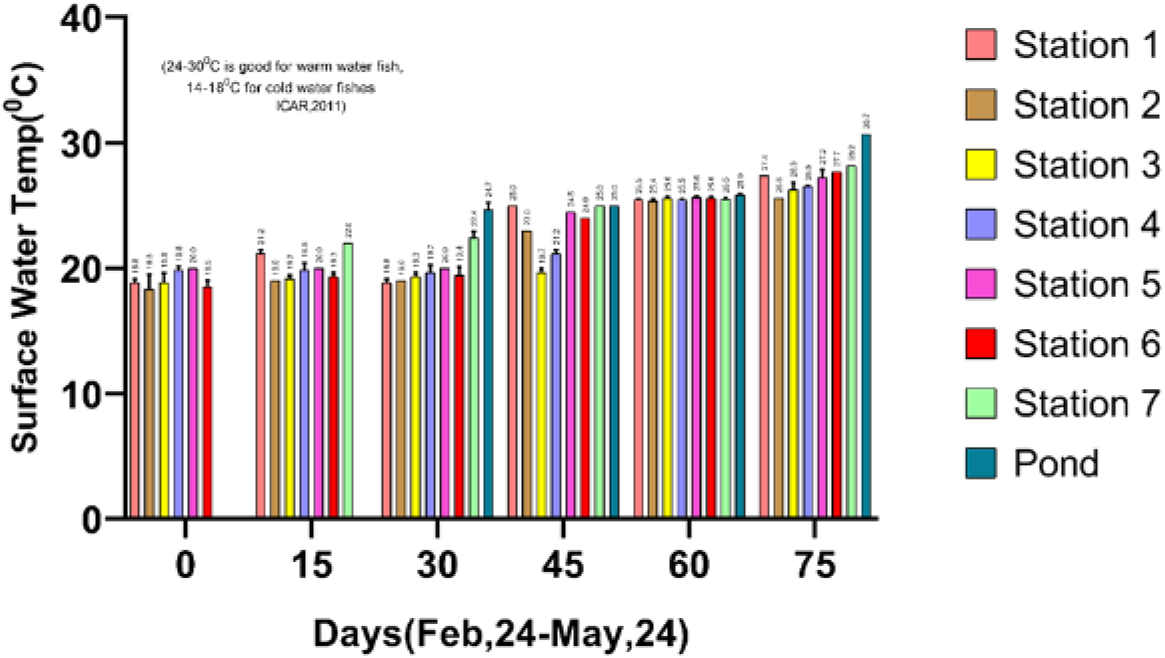
Figure 17 : Air Temperature during aquatic study



2.4.3.2. Surface Water Temperature

63. The mean temperature for Station 1 over the entire period was 23.25± 3.43°C, indicating moderate variability. The mean temperature for Station 2 was 21.65± 3.05°C, reflecting consistent but notable changes over time. The mean temperature for Station 3 was 21.78± 3.25°C. Station 4 temperatures varied from 19°C to 26.6°C, starting at an average of 19.67°C in February and increasing to 26.6°C during May. The mean temperature for Station 4 was 22.1± 2.71°C. The mean temperature for Station 5 was 22.9± 2.97°C. Station 6 had temperatures ranging from 18°C to 27.7°C, with a mean of 22.38°C and a standard deviation of 3.73°C, indicating higher variability. The catchment area pond showed a notable rise from 24°C to 30.7°C, with the mean temperature at 26.23°C ± 2.87°C. These observations indicated varying degrees of temperature stability and increase across different stations, reflecting diverse local environmental conditions in Kopili. The congenial range of temperature for warm water fishes is 24-30°C and cold-water fishes is 14-18°C (ICAR 2011). All locations are favorable for the fish species found in Kopili with respect to surface water temperature.

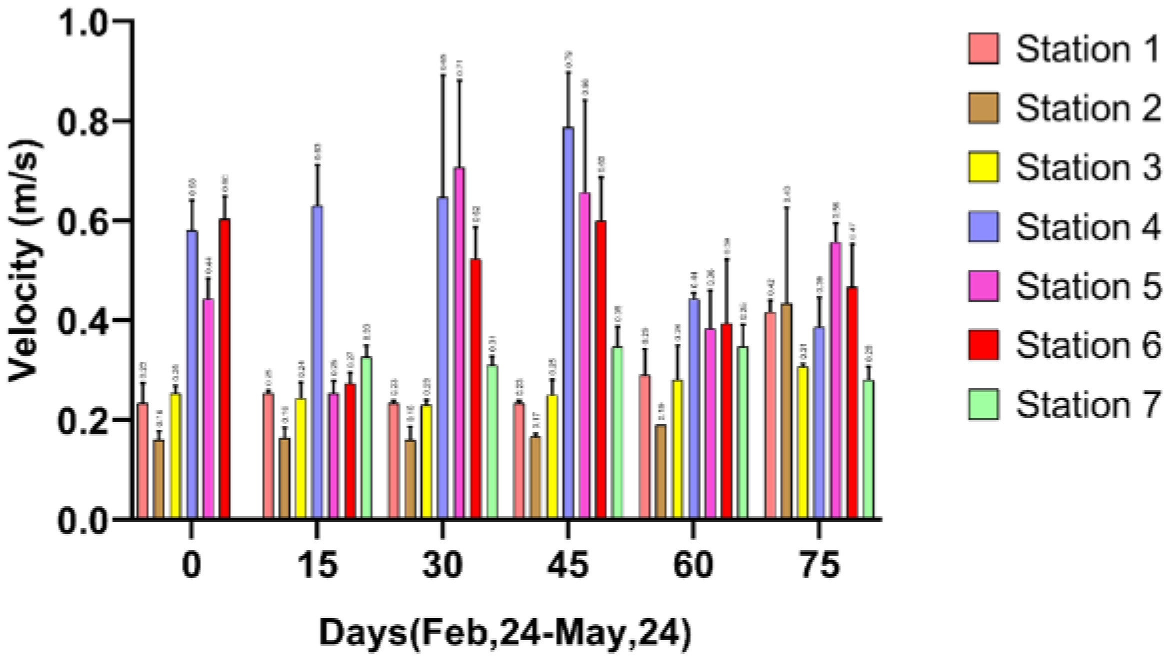
Figure 18 Surface water temperature



2. 4.3.3. Water Velocity

64. The water velocity measurements in meters per second (m/s) were recorded across various stations from February 2024 to May 2024. During the first sampling in February, Station 1 recorded water velocities ranging from 0.21 m/s to 0.28 m/s. Station 2 showed lower velocities, ranging from 0.15 m/s to 0.18 m/s. Station 3 had values between 0.24 m/s and 0.27 m/s. Station 4 recorded notably higher velocities, with values between 0.54 m/s and 0.65 m/s. Station 5 recorded velocities ranging from 0.4 m/s to 0.48 m/s. Station 6 had even higher velocities, between 0.56 m/s and 0.65 m/s. Over the subsequent sampling periods, water velocities showed notable variation. By the sixth sampling in May 2024, Station 1 had velocities ranging from 0.39 m/s to 0.43 m/s. Station 2 recorded a wider range of velocities, from 0.28 m/s to 0.65 m/s. Station 3 had velocities between 0.3 m/s and 0.31 m/s. Station 4 showed a slight decrease with velocities ranging from 0.32 m/s to 0.43 m/s. Station 5 had a range from 0.53 m/s to 0.6 m/s, showing an increase over time. Station 6 also saw a range from 0.39 m/s to 0.56 m/s. Station 7 had velocities between 0.25 m/s and 0.3 m/s. The mean water velocity across all stations and times was approximately 0.36 ±0.17 m/s, indicating substantial variation in water velocities over time and across different stations.

Figure 19 Water Surface Velocity



2.4.3.4. Secchi disc Turbidity

65. The Sacchi disc turbidity measurements were recorded at seven different stations and one pond over six sampling periods from February to May 2024. The results show that most stations maintained a constant turbidity level, labelled as "BV" (Bottom Visible), indicating the water was clear enough to see the bottom. However, Station 7 showed variations in turbidity levels during the later sampling periods.

66. The Sacchi disc turbidity results show that the water clarity remained generally high across most stations and the pond, with clear visibility to the bottom. Station 7 experienced a decrease in water clarity during the last two sampling periods, with turbidity values of 15 cm dropping to 11 cm, indicating some variability in water conditions at this location (Table 12).

Table 12: Secchi disc Turbidity across all stations and months

time period in days	1st sampling (0 days, Feb 2024)	2nd sampling (15 days, March 2024)	3rd sampling (30 days, March 2024)	4th Sampling (45 days, April 2024)	5th sampling (60 days, April 2024)	6th sampling (75 days, May 2024)
Station 1	BV	BV	BV	BV	BV	BV
Station 1	BV	BV	BV	BV	BV	BV
Station 1	BV	BV	BV	BV	BV	BV
station2	BV	BV	BV	BV	BV	BV
station2	BV	BV	BV	BV	BV	BV
station2	BV	BV	BV	BV	BV	BV
station3	BV	BV	BV	BV	BV	BV
station3	BV	BV	BV	BV	BV	BV
station3	BV	BV	BV	BV	BV	BV
station 4	BV	BV	BV	BV	BV	BV
station 4	BV	BV	BV	BV	BV	BV
station 4	BV	BV	BV	BV	BV	BV
station 5	BV	BV	BV	BV	BV	BV
station 5	BV	BV	BV	BV	BV	BV
station 5	BV	BV	BV	BV	BV	BV
station 6	BV	BV	BV	BV	BV	BV
station 6	BV	BV	BV	BV	BV	BV
station 6	BV	BV	BV	BV	BV	BV
station 7		BV	BV	BV	15	11
station 7		BV	BV	BV	15	11
station 7		BV	BV	BV	16	11
pond 8			BV	BV	BV	BV
pond 8			BV	BV	BV	BV
pond 8			BV	BV	BV	BV

B. Chemical Parameters of water

2.4.3.5. Conductivity

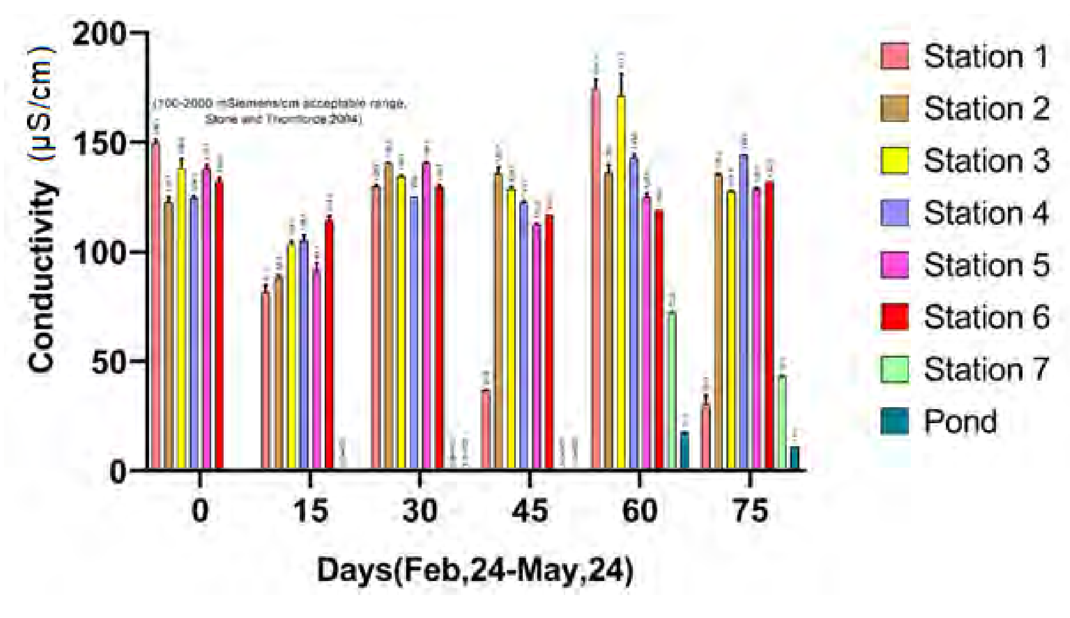
67. The conductivity measurements (in mV) across various stations from February to May 2024 exhibit considerable variation. At Station 1, the values ranged from 27 mV to 151 mV, with an average of approximately 110.5±53.18 mV. Conductivity decreased notably after the first sampling, but then slightly fluctuated. For example, in February, conductivity was between 148 mV and 151 mV, while by May, it had dropped to between 27 mV and 35 mV. Station 2 showed more consistent values, ranging from 87 mV to 141 mV, with an average of about 129.75 mV ±15.37 mV. The values remained relatively stable across

the sampling periods. Similarly, Station 3 displayed conductivity values ranging from 102 mV to 179 mV, with an average of approximately 144.75 ±21.92 mV, maintaining stability over time. Station 4 showed slightly less variability with values ranging from 102 mV to 145 mV, averaging about 126.5 ±.87 mV.

68. In contrast, Station 5 had a range of 89 mV to 141 mV, with an average conductivity of about 122.17 ±17.06 mV. Station 6 exhibited minor fluctuations, with values from 112 mV to 133 mV, averaging 123.83 ±7.46 mV. Station 7 and the pond exhibited markedly different patterns. Station 7 started with negligible readings, around 0.02 mV, until the fourth sampling period, then increased sharply to 72 mV to 73 mV by May. The pond had minimal values initially, around 0.002 mV, before rising to between 11 mV and 17.7 mV by May. The conductivity data reveals diverse trends across the different stations. While Stations 1 and 7 showed notable changes over time, with Station 7 starting from almost zero and rising sharply, other stations like Station 2, Station 3, and Station 6 remained relatively stable (Figure 20). The observed variations suggest distinct environmental conditions and influences at each station affecting the conductivity measurements.

69. Stone and Thomforde (2004)[9] recommended a desirable conductivity range of 100 to 2,000 µS/cm for fish. This range ensures an optimal environment for fish health and productivity, balancing essential mineral content without reaching levels that might stress or harm aquatic life. Usually, the conductivity of Fresh water is less than 325 µS/cm. From 325 µS/cm to 975 µS/cm is called marginal.

Figure 20 : Kopili River water conductivity



[9] Stone, N. M., & Thomforde, H. K. (2004). Understanding your fish pond water analysis report (pp. 1-4). Cooperative Extension Program, University of Arkansas at Pine Bluff, US Department of Agriculture and County Governments Cooperating.

2.4.3.6. Dissolved oxygen

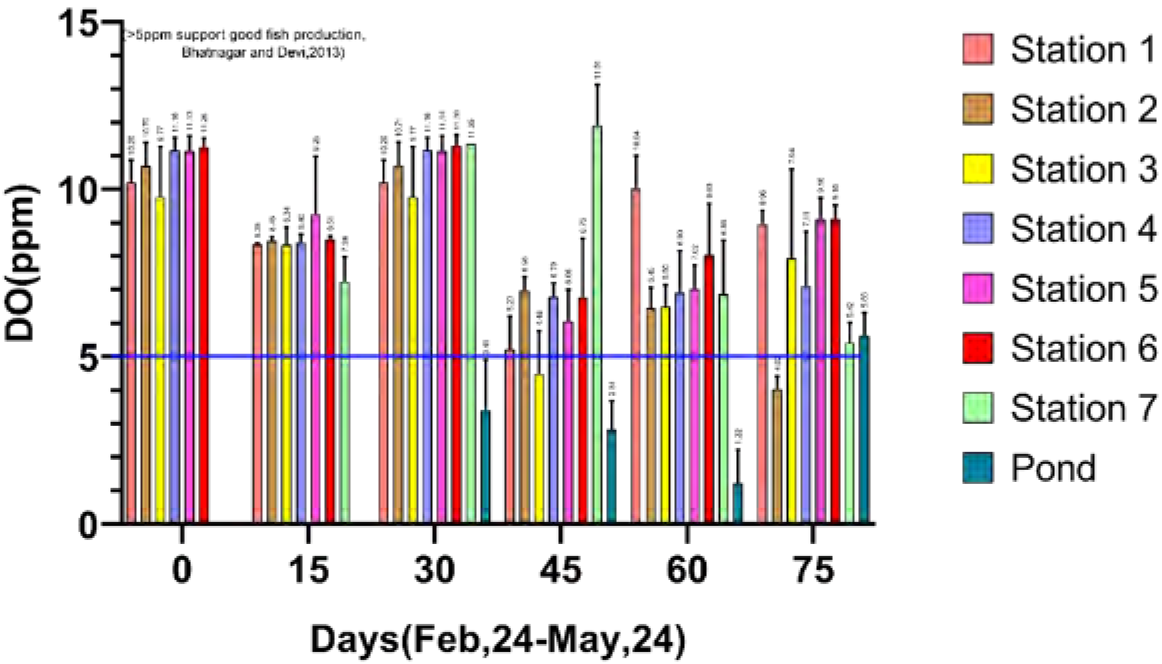
70. The dissolved oxygen (DO) measurements (in ppm) across various stations from February to May 2024 show noticeable variation. At Station 1, the values ranged from 4.186 ppm to 11.028 ppm, with an average of approximately 8.99 ±1.96 ppm. The highest DO concentration was recorded in the initial sampling period, with a gradual decrease over time, hitting the lowest in the fourth sampling period before rising again in the final two samplings. Station 2 exhibited a broader range of DO values, from 3.62 ppm to 11.1895 ppm, averaging about 7.83 ±2.59 ppm. The DO levels at this station also showed a decreasing trend over time, with notable fluctuations.

71. Station 3 had a DO range of 3.622 ppm to 10.865 ppm, with an average of 7.93 ±2.38 ppm. The values at Station 3 indicated a notable dip during the second sampling, followed by a mixed trend. Station 4 showed DO levels ranging from 5.456 ppm to 11.592 ppm, with an average of 8.56 ±1.96 ppm. This station had relatively stable readings, with slight fluctuations. Station 5 exhibited DO levels from 4.99 ppm to 11.5115 ppm, with an average of 8.22 ±1.92 ppm, showing a slight decrease over time.

72. Station 6 had a range of DO values from 4.991 ppm to 11.6725 ppm, averaging 9.07 ±2.00 ppm. This station showed a notable drop in the fourth sampling period but maintained higher readings in other periods. Station 7 presented a wider variation in DO values, from 4.99 ppm to 13.28 ppm, with an average of 8.16 ± 2.79 ppm. The catchment area pond had the lowest DO values, ranging from 0.2415 ppm to 6.35 ppm, with an average of 3.84 ±1.89 ppm, indicating much lower oxygen levels compared to the stations. The data reveal distinct variations in DO levels across different sampling periods and stations, with some locations exhibiting more stability than others (Figure 21).

73. Dissolved oxygen (DO) levels greater than 5 parts per million (ppm) are essential to support good fish production. Adequate DO levels are crucial for the respiration of fish and other aquatic organisms. When DO levels fall below this threshold, fish can become stressed, their growth and reproductive rates can decline, and their susceptibility to diseases can increase. Consistently maintaining DO levels above 5 ppm ensures a healthy and productive aquatic environment (Bhatnagar & Devi 2013).

Figure 21 : Kopili River water DO



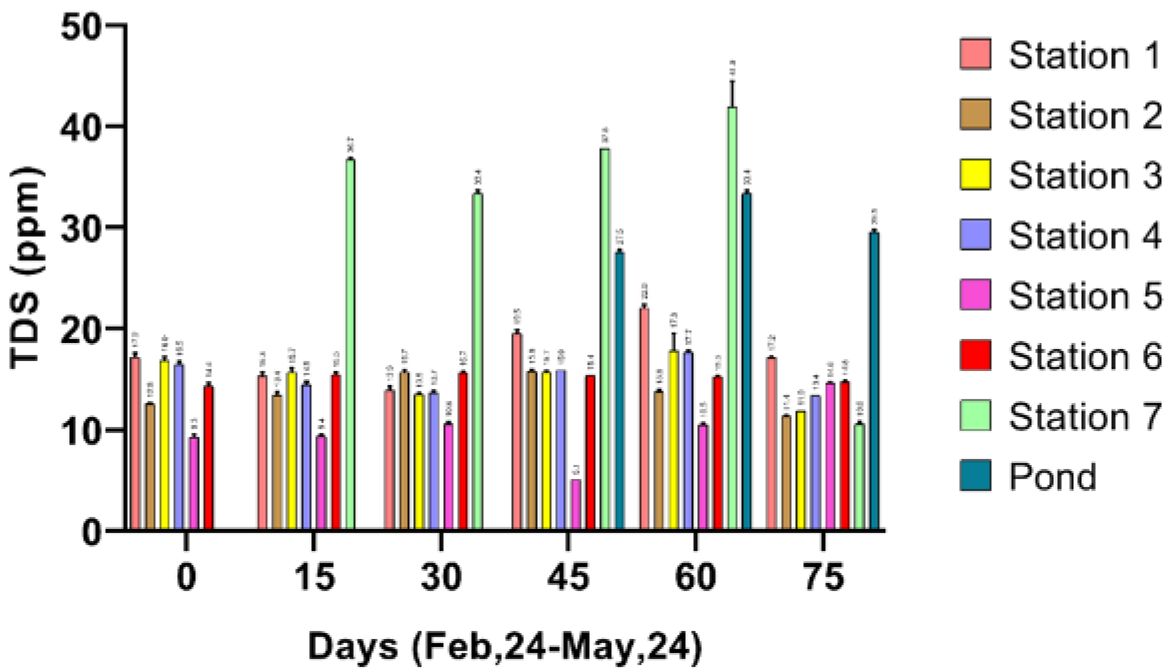
2.4.3.7. Total Dissolve Solid

74. The Total Dissolved Solids (TDS) measurements in ppm were recorded at various stations over a period from February 2024 to May 2024. During the first sampling in February 2024, TDS levels at Station 1 ranged from 16.7 to 17.5 ppm, while Station 2 had lower values, ranging from 12.5 to 12.7 ppm. Station 3 and Station 4 showed similar TDS levels, around 16.2 to 17.2 ppm and 16.2 to 16.7 ppm, respectively. Station 5 had the lowest TDS levels at around 9.1 to 9.6 ppm. Station 6 displayed values between 14.2 and 14.7 ppm. Station 7 and the pond did not have data for the first sampling (Figure 22).

75. By the sixth sampling in May 2024, TDS levels showed notable variations. Station 1 recorded TDS levels ranging from 17.1 to 17.3 ppm. Station 2 saw a decrease in TDS levels, ranging from 11.3 to 11.4 ppm. Station 3 had a notable drop to around 11.9 ppm. Station 4's TDS levels stabilized around 13.4 ppm. In contrast, Station 5 saw a notable increase, with values around 14.6 to 14.7 ppm. Station 6 had slightly higher TDS levels, ranging from 14.7 to 14.9 ppm. Station 7 showed a dramatic drop to around 10.3 to 10.7 ppm from earlier higher values. The pond maintained consistent TDS levels between 29.4 and 29.8 ppm. The mean TDS level across all stations and times was approximately 18.4 ±9.2 ppm, indicating substantial variation across different stations and over time. TDS levels varied considerably, with Stations 5 and 7 showing the most notable changes over the sampling period. A water body with TDS values less than 1500mgL^{-1} considered

favorable for aquatic bodies (Kalita et al., 2022)[10]. Hence, the TDS levels in all the sampled stations are favourable for fishes.

Figure 22 : Kopili River TDS



2.4.3.8. Total Suspended Solid

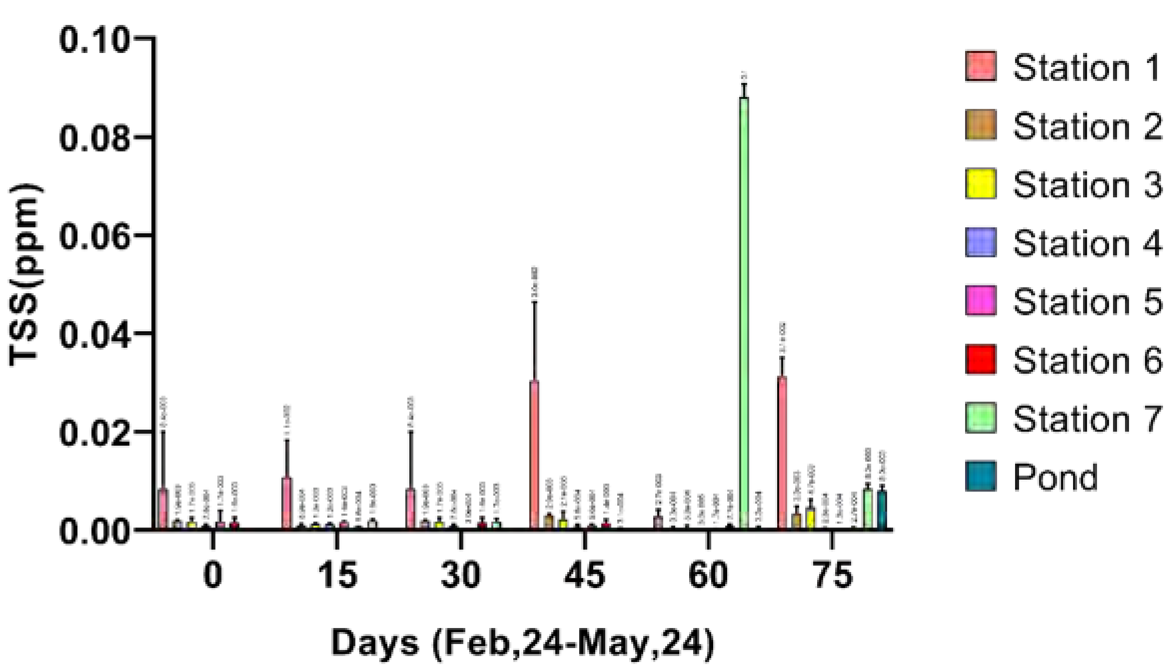
76. The Total Suspended Solids (TSS) measurements in ppm were taken across various stations from February 2024 to May 2024. During the initial sampling in February 2024, the TSS levels at Station 1 varied from 0.000333 ppm to 0.021667 ppm. Station 2 showed relatively lower levels, ranging from 0.001667 ppm to 0.002 ppm, while Station 3 had values between 0.001 ppm and 0.002667 ppm. Station 4 and Station 5 recorded TSS levels between 0.000333 ppm and 0.001 ppm, and 0.000333 ppm to 0.004333 ppm, respectively. Station 6 had TSS levels ranging from 0.000667 ppm to 0.002667 ppm. There was no data recorded for Station 7 and the pond for the first sampling.

77. As the sampling continued, the TSS levels varied notably over time. By the sixth sampling in May 2024, Station 1 recorded higher levels ranging from 0.027 ppm to 0.034 ppm. Station 2 saw TSS levels ranging from 0.002 ppm to 0.005 ppm. Station 3 also had an increase with values between 0.003 ppm and 0.006 ppm. Station 4 maintained relatively low levels, around 0.0001 ppm to 0.0003 ppm. Station 5 showed a decrease, with values between 0.0001 ppm and 0.0002 ppm. Station 6 had TSS levels ranging from

[10] Kalita, P. C., Talukdar, J. B., & Sarma, T. (2022). Effects of PH, TDS (Total Dissolved Solid) and TSS (Total Suspended Solid) on Aquatic Organisms of Duwani and Bomani Wetland of Kamrup Metro District of Assam, India. *Journal of Xi'an Shiyou University, Natural Science Edition*, *18*(11), 106-111.

0.0001 ppm to 0.0006 ppm. Notably, Station 7 exhibited a notable increase in TSS levels, particularly in the later stages, ranging from 0.007 ppm to 0.09 ppm (Figure 23) The pond also showed measurable TSS levels between 0.007 ppm and 0.009 ppm towards the end of the sampling period. The mean TSS level across all stations and times was approximately 0.007 ±0.015 ppm, indicating substantial variation in TSS concentrations over time and across different stations. The TSS levels generally increased over the sampling period, with Station 7 showing the most dramatic rise in TSS levels. There is no single, universally accepted TSS threshold level, a general guideline is to aim for levels below 100 ppm to maintain good water quality and minimize environmental impacts (Kalita et al 2022). Hence all the sample stations are favourable for fish in terms of TSS.

Figure 23 : Kopili River TSS



2.4.3.9. Total Hardness

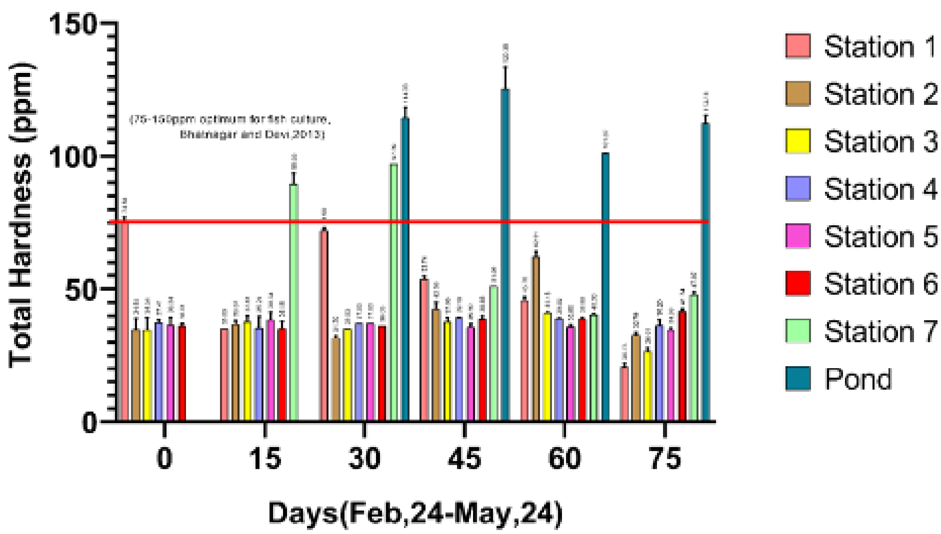
78. The total hardness (ppm) results across various stations from February to May 2024 revealed notable variations both across stations and over time. At Station 1, the total hardness values ranged from 19.4 ppm to 77.2 ppm, with an average of 48.73 ±22.91 ppm. These values show a clear decreasing trend over time, particularly notable in the last sampling period. Station 2 exhibited a range from 30.03 ppm to 63.63 ppm, averaging about 39.74 ±12.50 ppm. Station 2 experienced fluctuations in hardness levels, but overall, the values were relatively stable with slight increases towards the later sampling periods.

79. Station 3's hardness levels ranged from 25.88 ppm to 41.41 ppm, with an average of 35.11 ppm and a standard deviation of 4.83 ppm. This station demonstrated the most stable hardness values over time. Station 4 had hardness levels from 30.03 ppm to 39.5

ppm, averaging 37. ±2.79 ppm, indicating minimal variation. Station 5 showed values ranging from 33 ppm to 41.44 ppm, with an average of 36. ±2.60 ppm, which also remained fairly consistent over time.

80. Station 6 had hardness levels between 32.03 ppm and 42.56 ppm, with an average of 38.53 ±3.59 ppm, showing a slight increase towards the later sampling periods. Station 7 displayed a much broader range from 40 ppm to 97.097 ppm, averaging 68.57 ppm with a notable standard deviation of 25.78 ppm, indicating considerable variability. The pond had the highest and most consistent hardness levels, ranging from 101 ppm to 134.13 ppm, with an average of 116.34 ±10.32 ppm. The pond's consistently high values indicate a different water quality profile compared to the other stations, likely due to its stagnant nature. The data illustrate diverse trends in water hardness, with some stations showing marked changes over time, while others remained stable. Bhatnagar et al. (2004) indicated that hardness values less than 20 ppm cause stress to fish, while 75-150 ppm is considered optimal for fish culture. Hardness levels exceeding 300 ppm are lethal to fish, as they increase pH levels, leading to the non-availability of essential nutrients.

Figure 24 : Kopili River Total Hardness



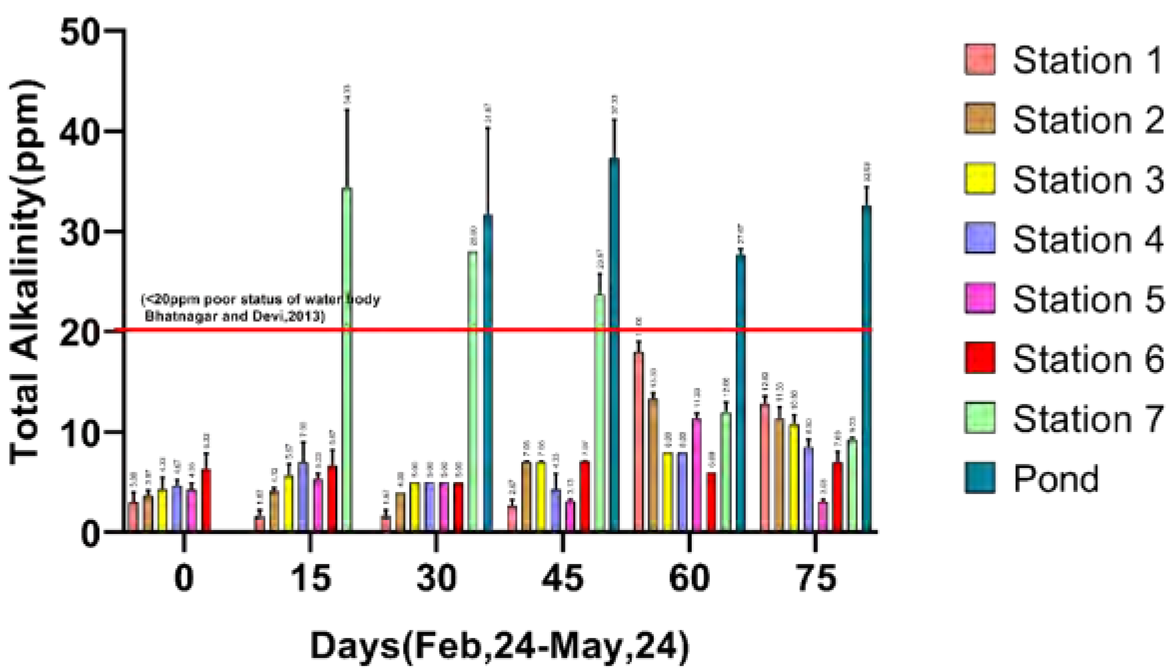
2.4.3.10. Alkalinity

81. The total alkalinity (ppm) data collected over six samplings from February to May 2024 at various stations indicated noticeable time-based variations. In the first sampling period (0 days, February 2024), Station 1 recorded alkalinity values of 2, 3, and 4 ppm. By the second sampling period (15 days, March 2024), the values slightly varied to 2, 1, and 2 ppm, reflecting a consistent low range. However, a marked increase was observed in the fifth sampling period (60 days, April 2024) with values rising to 17, 18, and 19 ppm. This increase continued into the sixth sampling period (75 days, May 2024), with values stabilizing around 12 to 13.5 ppm. The mean alkalinity at Station 1 over this period was 8.08 ±7.01 ppm, indicating a notable increase and variation over time.

82. Similar trends were observed at other stations. At Station 2, initial alkalinity values ranged from 3 to 4 ppm in February 2024, remained relatively stable in March 2024, and increased to around 7 ppm by the fourth sampling period (45 days, April 2024). In the fifth and sixth sampling periods, values ranged from 10 to 14 ppm, with a mean of 8. ±4.02 ppm. Station 3 followed a similar pattern, starting with values around 5 ppm, increasing slightly to 7 ppm in March and April, and then stabilizing at 9 to 11.6 ppm by May. The mean value for Station 3 was 7.08 ±2.74 ppm. At Station 7, there was a dramatic increase from 28 ppm in April to 43 ppm by the third sampling period, before settling between 9 and 13 ppm in May, showing a mean of 22.17 ±11.37 ppm. The pond also exhibited notable fluctuations, starting at 30 ppm in April and reaching up to 41 ppm by May, with a mean of 32.67 ±5.55 ppm. These data reflect substantial time-based variability in total alkalinity across different stations, with general trends of increasing alkalinity levels from February to May 2024. Very low alkalinity values of Station 1 to 6 indicated low buffering capacity of the Kopili river water in the study stretch (Figure 25).

83. Bhatnagar et al. (2004)[11] suggested that total Alkalinity levels in water with less than 20 ppm indicating a poor status unsuitable for fish and prawn culture. Levels between 20-50 ppm denote low to medium quality, which may be marginally acceptable but not ideal. The desirable range for optimal fish and prawn health and productivity is between 80-200 ppm, as it ensures an adequate supply of essential minerals.

Figure 25 : Kopili River Total Alkalinity



[11] Bhatnagar, A., Jana, S.N., Garg, S.K. Patra, B.C., Singh, G. and Barman, U.K., (2004), Water quality management in aquaculture, In: Course Manual of summerschool on development of sustainable aquaculture technology in fresh and saline waters, CCS Haryana Agricultural, Hisar (India), pp 203- 210.

2.4.3.11. Nitrate

84. The nitrate (ppm) results from February to May 2024 exhibit considerable variation across different stations and sampling periods. Station 1 shows an initial nitrate concentration around 1.26 ppm, which then drops to 0 ppm during the third and fourth sampling periods before rising notably to an average of approximately 1.34 ppm by the fifth sampling, and peaking at 7.12 ppm by the sixth sampling. The mean nitrate concentration for Station 1 over this period is 2.04 ±2.96 ppm, indicating notable fluctuations, especially in the later periods.

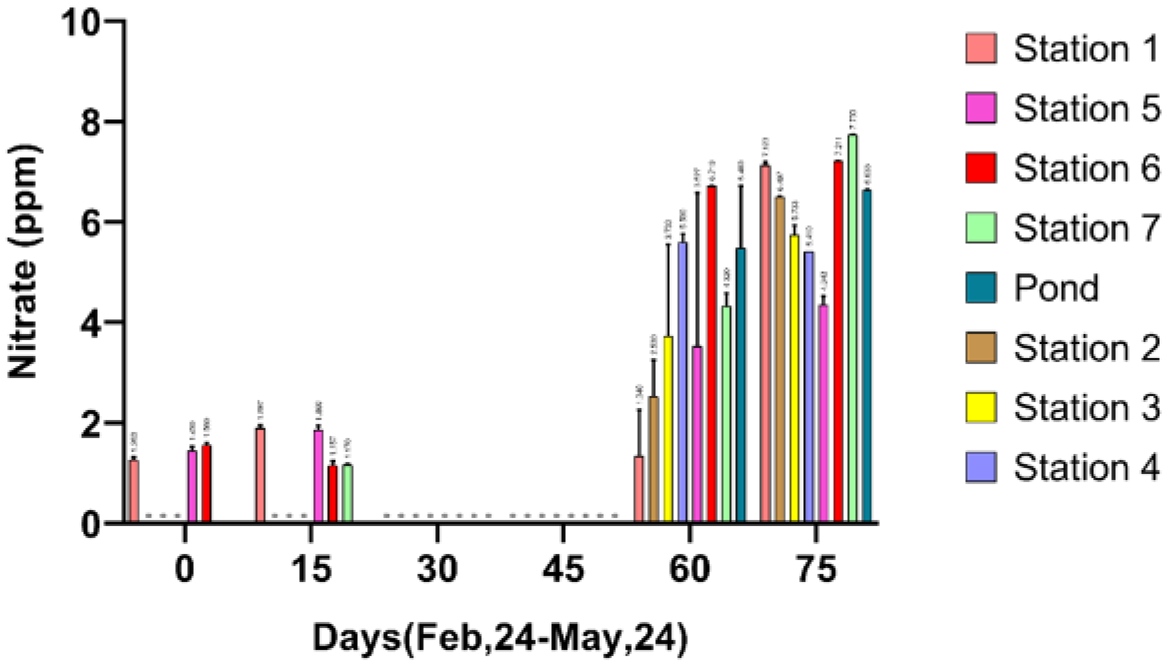
85. Station 2 consistently recorded 0 ppm nitrate for the first four sampling periods. In the fifth and sixth sampling periods, the nitrate levels increased to an average of 2.53 ppm and 6.50 ppm respectively. The overall mean for Station 2 is 1.84 ±3.06 ppm. Similarly, Station 3 showed 0 ppm nitrate for the first four sampling periods, with an increase to an average of 3.07 ppm in the fifth sampling and 5.73 ppm in the sixth sampling. The mean for Station 3 is 1.47 ±2.75 ppm.

86. Station 4 consistently recorded 0 ppm nitrate for the first four sampling periods, followed by a notable increase to an average of 5.59 ppm in the fifth sampling period and a consistent 5.41 ppm in the sixth sampling period. The mean for Station 4 is 2.23 ppm with a standard deviation of 2.87 ppm. Station 5 also shows initial nitrate levels around 1.45 ppm, dropping to 0 ppm in the third and fourth sampling periods, then increasing notably to an average of 3.53 ppm in the fifth sampling and 4.34 ppm in the sixth sampling. The mean for Station 5 is 1.90 ±1.91 ppm.

87. Station 6 recorded an average of 1.56 ppm in the first two sampling periods, followed by 0 ppm in the third and fourth periods, and a notable increase to around 6.71 ppm by the fifth and sixth periods. The mean nitrate concentration for Station 6 is 2.79 ±2.96 ppm. Station 7 had no data for the first period, recorded an average of 1.17 ppm in the second sampling, and then 0 ppm in the third and fourth periods, followed by an increase to an average of 4.32 ppm and 7.73 ppm in the fifth and sixth periods, respectively. The mean for Station 7 is 3.35 ±3.48 ppm (Figure 26).

88. Finally, the pond showed 0 ppm nitrate in the first four sampling periods and an increase to an average of 5.48 ppm by the fifth and sixth sampling periods. The mean nitrate concentration for the pond is 2.04 ±2.73 ppm. The nitrate levels across all stations indicate notable temporal variations, with generally low levels in the initial periods and marked increases in the later periods, particularly the fifth and sixth sampling periods. The US-EPA recommends a nitrate level of less than 8 mg/l NO_3 (or 1.8 mg/l as N) to support good water quality in rivers. Hence, all the sample stations are congenial for fishes as per Nitrate value is concerned.

Figure 26 : Kopili River Nitrate



2.4.3.12. Nitrite

89. The nitrite (ppm) results from February to May 2024 demonstrate a range of variations across different stations and sampling periods. Initially, all stations recorded 0 ppm nitrite levels in the first three sampling periods. From the fourth sampling period onwards, the nitrite levels began to increase slightly. Station 1 showed a gradual increase from 0.015 ppm in the fourth sampling to an average of 0.037 ppm in the fifth sampling and then a slight decrease to 0.026 ppm by the sixth sampling. The mean nitrite concentration for Station 1 over the entire period was 0.019 ±0.017 ppm, indicating a slight but consistent increase in nitrite levels over time.

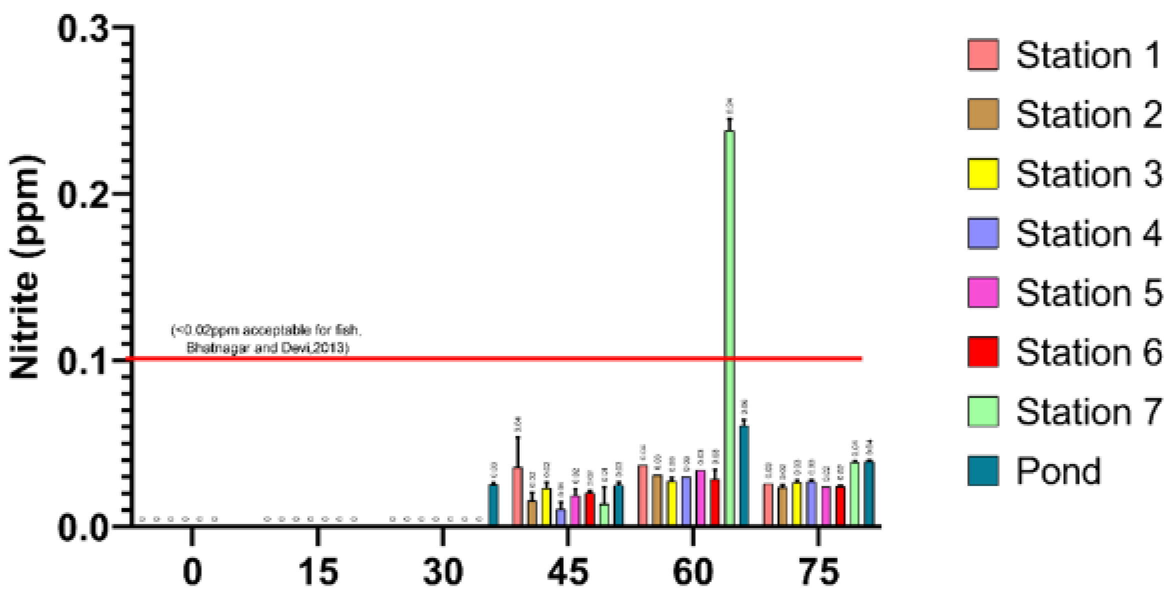
90. Station 2 recorded a similar trend, with nitrite levels remaining at 0 ppm for the first three periods, then increasing to an average of 0.016 ppm in the fourth sampling, and peaking at 0.031 ppm in the fifth sampling before slightly decreasing to 0.024 ppm in the sixth sampling. The mean nitrite concentration for Station 2 was 0.015 ±0.014 ppm. Station 3 also recorded 0 ppm nitrite initially, followed by a gradual increase to an average of 0.023 ppm in the fourth sampling and stabilizing at around 0.027 ppm by the sixth sampling. The mean for Station 3 was 0.017 ppm, with a standard deviation of 0.014 ppm.

91. Stations 4, 5, and 6 exhibited similar trends, with initial 0 ppm readings, followed by slight increases in the fourth sampling period. Station 4 had a mean of 0.014 ±0.013 ppm, while Station 5 showed a mean of 0.014 ±0.012 ppm. Station 6 recorded a mean of 0.013 ±0.012 ppm. Station 7 showed a notable difference, with no initial data and subsequent increases to 0.244 ppm in the fifth sampling, followed by a decrease to 0.039 ppm in the sixth sampling. The mean for Station 7 was 0.098 ±0.107 ppm, indicating notable fluctuations.

92. The pond showed slight variations with nitrite levels initially at 0.024 ppm, peaking at 0.064 ppm in the fifth sampling, and slightly decreasing to 0.039 ppm by the sixth sampling. The mean nitrite concentration for the pond was 0.042 ppm, with a standard deviation of 0.018 pp. The nitrite levels across all stations indicate a general trend of initially low or non-existent levels, with slight increases observed from the fourth sampling period onwards, and some stations showing more notable fluctuations than others.

93. Stone and Thomforde (2004) suggested that the desirable range for nitrite (NO_2) in water is 0-1 mg/L, with levels less than 4 mg/L being acceptable. According to Bhatnagar et al. (2004), nitrite levels between 0.02-1.0 ppm are lethal to many fish species, levels above 1.0 ppm are lethal for many warm water fishes, and levels below 0.02 ppm are acceptable.

Figure 27 : Kopili River Nitrite



2.4.3.13. Phosphate

94. The Soluble Inorganic Phosphate (ppm) results from February to May 2024 across various stations and sampling periods reveal notable fluctuations. Initially, phosphate levels varied notably among stations. Station 1 showed phosphate concentrations starting at 0.03 ppm and fluctuating across the sampling periods, peaking at 0.38 ppm in the second sampling before dropping to 0 ppm in the sixth sampling. The mean phosphate level for Station 1 over the entire period was approximately 0.18 ±0.14 ppm, indicating moderate variability in phosphate levels over time.

95. Stations 2 and 3 also exhibited fluctuations, with initial phosphate levels around 0.30 ppm and 0.04 ppm respectively. Station 2 showed a notable drop to 0 ppm by the fifth

and sixth samplings, with a mean of approximately 0.20 ± 0.19 ppm. Station 3 had a peak at 0.38 ppm in the fourth sampling, followed by a drop to 0 ppm by the sixth sampling, with a mean of around 0. ±0.12 ppm. Stations 4 and 5 followed similar trends, with initial phosphate levels dropping to 0 ppm in later samplings. Station 4 had a mean phosphate level of about 0.14 ppm (standard deviation 0.15 ppm), while Station 5 showed higher initial levels with a mean of 0.27 ±0.19 ppm. Station 6 demonstrated lower variability, starting at 0.06 ppm and peaking at 0.43 ppm in the fourth sampling, but consistently dropping to 0 ppm by the sixth sampling. The mean phosphate concentration for Station 6 was approximately 0.17 ±0.12 ppm. Station 7 recorded high initial phosphate levels of around 0.28 ppm in the second sampling, with a mean of 0.21 ±0.12 ppm. The pond samples showed low phosphate levels overall, peaking at 0.43 ppm in the sixth sampling, with a mean of about 0.23 ±0.16 ppm.

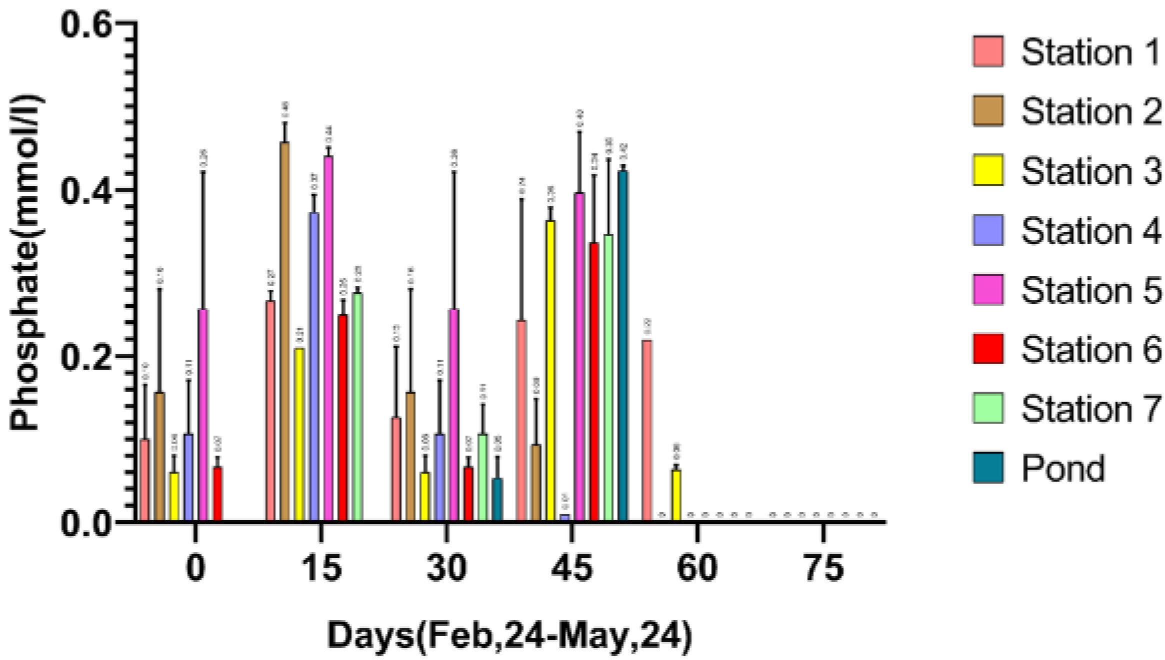
96. In summary, phosphate levels across all stations showed notable initial variations, with a general trend of reduction to 0 ppm by the later sampling periods. The mean phosphate levels ranged from 0.14 ppm to 0.27 ppm across stations indicating moderate to high variability. This suggests that phosphate concentrations in the sampled water bodies were influenced by temporal factors and possibly external environmental conditions, leading to initial spikes followed by a decline to minimal levels.

97. After analysis of the nutrient data of station 2, there is no evident sign of eutrophication in station 2 which will ultimately serve as the reservoir of LKHEP after commission. Further due to acidic water pH during the entire study period no fish and plankton were recorded from this station. Generally, Indian river systems have very low total phosphate concentration (>5 µg/L) and in many cases not within the detectable limits (Unni, 2003)[12]. Generally, standard value in pristine stream is 0.01 µg/L (EPA, 2012)[13].

[12] Unni . K.S ., 2003 . Ecology of Indian Rivers . International Book Distributors, Dehra Dun., 312p.

[13] https://archive.epa.gov/water/archive/web/html/vms56.html#:~:text=Monitoring%20phosphorus%20is%20challenging%20because,to%20identify%20serious%20problem%20areas.

Figure 28 : Kopili River Phosphate



2.4.3.14. Biochemical Oxygen Demand (BOD_3) or Biological Oxygen Demand

98. The Biochemical Oxygen Demand (BOD_3) (ppm) data collected across six sampling periods from February to May 2024 show distinct variations over time and among different stations. For Station 1, BOD3 (ppm) started low, ranging from 0.178 to 0.66 ppm in February, and slightly fluctuated in March, then increased notably to a range of 0.498 to 2.246 ppm by May. The mean BOD_3 (ppm) for Station 1 across the six periods was 0.877 ±0.739 ppm, indicating a moderate increase over time with some variability.

99. Station 2 showed a wider range of initial BOD_3 (ppm) values, from 0.572 to 2.25 ppm in February. This range saw more fluctuations in March, stabilizing somewhat in April, and then spiking to values between 4.193 and 4.993 ppm by May. The mean alkalinity for Station 2 was 1.99 ±1.83 ppm, indicating a higher degree of variability and a notable overall increase. Similarly, Station 3 exhibited a mean of 1.47 ±1.24 ppm, with initial values from 0.08 to 2.17 ppm in February and peaking at 3.999 ppm by May. Station 4 started with values between 0.8 and 2.34 ppm and showed an increase to between 0.564 and 3.869 ppm, resulting in a mean of 1.57 ±0.90 ppm. Station 5 showed the highest variability, starting from 0.08 to 3.39 ppm and later ranging from 0.112 to 3.09 ppm, with a mean of 1.83 ±1.13 ppm.

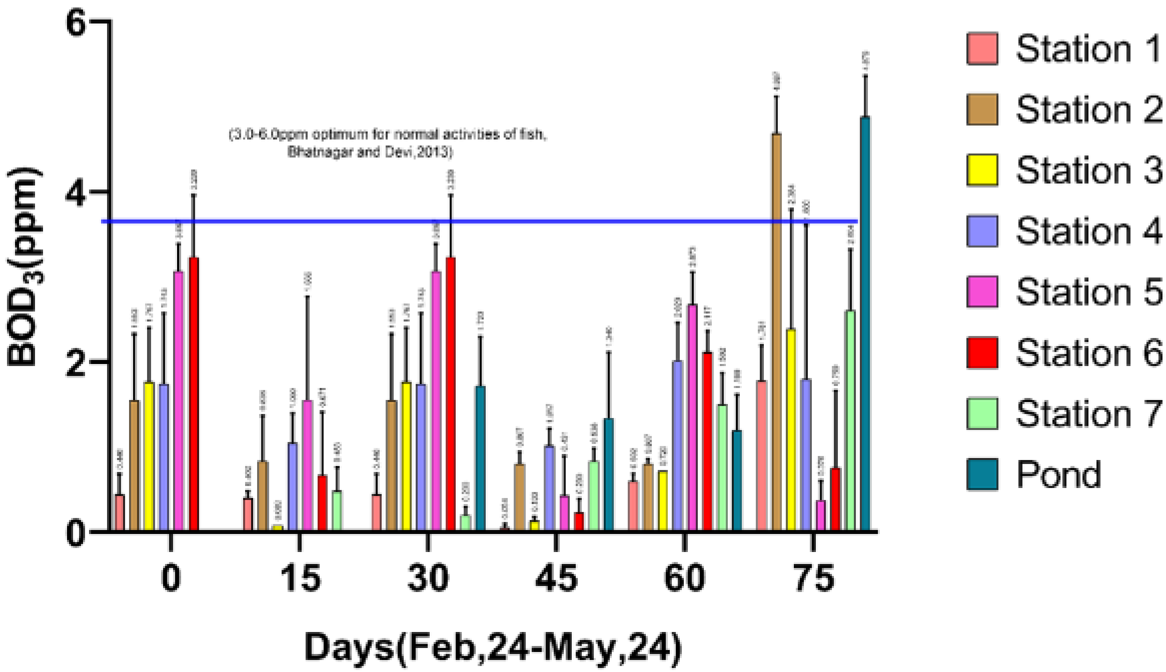
100. Station 6 exhibited a notable range and variability, from 0.241 to 3.94 ppm in February to values between 0.088 and 1.792 ppm by May, with a mean BOD_3 (ppm) of 1.52 ±1.47 ppm. Station 7 presented substantial increases from February to May, with initial values ranging from 0.1 to 0.644 ppm, later reaching 0.676 to 3.06 ppm by May. The mean for Station 7 was 0.918 ±0.752 ppm. The catchment area pond displayed the highest mean BOD_3 (ppm) overall, with initial values from 0.49 to 2.09 ppm in February

rising between 4.427 and 5.384 ppm by May. The mean BOD_3 (ppm) for the pond was 2.96 ±1.64 ppm.

101. The data reflect temporal and spatial variability in total BOD_3 (ppm) across the sampling periods and stations, with a general trend of increasing BOD_3 (ppm) levels from February to May 2024. The pond showed the highest BOD_3 (ppm) levels and variability, whereas the stations exhibited varied trends with increases over time.

102. According to Bhatnagar et al. (2004), a Biological Oxygen Demand (BOD) level between 3.0-6.0 ppm is optimal for the normal activities of fish. Levels between 6.0-12.0 ppm are sublethal, causing stress to fish, while levels above 12.0 ppm can typically result in fish kills due to suffocation.

Figure 29: Kopili River Total Alkalinity



2.4.3.15. Chemical Oxygen Demand (COD)

103. The Chemical Oxygen Demand (COD) of the study stations from February to May 2024 showed notable variation both over time and across different stations. At Station 1, COD levels ranged from 3.73 ppm to 4.8 ppm in February, increasing consistently to between 12.4 ppm and 12.8 ppm by May. The mean COD concentration for Station 1 across all sampling periods was 7.75 ppm ±3.32 ppm, indicating a notable increase over time with moderate variability.

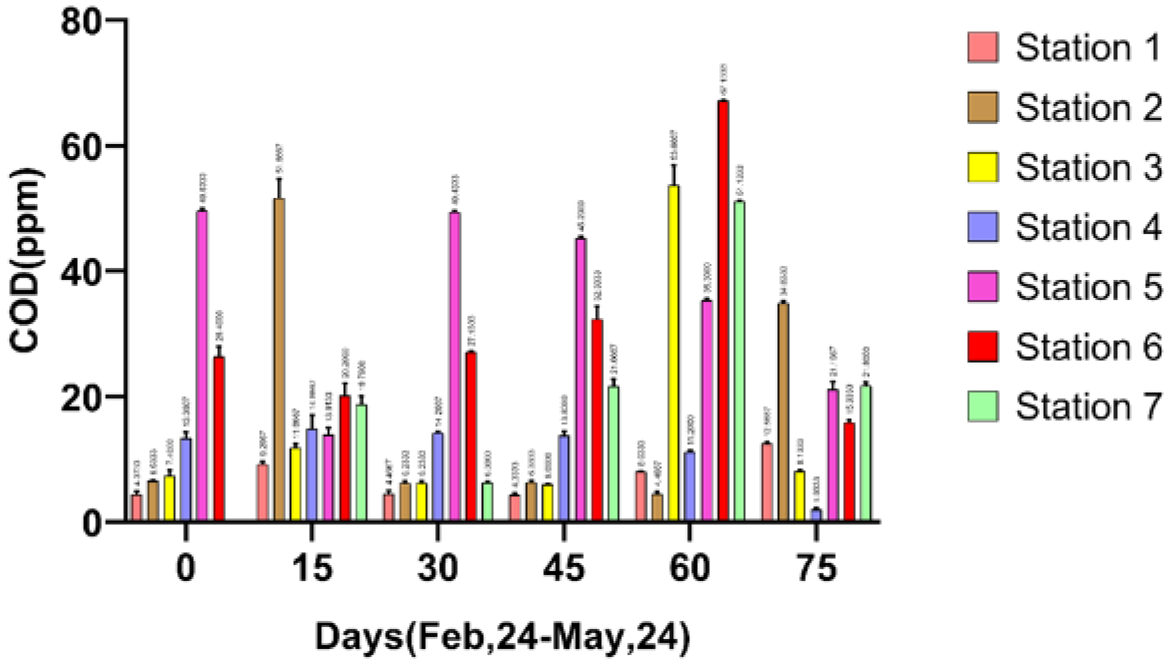
104. Station 2 exhibited a stark contrast, with initial COD levels between 6.4 ppm and 6.7 ppm in February, peaking dramatically to between 34.6 ppm and 35.2 ppm by May. The mean COD concentration for Station 2 was notably higher at 23.28 ±19.23 ppm, reflecting substantial temporal and spatial variation. Similarly, Station 3 showed initial COD levels ranging from 6.4 ppm to 8.2 ppm in February, which surged to values between 8 ppm and 8.4 ppm in May. The mean for Station 3 was 12.5 ±16.97 ppm, indicating large fluctuations over the sampling period.

105. Station 4 demonstrated consistently high initial COD levels, ranging from 12.4 ppm to 14.4 ppm in February, and showed a decrease to between 1.6 ppm and 2.3 ppm by May. The mean for Station 4 was 11.62 ±5.71 ppm, indicating a reduction over time. Station 5 had the highest initial COD levels among all stations, with values ranging from 49.3 ppm to 50 ppm in February, which decreased to between 19.9 ppm and 22.4 ppm by May. The mean COD concentration for Station 5 was 34.93 ±.38 ppm, reflecting high initial values that decreased over time.

106. Station 6 displayed COD levels ranging from 24.5 ppm to 27.5 ppm in February, reaching between 15.5 ppm and 16.3 ppm by May. The mean COD concentration for Station 6 was 29.8 ±18.38 ppm, indicating high and somewhat stable levels with a slight decrease. Station 7 presented varying initial COD levels, and by May, the range was 21 ppm to 22.4 ppm. The mean for Station 7 was 22.03 ±12.96 ppm, showing stable levels with moderate variability. The COD data indicates diverse trends over time across different stations. Some stations, like Stations 1, 2, and 3, showed increasing trends, while others like Stations 4 and 5 displayed decreasing trends over the sampling period. The variation among stations reflects differences in local environmental factors affecting COD levels. COD level greater than 200 mg/l indicative of water receiving effluents (Chapman 1992)[14]. In the sampled stations, COD values where below 200 mg/l indicates favourable values for aquatic species.

[14] Chapman, D. (1992) Water Quality Assessment: A Guide to the Use of Biota, Sediment and Water in Environmental Monitoring. WHO, Geneva, 585 p.

Figure 30: Chemical Oxygen Demand



2.4.3.16. Calcium

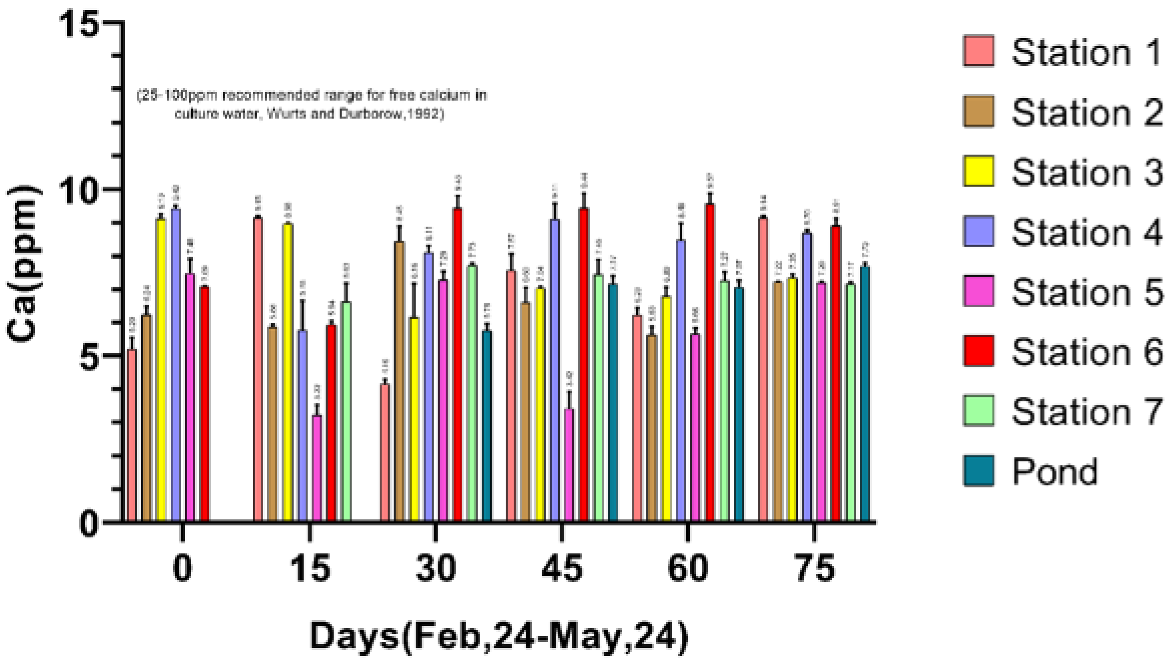
107. The calcium concentration (ppm) data collected from February to May 2024 demonstrates variation over time and among different stations. In the initial sampling in February, calcium levels at Station 1 ranged from 5.0 to 5.6 ppm, while by May, they had increased to a range of 9.08 to 9.2 ppm. The mean calcium concentration for Station 1 across all sampling periods was 6.65 ±1.87 ppm, indicating a notable increase over time with consistent upward trends.

108. Station 2 showed initial calcium levels ranging from 5.8 to 6.5 ppm in February, which fluctuated and generally increased to a range of 7.21 to 7.24 ppm by May. The mean calcium concentration for Station 2 was 6.88 ±1.03 ppm, reflecting a steady increase over the sampling period. Station 3 had the highest initial calcium levels among all stations, with values between 9.0 and 9.27 ppm in February, decreasing slightly to a range of 7.24 to 7.44 ppm by May. The mean for Station 3 was 7.82 ±1.19 ppm, showing a decreasing trend.

109. Station 4 exhibited high initial calcium levels, ranging from 9.334 to 9.48 ppm, and maintained high levels throughout the sampling period, ending with values between 8.65 and 8.79 ppm in May. The mean for Station 4 was 8.58 ±0.79 ppm, indicating relatively stable high calcium levels. Station 5 displayed initial calcium levels ranging from 7.0 to 7.8 ppm in February, fluctuating more than other stations, with levels in May ranging from 7.17 to 7.231 ppm. The mean for Station 5 was 5.94 ±1.68 ppm, indicating variability.

110. Station 6 showed high calcium levels consistently, starting at 7.08 to 7.1 ppm in February and reaching between 8.67 to 9.43 ppm by May. The mean calcium concentration for Station 6 was 8.63 ±1.23 ppm, reflecting high and stable levels. Station 7 had varying initial calcium levels, and by May, the range was 7.11 to 7.21 ppm, with a mean of 7.23 ±0.25 ppm, indicating stable levels. The pond showed initial calcium levels ranging from 5.64 to 6.0 ppm, increasing to 7.0 to 7.8 ppm by May, with a mean of 6.95 ±0.66 ppm, reflecting a moderate increase over time. The data indicates an upward trend in calcium concentration over time for most stations, with Station 3 showing a slight decrease. Wurts and Durborow (1992) recommended that the range for free calcium in culture waters should be 25 to 100 mg/L, which corresponds to a calcium carbonate ($CaCO_3$) hardness of 63 to 250 mg/L. All the sampling stations have low calcium level below requirement levels.

Figure 31: Variation of Calcium across different study station



2.4.3.17. Chloride

111. The chloride concentration (ppm) data collected from February to May 2024 reveals variation both over time and across different stations. In the initial sampling in February, chloride levels at Station 1 ranged from 0.3 to 2.4 ppm. By May, these levels increased to a range of 2.165 to 2.468 ppm. The mean chloride concentration for Station 1 across all sampling periods was 1.96 ±0.99 ppm, indicating a moderate increase over time with some variability.

112. Station 2 showed initial chloride levels ranging from 3.5 to 4 ppm in February, which decreased to a range of 1.346 to 1.424 ppm by May. The mean chloride concentration for Station 2 was 3.35 ±1.23 ppm, reflecting a decrease over the sampling period. Station 3 had lower initial chloride levels, with values between 0.2 and 1.4 ppm in February,

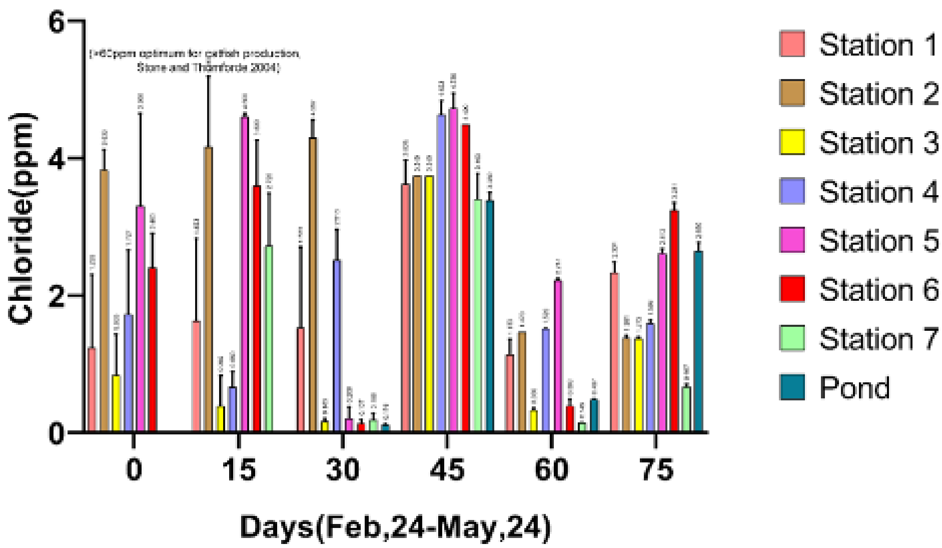
increasing to a range of 1.346 to 1.399 ppm by May. The mean for Station 3 was 1.31 ± 0.42 ppm, showing a slight increase over time.

113. Station 4 exhibited initial chloride levels ranging from 1.12 to 2.8 ppm, and these levels increased to a range of 1.519 to 1.624 ppm in May. The mean for Station 4 was 2.32 ±1.30 ppm, indicating a relatively stable trend with slight increases. Station 5 displayed higher initial chloride levels, ranging from 1.948 to 4.652 ppm in February, and fluctuated with levels in May ranging from 2.541 to 2.672 ppm. The mean for Station 5 was 3.10 ±1.13 ppm, indicating variability.

114. Station 6 showed an increase in chloride levels consistently, starting at 1.9 to 2.9 ppm in February and reaching between 3.124 to 3.332 ppm by May. The mean chloride concentration for Station 6 was 3.01 ±0.78 ppm, reflecting high and increasing levels. Station 7 had varying initial chloride levels, and by May, the range was 0.624 to 0.689 ppm, with a mean of 1.51 ±1.17 ppm, indicating stable low levels. The pond showed initial chloride levels ranging from 0.1 to 0.124 ppm, increasing to 2.546 to 2.781 ppm by May, with a mean of 1.76 ±1.43 ppm, reflecting a moderate increase over time.

115. The data indicates different trends in chloride concentration over time for various stations, with some showing increasing trends and others decreasing. The variation among stations reflects differences in local environmental factors affecting chloride levels. According to Stone and Thomforde (2004), the desirable range of chlorides for commercial catfish production is above 60 mg/L. The natural chloride content of Indian Rivers is 3.2 ppm (Berner and Berner, 1987)[15].The chloride levels in sampled stations are safe for aquatic species.

Figure 32: Variation of Chloride across different study station



[15] Elizabeth Kay Berner, Robert A. Berner 1987. The Global Water Cycle: Geochemistry and Environment. Prentice-Hall.

2.4.3.18. Iron

116. The iron (ppm) results from February to May 2024 across various stations show some variation, although most of the values are consistent. Station 1 consistently recorded an iron concentration of 0.5 ppm across all six sampling periods, resulting in an average of 0.5 ppm. This stability in Station 1 indicates a low but consistent presence of iron in the water, without many fluctuations over time.

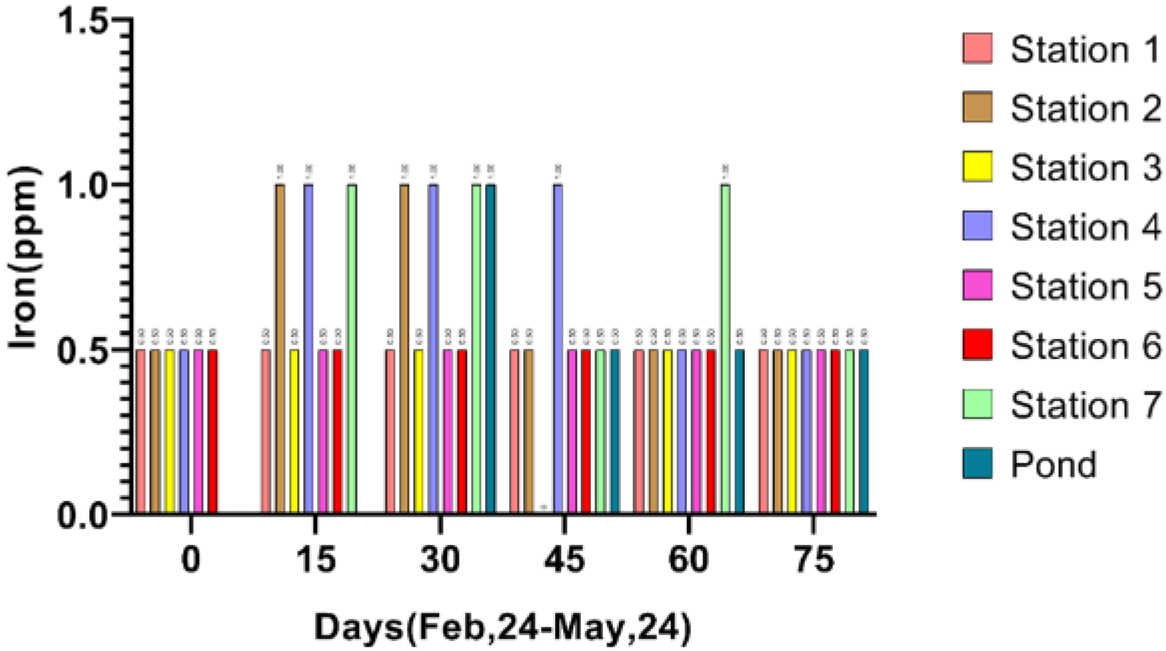
117. Station 2 showed slightly more variability, with iron levels alternating between 0.5 ppm and 1 ppm. The average iron concentration for Station 2 was approximately 0.67 ±0.25 ppm. This suggests occasional increases in iron concentration at this station. Station 3 also maintained a generally stable iron concentration of 0.5 ppm, except for the fourth sampling period when the level dropped to 0 ppm. The average for Station 3 was around 0.42 ±0.22 ppm, indicating a slight fluctuation during the fourth sampling.

118. Station 4 exhibited a pattern similar to Station 2, with iron levels alternating between 0.5 ppm and 1 ppm. The average for Station 4 was 0.75 ±0.25 ppm. This station showed more pronounced fluctuations, particularly during the mid-sampling periods. Station 5 recorded a consistent 0.5 ppm across all sampling periods, mirroring the stability seen in Station 1, with an average of 0.5 ppm.
Station 6 also consistently recorded 0.5 ppm of iron, resulting in an average of 0.5 ppm. Station 7 showed variability similar to Stations 2 and 4, with iron levels alternating between 0.5 ppm and 1 ppm. The average for Station 7 was 0.75 ± 0.25 ppm, indicating some periodic increases in iron concentration. Lastly, the pond showed a decrease from 1 ppm to 0.5 ppm after the first sampling, resulting in an average of 0.67 ±0.25 ppm, reflecting the initial higher concentration and subsequent stabilization.

119. The iron concentrations were generally stable at 0.5 ppm across most stations, with some stations like Stations 2, 4, 7, and the pond showing occasional increases to 1 ppm. The standard deviations were low, indicating minor fluctuations in iron levels across the different sampling periods. Iron (soluble ionized form) levels should not exceed 0.2 ppm for warm water fishes and 0.1 ppm for salmonid fishes (ICAR 2011)[16]. Station 2 , 4 7 and pond contain higher amount of Iron than required for aquatic species

[16] ICAR 2011. HandBook of Fisheries and Aquaculture, Directorate Of Knowledge Management In Agriculture , New Delhi

Figure 33 : Variation of Iron across different study station



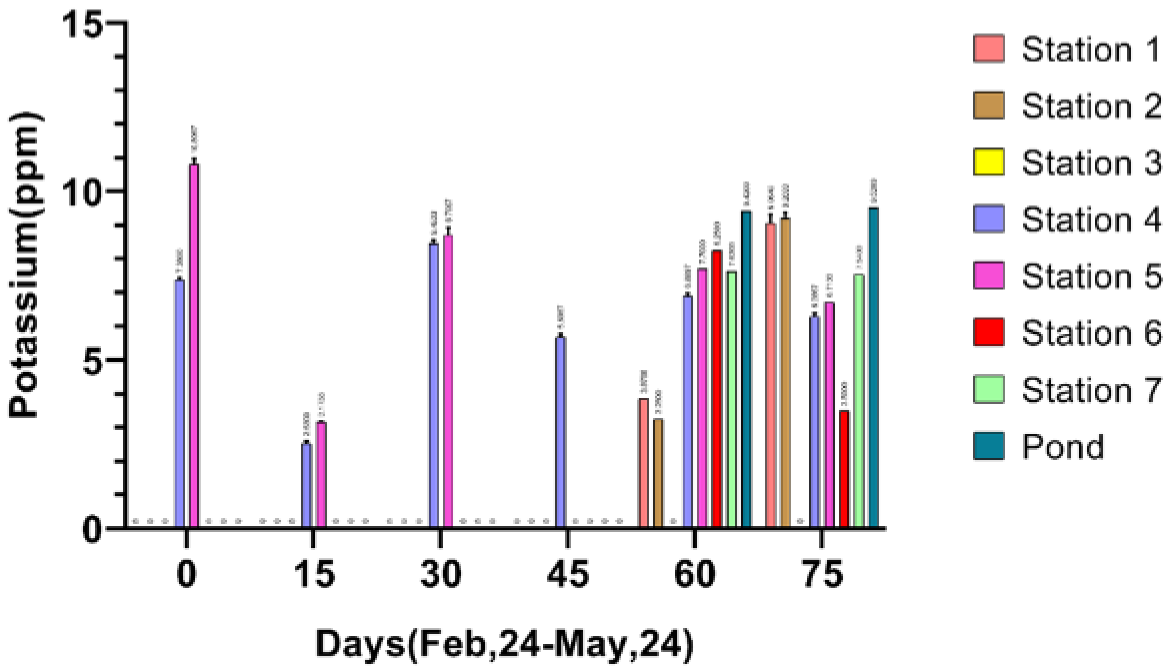
2.4.3.19. Potassium

120. The Potassium (ppm) results were measured at different stations and times from February 2024 to May 2024. During the initial sampling in February, no Potassium was detected at any of the stations or the pond. By the second sampling in March, only Station 4 and Station 5 showed detectable levels of Potassium, ranging from 2.45 ppm to 3.18 ppm. As time progressed, the Potassium levels increased. By the third sampling, levels at Station 4 and Station 5 had increased notably, with Station 4 ranging from 8.34 ppm to 8.56 ppm, and Station 5 from 8.45 ppm to 8.84 ppm.

121. In April and May, Potassium levels continued to rise across more stations. The fifth sampling in April saw Potassium levels in Station 1 at 3.87 ppm, and stations 4, 5, 6, and 7 had notable levels ranging from 5.62 ppm to 8.25 ppm. By the final sampling in May, Potassium levels at Station 1 peaked at 9.36 ppm, with the pond reaching a high of 9.52 ppm. The mean Potassium levels across all stations and times were approximately 6.12 ±2.94 ppm, indicating higher variation in Potassium concentrations over time and across different stations. The results suggest a clear temporal increase in Potassium levels, with the highest variability observed towards the later sampling periods. For fish welfare, the threshold level is generally considered to be between 200 ppm and 400 ppm. This range is suitable for catfishes and does not lead to hyperkalaemia or hypokalaemia (Basalo 2022)[17].

[17] Basalo, P. F. X. (2022). Potassium homeostasis and fish welfare in coupled aquaponic systems. *Fish. Aquac. J*, *13*(2), 1000290.

Figure 34 : Variation of Potassium across different study station

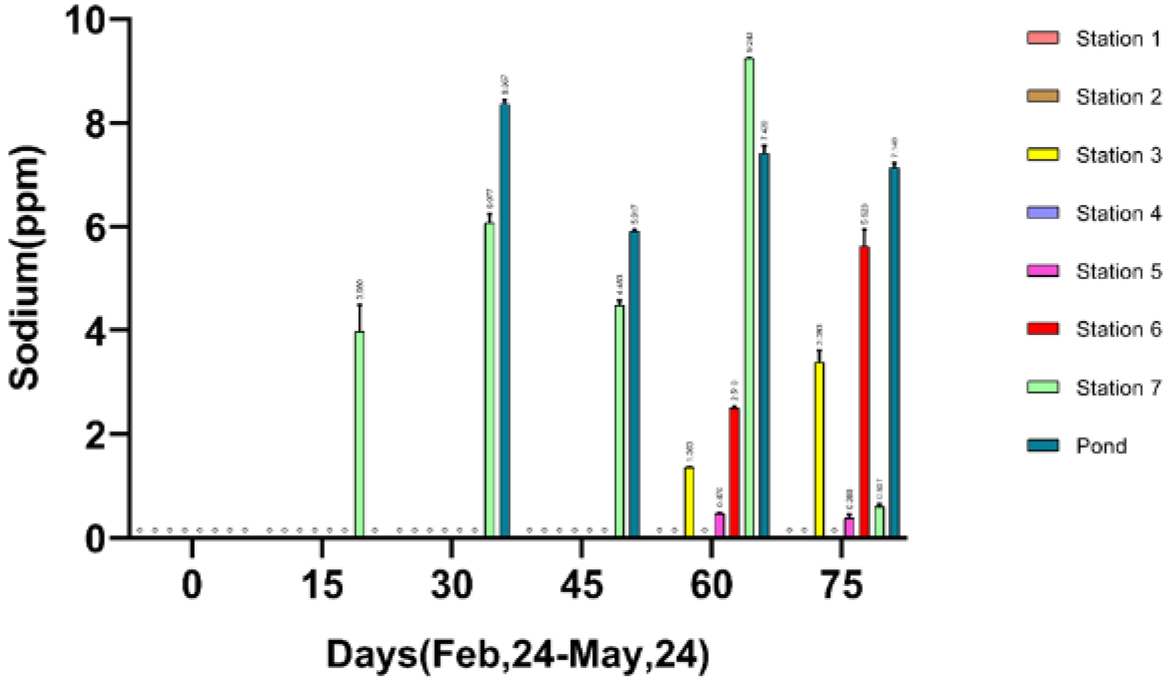


2.4.3.20. Sodium

122. The Sodium (ppm) results indicated varying levels of Sodium across different stations and times from February 2024 to May 2024. Initially, no Sodium was detected at any station during the first sampling in February 2024. By the second sampling in March 2024, Sodium was detected only at Station 7, with levels ranging from 3.47 ppm to 4.49 ppm. As time progressed, the third sampling in late March showed an increase in Sodium levels at Station 7 to between 5.92 ppm and 6.26 ppm. Additionally, the pond showed notable Sodium levels, all around 8.33 ppm to 8.45 ppm.

123. In April and May, more stations exhibited detectable Sodium levels. By the fourth sampling, Station 3 showed Sodium levels around 1.36 ppm to 1.37 ppm, while Station 7 had levels ranging from 4.42 ppm to 4.59 ppm. The pond continued to show high Sodium levels, around 5.89 ppm to 5.94 ppm. By the fifth sampling in April, Station 6 showed notable Sodium levels, ranging from 2.48 ppm to 2.54 ppm, and Station 7 exhibited a peak of 9.23 ppm to 9.26 ppm. The pond remained high, with levels around 7.26 ppm to 7.54 ppm. In the final sampling in May, Station 3's Sodium levels ranged from 3.21 ppm to 3.65 ppm, and Station 6 showed levels from 5.33 ppm to 5.97 ppm. The mean Sodium level across all stations and times was approximately 3.83 ±3.22 ppm, indicating substantial variation over time and across different stations. The Sodium levels increased drastically over the sampling period, with Station 7 and the pond showing the highest concentrations. There are no specific sodium threshold levels mentioned in the sources for aquatic life, as sodium is not typically considered a significant factor in eutrophication processes.

Figure 35 : Variation of Sodium across different study station



2.4.3.21. Sulphate

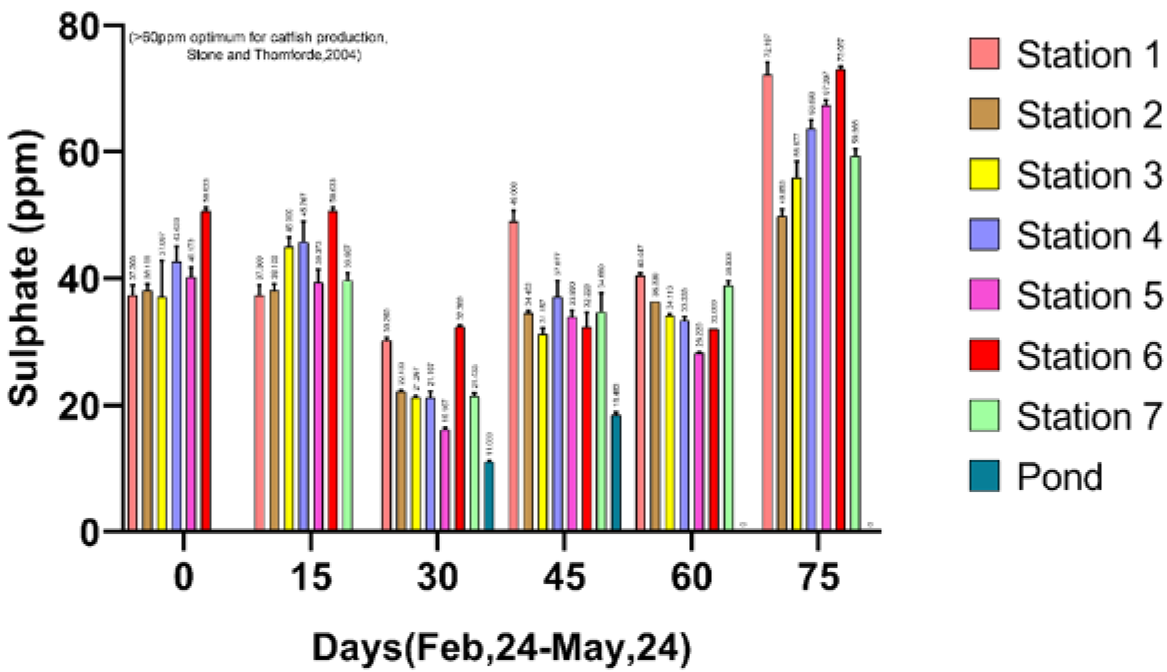
124. The Sulphate (ppm) results were measured at various stations from February 2024 to May 2024. In the first sampling in February 2024, the Sulphate levels ranged from 33 ppm to 51.3 ppm across all stations, with the pond showing no detectable Sulphate. The second sampling in March 2024 showed Sulphate levels remaining relatively consistent at each station, with slight variations. For example, Station 1 maintained levels around 37.4 to 38.9 ppm, while Station 4 stayed around 43.1 to 44.8 ppm. The pond also showed consistent results, ranging from 10.9 to 11.2 ppm.

125. As time progressed, the third sampling in late March 2024 saw a drop in Sulphate levels at most stations, with Station 5 and the pond showing the lowest values at around 16 ppm and 18.67 ppm, respectively. By the fourth sampling in April 2024, there was a slight increase in Sulphate levels, with Stations 1, 2, and 3 ranging between 30 ppm to 50 ppm. By the fifth sampling, Sulphate levels had increased across all stations, peaking at around 40.67 ppm to 40.67 ppm at Station 1, while the pond showed no detectable Sulphate. The final sampling in May 2024 recorded the highest Sulphate levels, especially at Station 1, ranging from 70.33 ppm to 74.23 ppm.

126. Sulphate level across all stations and times was approximately 38.2 ±18.9 ppm, indicating considerable variation in Sulphate concentrations over time and across different stations. The Sulphate levels showed an initial decrease followed by a notable increase, with Station 1 and Station 6 showing the highest levels towards the end of the sampling period. The toxicity of sulfate to aquatic life varies depending on water hardness. For example, a study on rainbow trout found that a concentration of 100 ppm SO_4^{2-} was

toxic, while another study on aquatic moss found toxicity at concentrations ranging from 100 to >250 ppm (Meays et al., 2013)[18].

Figure 36 : Variation of Sulphate across different study station



B. **Bacteriological parameters of water**

2.4.3.22. Coliform bacteria

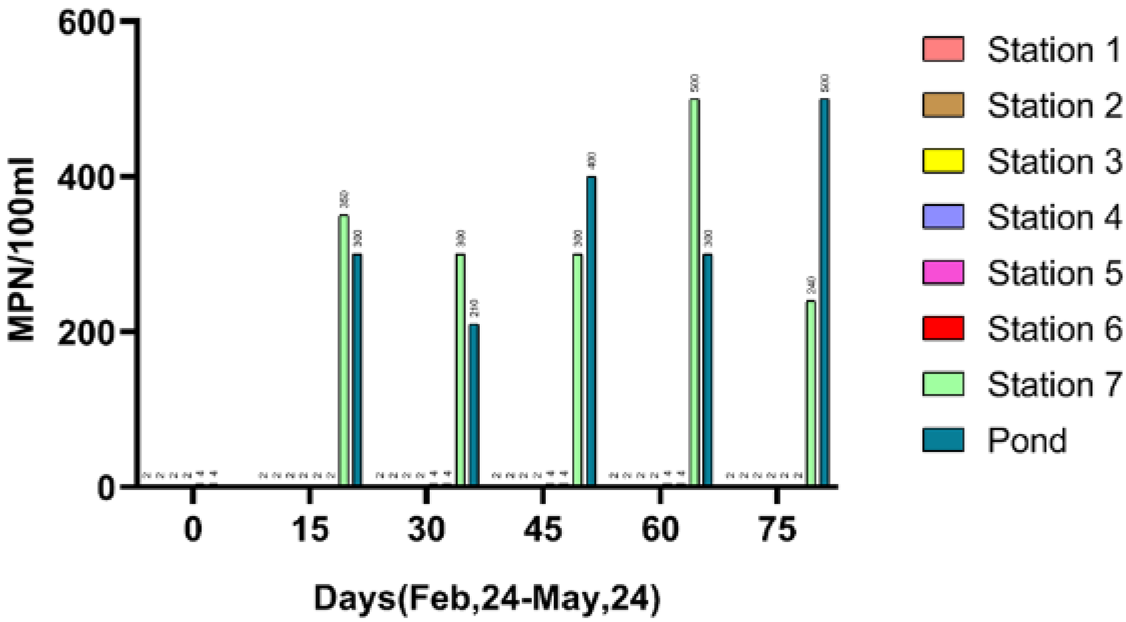
127. The Coliform Bacteria per 100 milliliters (ml) measurements were recorded across various stations from February 2024 to May 2024. For most stations (Stations 1 through 4), the MPN/100ml remained consistently low and unchanged at a value of 2 throughout all sampling periods. This suggests a relatively stable and low level of microbial presence in these locations. However, more variability was observed in other stations and the pond. Station 5 and Station 6 both recorded an MPN/100ml of 4 during the first sampling in February, then dropped to 2 in subsequent samplings, with fluctuations between 2 and 4 across the sampling periods. Station 7 showed a dramatic increase in MPN/100ml starting from the second sampling in March, with values reaching 350. The readings then varied between 300 and 500, suggesting a high microbial presence and considerable variation

[18] Meays, C., Nordin, R., Protection, W., & Branch, S. (2013). Ambient water quality guidelines for sulphate. *Technical Appendix. Water Protection & Sustainability Branch: Environmental Sustainability and Strategic Policy Division, BC Ministry of Environment*.

over time. The pond also exhibited high MPN/100ml values, starting at 300 in the second sampling and fluctuating between 210 and 500 in subsequent samplings.

128. The mean MPN/100ml for Stations 1 through 4 was consistently 2, with a standard deviation of 0, indicating no variation. For Station 5 and Station 6, the mean MPN/100ml was 3, reflecting some variability. Station 7 and the pond had much higher means of approximately 338 and 342, respectively, indicating fluctuations in microbial presence. These variations highlight the differences in microbial activity across different sampling locations and time periods, suggesting that some areas are more prone to changes in microbial populations than others. The MPN values of thermotolerant coliforms in water samples were within the limits for the fresh water that can be used for fish farming and irrigation (1000 MPN/100 mL) (Gorlach-Lira et al., 2013)[19].

Figure 37 : Variation of Coliform Bacteria across different study station



C. Heavy metals (Pb & As)

129. Heavy metals (Pb & As) was not detected from water of River Kopili as well as groundwater samples collected during the entire study period**.**

[19] Gorlach-Lira, K., Pacheco, C., Carvalho, L. C. T., Melo, H. N., & Crispim, M. C. (2013). The influence of fish culture in floating net cages on microbial indicators of water quality. *Brazilian Journal of Biology*, *73*(3), 457-463.

2.4.4. Riparian vegetation

130. One hundred six (106) different species of plants were identified from the Sampling stations (Table 13). As per the observation, the overall vegetation seems to be the tropical moist deciduous forest. Few rheophytes are restricted range species and only found in Kopili river basin.

Table 13 : Riparian vegetation in different study stations
(Rheophytes species are in highlighted boxes)

Sl. no	**Name of the flora**	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Station 6**	**Station 7**
1	*Melia azedarachta,*	+	+	+	-	+	+	+
2	*Dillenia indica*	+	+	-	+	+	+	+
3	*Albizzia* sp	+	+	-	-	+	+	+
4	*Samanea saman*	+	+	-	-	+	+	+
5	*Crateva religiosa*	+	+	-	+	+	+	+
6	*Ficus benghalensis*	+	+	-	-	+	+	+
7	*Ficus hispida*	+	+	-	-	+	+	+
8	*Ficus religiosa*	+	+	-	-	+	+	+
9	*Tamarix dioica*	+	+	-	-	+	+	+
10	*Delonix regia*	+	+	-	-	+	+	+
11	*Alstonia scholaris*	+	+	-	+	+	+	+
12	*Mallotus* sp	+	+	-	-	+	+	+
13	*Artocarpus heterophyllus*	+	+	-	-	+	+	+
14	*Aegle marmelos*	+	+	+	-	+	+	+
15	*Syzygium* sp.	+	+	-	+	+	+	+
16	*Mangifera indica*	+	+	-	-	+	+	+
17	*Mengifera sylvatica*	+	+	-	-	+	+	+
18	*Terminalia cebula*	+	+	+	-	+	+	+
19	*Elaeocarpus* sp	+	+	+	-	+	+	+
20	*Musa paradisiaca*	+	+	-	-	+	+	+
21	*Musa acuminata*	+	+	-	-	+	+	+
22	*Morus alba*	+	+	-	-	+	+	+
23	*Ziziphus mauritiana*	+	+	-	-	+	+	+
24	*Spondius mengifera*	+	+	-	+	+	+	+
25	*Annoa squamosa*	+	+	-	-	+	+	+
26	*Citrus maxima*	+	+	+	-	+	+	+
27	*Phoenix sylvestris*	+	+	-	-	+	+	+
28	*Averrhoa* sp.	+	+	-	-	+	+	+
29	*Treminalia belerica*	+	+	-	-	+	+	+
30	*Randia* sp.	+	+	-	-	+	+	+

Sl. no	**Name of the flora**	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Station 6**	**Station 7**
31	*Melastoma* spp.	+	+	-	-	+	+	+
32	*Tamarindus indica*	+	+	-	-	+	+	+
33	*Moringa oleifera*	+	+	-	-	+	+	+
34	*Mesua ferrea*	+	+	-	-	+	+	+
35	*Calamus* spp.	+	+	-	-	+	+	+
36	*Neolamarckia cadamba*	+	+	-	-	+	+	+
37	*Bambusa vulgaris*	+	+	-	+	+	+	+
38	*Bambusa tulda*	+	+	-	-	+	+	+
39	*Bambusa pallida*	+	+	+	-	+	+	+
40	*Bambusa nutans*	+	+	-	-	+	+	+
41	*Dendrocalamus hamiltonii*	+	+	-	-	+	+	+
42	*Acorus calamus*	+	+	-	-	+	+	+
43	*Aegle mermelos*	+	+	-	-	+	+	+
44	*Hydnocarpas kurzii*	+	+	-	-	+	+	+
45	*Diospyros peniculata*	+	+	-	+	+	+	+
46	*Saraca asoca*	+	+	-	-	+	+	+
47	*Alpinia galanga*	+	+	-	-	+	+	+
48	*Rauvolfia serpentina*	+	+	-	-	+	+	+
49	*Terminalia arjuna*	+	+	+	-	+	+	+
50	*Spondias* sp.	+	+	-	-	+	+	+
51	*Baccuria sepida*	+	+	-	-	+	+	+
52	*Garcinia pedunculata*	+	+	-	-	+	+	+
53	*Bombax ceiba*	+	+	-	+	+	+	+
54	*Premna benghalensis*	+	+	-	-	+	+	+
55	*Lagerstromia speciosa*	+	+	+	-	+	+	+
56	*Ageratum conyzoides L.*						+	
57	*Alstonia scholaris* (L.) Rr. Br.	-	-	-	-	+		-
58	*Arundo donax* L.	-	-	-	-		+	-
59	*Balakata baccata* (Roxb.) Esser	-	-	+	+	-		-
60	*Bombax ceiba* L.	-	-	+	-	-	-	-
61	*Capparis acutifolia* Sweet	-	-		-	+	-	-
62	*Carallia brachiata* (Lour.) Merr.	-	-	-	-	-	-	-
63	*Carissa kopilii*	-	-	+	-	+	-	-
64	*Colocasia sp.*	-	-	-	-	-	+	-
65	*Colona floribunda* (kurz) Craib	-	-	-	-	-		-
66	*Cuphea sp.*	-	-	-		-	+	-
67	*Dalbergia sp.*	-	-	-	+	-		-
68	*Dalhousiea bracteata* (Roxb.)	-	-	-	-	+	-	-
69	*Dendrocnide sinuate* (Blume) Chew	-	-	-	-	+	-	-
70	*Derris sp.*	-	+	-	-	-	-	-

Sl. no	**Name of the flora**	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Station 6**	**Station 7**
71	*Duabanga grandiflora* (Roxb. ex DC.)Walp.	-	-	-	-	-	-	-
72	*Eriobotyra angustissima* Hook.f.	-	-	-	+	+	-	-
73	*Eugenia bracteata* (Willd.) Roxb. ex DC.	-	-	+	-	-	-	-
74	*Ficus hispida* L.	-	-	-	-	-	+	-
75	*Ficus racemosa* L.	-	-	-	-	+	-	-
76	*Ficus semicordata* Buch. – Ham. Sm.	-	-	-	+	-	-	-
77	*Flueggea virosa* (Roxb. ex Willd.) Royle	-	-	-	-	-	+	-
78	*Hellenia speciosa* (J. Koenig) S.R. Dutta	-	-	-	+	-	-	-
79	*Hiptage benghalensis* (L.) Kurz	-	-	-		+	-	-
80	*Homonoia riparia* Lour.	-	-	-	+	-	-	-
81	*Ixora yunnanensis*					+		
82	*Jasminum laurifolium* Roxb. ex. Hornem.	-	+	-	-	-	-	-
83	*Litsea monopetala* (Roxb.) Pers.	-		-	-	-	+	-
84	*Microcos paniculata* L.	-	+	-	-	-		-
85	*Mimosa pudica* L.	-		-	-	-	+	-
86	*Monoon simiarum* (Buch. – Ham. ex Hook. f. & Thomson) B. Xue & R.M.K. Saunders	-	+	-	-	-	-	-
87	*Munronia sp.*	-	+	-	-	-	-	-
88	*Musa balbisiana* Colla	-		+		-	-	-
89	*Olax acuminata* Wall. ex. Benth.	-	+		+	-	-	-
90	*Pavetta pufii* Barbhuiya, J. Sarma & S. Dey	-	-		+	-	-	-
91	*Phoebe sp.*	-	-	+	-	-	-	-
92	*Pterospermum acerifolium* (L.) Willd.	-	-	+	-	-	-	-
93	*Ricinus communis* L.	-	-	-	-	-	+	-
94	*Schefflera sp.*	-	-	-	+	-		-
95	*Senegalia tamarindifolia* (L.) Britton & Rose	-	-	-		-	+	-
96	*Sterculia villosa* Roxb. ex. Sm.	-	-	+	-	+	-	-
97	*Syzygium cumini* (L.) Skeels	-	-	+	-		-	-
98	*Syzygium cyanophyllum*	-	+	+	-		-	-
99	*Syzygium polypetalum* (Wall.) Merr. & L. M. Perry		+		+	+	-	-
100	*Tarenna pumila* (Hook. f.) Merr.		+	+	-	-	-	-
101	*Tetrameles nudiflora* R. Br.	-	-	+	-	-	-	-
102	*Thunbergia grandiflora* Roxb.	-	-	-	-	+	-	-
103	*Thysanolaena latifolia*	-	-	-	-		-	-
104	*Trema orientale* (L.) Blume	-	-		+		-	-
105	*Ulmus lanceifolia* Roxb.	-	-	+	-	+	-	-
106	*Urena lobata* L.	-	-		-	-	+	-
107	*Wallichia oblongifolia* Griff.	-	-	+	-	-	-	-

2.4.4.1. Rheophytes

131. Recent scientific papers suggested that there are few species of plants which were not captured during the EIA in 2014-2015, Supplementary EIA during 2016-2017, Biodiversity study in 2021, 2023. The species are reported from the upstream and downstream of the LKHEP Dam during 2018-2020. Biodiversity assessments were required following the discovery of additional Critical Habitat-qualifying species which might be impacted by the Project. ADB has requested to reconfirm the species from the area. APGCL has requested one of the authors of the papers who found the new rheophytes species from the downstream area for the fresh assessment on the presence of the species in the area.

132. The species are:

1. *Carissa kopili*
2. *Syzygium nivae*
3. *Pavetta puffii*
4. *Syzygium cyanophyllum*
5. *Ixora yunnanensis*

133. Five species of rheophytes have been identified within the Kopili River, including downstream of the LKHEP Dam and within the inundation area.. Four of these species, are considered endemic, meaning that they have an extent of occurrence less than 50,000 km2 (IFC, 2019[20]). The extent of occurrence for *I. yunnanensis* and its endemism status is unknown.

134. Rheophytes are defined as plant species which are confined to the beds of swift-running streams and rivers and grow there up to flood-level but not beyond the reach of regularly occurring flash floods (van Steenis, 1981[21]). These plants typically occur via convergent evolution, meaning that they have evolved from a variety of different, unrelated terrestrial plant taxa including bryophytes (mosses, liverworts and hornworts) to angiosperms (flowering plants), and show similar adaptations to a restricted ecological niche (Kato, 2017[22]; Costa et al., 2020[23]). Most of the rheophytes are found in rain-forest areas, where swift-running streams offer sand bars and gravel beds or rocky bottoms and banks. Rheophytes are morphologically characterized by having

[20] IFC (2019) 'Biodiversity Conservation and Sustainable Management of Living Natural Resources International Finance Corporation ' s Guidance Note 6 .

[21] van Steenis, C. G. G. J. (1981) Rheophytes of the world: an account of the flood-resistant flowering plants and ferns and the theory of autonomous evolution. Springer.

[22] Kato, M. (2017) 'Diversity and Adaptations of Rheophytic Ferns', Fern Gaz, 20(5), pp. 169–179.

[23] Costa, L. M. S., Goetze, M., Rodrigues, A. V., Seger, G. D. dos S. and Bered, F. (2020) 'Global rheophytes data set: angiosperms and gymnosperms', Ecology, 101(8). doi: 10.1002/ecy.3056.

narrow, (ob)lanceolate leaves – leaflets (stenophylls) and other features that are adapted to the unique habitat. Survival in or at the edge of a river system can exert extreme and diverse stressors on the plants growing there. At times of high flooding, plants must be able to remain anchored and withstand the power of flowing water. During the long dry period, plants are exposed to hot, rocky, gravelly or sandy areas (Puff and Chayamarit, 2011[24]). Generally, most but not all rheophytes live in the air much longer than under flooded conditions, as water levels return to the more normal levels shortly after rains stop (Kato, 2017[22]). The characteristics uniting this group of plants are adaptations to fast flowing water environments with varying degrees of inundation, including narrow leaves and securely anchored root systems, along with a range of physiological adaptations that vary between species. Rheophytes are a highly adapted taxa and individual species have become even more specialised to the ecological niches in which they grow. Several studies have documented that rheophyte taxa are often endemic with narrow distributions and fragmented populations, making them range restricted and often threatened (Philbrick et al., 2010[25]; Yoshimura et al., 2019[26]; Costa et al., 2020[23]).

135. Rheophytes can be roughly divided into three main groups or life-forms:

1. Hydrophytic rheophytes — permanently submerged herbs.
2. Torrenticolous rheophytes — Submerged in vegetative state; flowering periodically when waters are low.
3. Rheophytic land plants —Shrubs or herbs, some mat-rooted on rocks. Special features of the shrubby land plants are a usually sympodial branching and short-petioled, mostly entire, and glabrous, often falcate or even sigmoid narrow leaves. Leaves of rheophytes are mostly simple, but rheophytes equally well occur in families with compound leaves. Due to short petioled narrow leave, tough and flexibility of stems, the rheophytes can stand firm against swift- running free flowing streams.

In the Kopili river basin all the rheophytes belong to Rheophytic land plants.

136. Rheophytes can also be divided into two main groups - obligate rheophytes (or 'true' rheophytes) and facultative rheophytes. Apart from being adapted for fast currents, the survival of obligate rheophytes are dependent on the oxygenated water brought along with fast currents for survival. Facultative rheophytes are just as adapted to survive in areas where fast currents run through, but are not dependent on these fast currents to

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[24] Puff, C. and Chayamarit, K. (2011) 'Living under water for up to four months of the year: observations on the rheophytes of the Mekong River in the Pha Taem National Park area (Thailand/Laos border)', *Thai Forest Bulletin (Botany)*, 39, pp. 173–205.

[25] Philbrick, C.T., Bove, C.P., & Stevens, H. I. (2010). Endemism in neotropical podosstemaceae. Annals of Missouri Botanical Garden, 97, 427-456.

[26] Yoshimura, H., Arakaki, S., Hamagawa, M., Kitamura, Y., Yokota, M. and Denda, T. (2019) 'Differentiation of germination characteristics in Scutellaria rubropunctata (Lamiaceae) associated with adaptation to rheophytic habitats in the subtropical Ryukyu Islands of Japan', Journal of plant research. Springer, 132, pp. 359–368.

survival. The above five species of importance seem to be obligate rheophytes but detail study is required for confirmation.

2.4.4.1.1. Adaptation in Rheophytes:

137. Rheophytes are less studied in comparison to terrestrial plants and other aquatic plants (Purahong et al., 2021[27]), however, some studies have investigated mechanisms that influence their survival. Some species have been shown to be negatively impacted by sedimentation and hydrological alteration, causing plant desiccation and senescence when habitats exceed light attenuation (Canfield and Wood, 2022[28]). Prolonged inundation, flood scour, high competition, and water level fluctuations disrupting sexual reproduction have also been documented (Erskine et al., 2009[29]; Costa et al., 2020[30]). Rheophytic plants are adopted to withstand flood conditions. They have special features search as flexible stems, buoyant seed or the ability to quickly establish route after flooding these adaptations help them survive and thrive in habitats prone to periodic flooding.

138. Normally rheophytes are adopted to thrive in first floating water environment typically found in the streams and rivers having rocky / stony surface, they may tolerate a range of water pH levels as their primary adaptation is to strong water currents. In Kopili the pH varies between 4 – 6 as was monitored for last 3 years and the rheophytes were found to be surviving in the low pH level.

139. However, some rheophytes may have specific tolerance for water pH but it would depend on the species.[31] A specific study on a bromeliad native to Brazil, found to occur in an environment with particular conditions to which it has adapted. The author highlighted the following point but it may not be applicable for all the rheophytes:

- *Dyckia brevifolia* sidling adobe a quiescence strategy when submerged.
- Complete submergence stress affects growth but not the survivals of seedlings.
- Expression of hypoxia markers genes remain unchanged during submergence.

[27] Purahong, W., Hossen, S., Nawaz, A., Sadubsarn, D., Tanunchai, B., Dommert, S., Noll, M., Ampornpan, L., Werukamkul, P. and Wubet, T. (2021) 'Life on the rocks: first insights into the microbiota of the threatened aquatic rheophyte Hanseniella heterophylla', *Frontiers in Plant Science*. Frontiers Media SA, 12, p. 634960.
[28] Samuel A. Canfield and James L. Wood "New Populations of the Rheophytic Macrophyte Podostemum ceratophyllum Michx. (Hornleaf Riverweed) in West Virginia," Castanea 86(2), 214-224, (7 January 2022). https://doi.org/10.2179/0008-7475.86.2.214
[29] Erskine, W., Chalmers, A., Keene, A., Cheetham, M. and Bush, R. (2009) 'Role of a rheophyte in bench development on a sand-bed river in southeast Australia', *Earth Surface Processes and Landforms*. Wiley Online Library, 34(7), pp. 941–953.
[30] Costa, L. M. S., Goetze, M., Rodrigues, A. V., Seger, G. D. dos S. and Bered, F. (2020) 'Global rheophytes data set: angiosperms and gymnosperms', *Ecology*, 101(8). doi: 10.1002/ecy.3056.
[31] "Responses to submergence and recovery in seedlings of the rheophyte Dyckia brevifolia (Bromeliaceae)" by Laís Mara Santana Costa et. al, Environmental and Experimental Botany Volume 201, September 2022, 104984 https://doi.org/10.1016/j.envexpbot.2022.104984

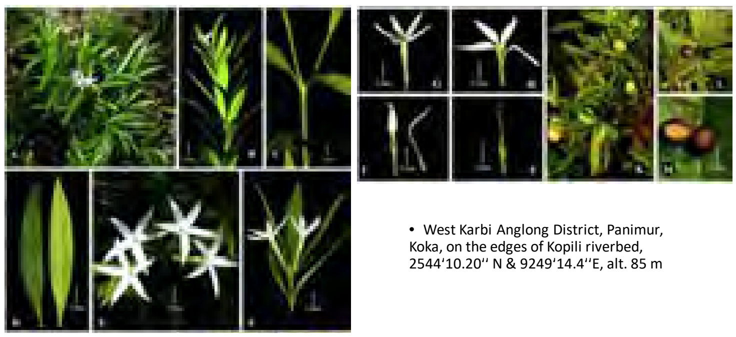
- Seedlings display key adaptive features both in submergence and de-submergence.

2.4.4.1.2. Species description and distribution

140. Range restricted/endemic species identified are shown in the Figure 38 to 42 and their global distribution are shown in the Map 14 to 18).

Figure 38: *Carissa kopilii*

Carissa kopilii (Family : Apocynaceae) 2020



- West Karbi Anglong District, Panimur, Koka, on the edges of Kopili riverbed, 2544‘10.20’’ N & 9249‘14.4’’E, alt. 85 m

Map 14: Distribution of *Carissa kopilii* as per literature[32]

Solid square (-) indicates previously known locality, and solid circle (C) indicates currently reported locality.

[32] Sarma, J., Barbhuiya, H. A. and Dey, S. (2020) ‘A new rheophytic species of Carissa (Apocynaceae) from Northeast India’, *Journal of Asia-Pacific Biodiversity*. Elsevier, 13(2), pp. 314–318.

Figure 39: *Syzygium nivae*

Map 15: Distribution of *Syzygium nivae* as per literature[33]

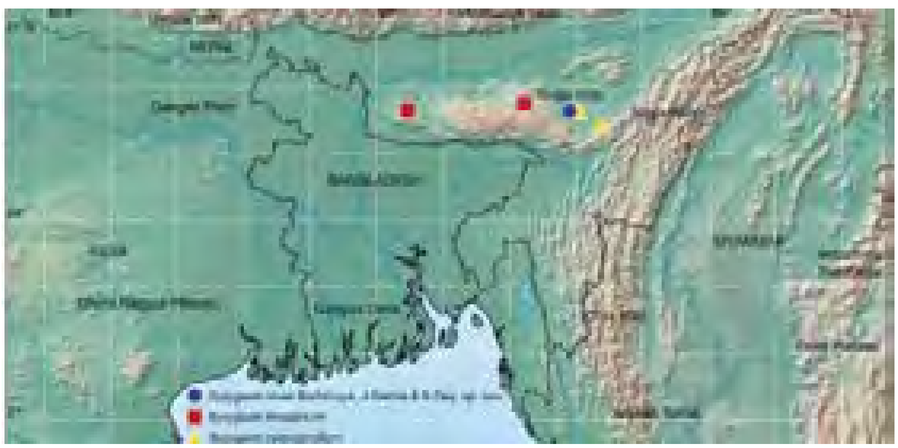


Figure 40: *Parvetta puffii*

[33] Sarma, J., Barbhuiya, H.A. and Dey, S. (2019) 'A new rheophytic species of Syzygium Gaertn.(Myrtaceae) from Assam, North East India', *Adansonia*. BioOne, 41(1), pp. 53–58.

Map 16: Distribution of *Parvetta puffii* as per literature[34]

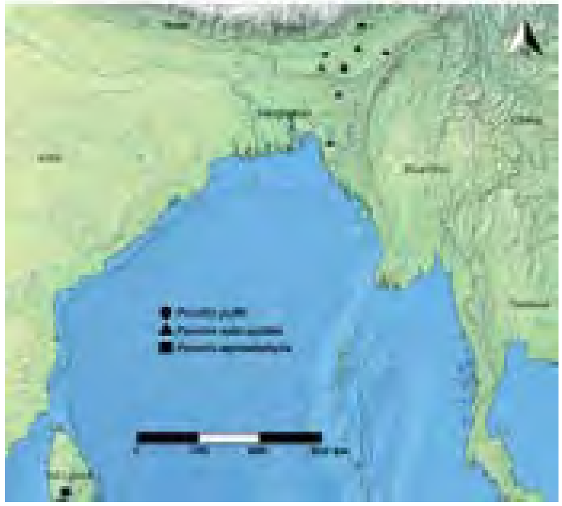
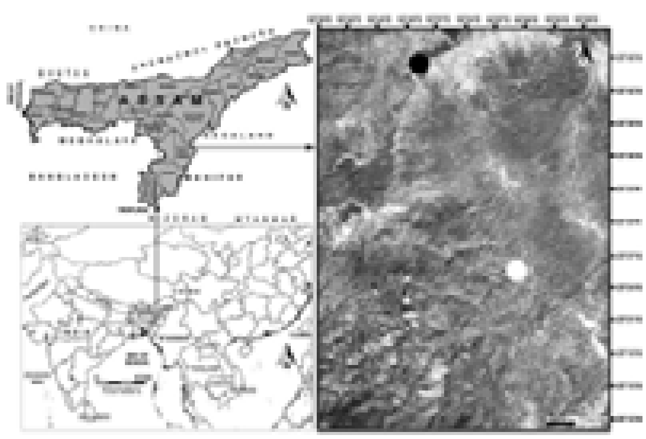


Figure 41: *Syxygium cyanophyllum*

Map 17: Distribution of *Syxygium cyanophyllum* as per literature



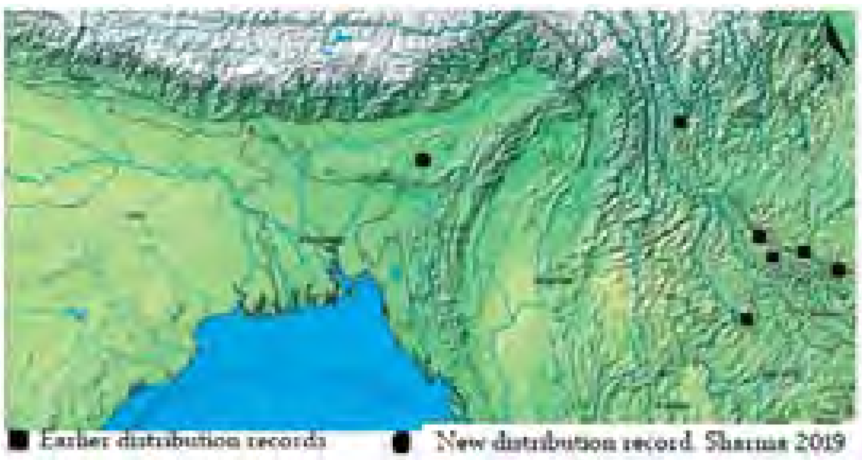
[34] Sarma, J., Barbhuiya, Hussain Ahmed and Dey, S. (2019a) 'A new rheophytic species of Pavetta (Rubiaceae) from Assam, northeast India', *Nordic journal of botany*. Wiley Online Library, 37(1), p. e02076.

Figure 42: *Ixora yunnanensis*

Ixora yunnanensis (Family: Rubiaceae) 2019
(not considered as range restricted and endemic species)

Flowering. April–May.
Rheophytic shrub in rock crevices at the edge of the Kopili River near Koka.
Location : 25°44'09.91" N, 92°49'15.1"E, 81.59 m msl
A new addition to the Rubiaceae of India and an extension of its range ca. 760 km westward.

Map 18: Distribution of *Ixora yunnanensis* as per literature[35]



2.4.4.1.3. New Distribution record of the 5 species

141. During 2018-2022 five new species were identified in the Kopili river basin which are shown in the Map 19.

[35] Sarma, J., Barbhuiya, Hussain Ahmed and Dey, S. (2019b) 'First Record of a Rheophytic Species of Ixora (Rubiaceae) in India', *Acta Phytotaxonomica et Geobotanica*. The Japanese Society for Plant Systematics, 70(1), pp. 57–61.

Map 19: Location of the species found as per literature

2.4.4.1.5. Area surveyed

142. Around 13.6 Kilometer upstream and 15.9 Kilometer downstream of the LKHEP dam has been surveyed on 5th to 6th April and 15th to 18th April 2024 (Map 20). Flowering season was selected. Flowering of *C. kopilii* and *S. nivae* is from August – October, hence survey is also proposed in August -October, 2024. Sampling stations are mentioned in Map 20.

143. In documenting the rheophytes of Kopili River stretches upstream up to the Tail Race of Kopili Project (Operated by NEEPCO) and downstream up to confluence of Amring River were visited during the month of April when the water levels recede in rivers and the majority of plants are in their reproductive phase (3 species out of 5). Sections of the rivers with rocky substrate were intensively sampled. The rheophytic status of some species were not clear, particularly those on river banks and edge of rivers, and those not at flowering stage. Those species and their localities will be revisited during the wet season (August- September), when the water flow and level are high. This will enable to determine whether a particular species is able to withstand spate and is therefore rheophytic. Notes were taken on the habitat conditions, and characteristic rheophytic features of the species encountered, particularly the leaf shape and form, stem characteristics, and rooting system. Voucher specimens were collected for unidentified species. Voucher specimens were not collected for every rheophyte species encountered

in the field. This is because such species were common and could be identified from the flower and fruits. Notes were taken to indicate presence of the rheophytic species at each locality.

144. Distribution maps of rheophytes of Kopili river in Dima Hasao and West Karbi Anglong districts in Assam were done using georeferenced photographs, consultation of available literature and field surveys.

Map 20: Sampling Locations for rheophytes

2.4.4.1.6. Distribution of rheophyte in the LKHEP influence zone

145. Rheophytes were not found in the sampling station No.1 and 6 (Map 20). All the patches were visited either directly (on the right bank) or by boat on the islands or on the left bank. Two seniors botanists were engaged including one of the authors who described the species from the site for the first time. The distribution polygons were delineated based on the ground distribution of all the rheophytes using GPS. Map 21 to Map 26 shows the distribution of rheophyte plants in Kopili river.

Map 21: Distribution of Rheophytes in Station 5.2 (Downstream)

Map 22: Distribution of Rheophytes in Station 5.1 (Downstream)

Map 23: Distribution of Rheophytes in Station 5. (Panimur) (Downstream)

Map 24: Distribution of Rheophytes in Station 4. (Power House) (Downstream)

Map 25: Distribution of Rheophytes in Station 3. (Dam) (Downstream)

Map 26: Distribution of Rheophytes in Station 2. (Submergence area) (Upstream)

146. List of plant species documented during the current survey in the river Kopili river (Table 14). It was not possible to locate *Pavetta pufii* Barbhuiya, J. Sarma & S. Dey and *Syzygium nivae* J. Sarma & S. Dey during recent survey. More extensive field survey will be needed in coming days (August to September) to locate these species in the wild population. The flowering season for *P. puffi* is noted as April to May and August to October for *S. nivae*.

Table 14: Distribution of the Rheophytes and associated species

1. Area: Dam site (Sampling point no 3)

Sl. No.	Scientific name	Family	Presence of the important species
1.	*Carissa kopilii* Barbhuiya, J. Sarma & S. Dey	Apocynaceae	✓
2.	*Phoebe* sp.	Lauraceae	
3.	*Pterospermum acerifolium* (L.) Willd.	Malvaceae	
4.	*Bombax ceiba* L.	Malvaceae	
5.	*Syzygium cumini* (L.) Skeels	Myrtaceae	
6.	*Syzygium cyanophyllum* (P.C. Kanjilal & D. Das) Raizada	Myrtaceae	✓
7.	*Tetrameles nudiflora* R. Br.	Tetramelaceae	
8.	*Wallichia oblongifolia* Griff.	Arecaceae	
9.	*Sterculia villosa* Roxb. ex. Sm.	Malvaceae	
10.	*Dalbergia* sp.	Fabaceae	
11.	*Eugenia bracteata* (Willd.) Roxb. ex DC.	Myrtaceae	
12.	*Musa balbisiana* Colla	Musaceae	
13.	*Ulmus lanceifolia* Roxb.	Ulmaceae	
14.	*Balakata baccata* (Roxb.) Esser	Euphorbiaceae	
15.	*Tarenna pumila* (Hook. f.) Merr.	Rubiaceae	

2. Area: Power house (Sampling Point 4)

Sl. No.	Scientific name	Family	Presence of the important species
1.	*Carissa kopilii* Barbhuiya, J. Sarma & S. Dey	Apocynaceae	✓
2.	*Eriobotyra angustissima* Hook.f.	Rosaceae	
3.	*Sterculia villosa* Roxb. ex. Sm.	Malvaceae	
4.	*Colona floribunda* (kurz) Craib	Malvaceae	
5.	*Syzygium polypetalum* (Wall.) Merr. & L. M. Perry	Myrtaceae	
6.	*Ulmus lanceifolia* Roxb.	Ulmaceae	
7.	*Thunbergia grandiflora* Roxb.	Acanthaceae	
8.	*Alstonia scholaris* (L.) Rr. Br.	Apocynaceae	
9.	*Hiptage benghalensis* (L.) Kurz	Malpighiaceae	

3. **Area: Garglosa guest house (Sampling Point 5.1)**

Sl. No.	Scientific name	Family	Presence of the important species
1.	*Microcos paniculata* L.	Malvaceae	
2.	*Munronia* sp.	Meliaceae	
3.	*Olax acuminata* Wall. ex. Benth**.**	Olacaceae	
4.	*Tarenna pumila* (Hook. f.) Merr.	Rubiaceae	
5.	*Syzygium polypetalum* (Wall.) Merr. & L. M. Perry	Myrtaceae	
6.	*Jasminum laurifolium* Roxb. ex. Hornem**.**	Oleaceae	
7.	*Carallia brachiata* (Lour.) Merr.	Rhizophoraceae	
8.	*Carissa kopilii* Barbhuiya, J. Sarma & S. Dey	Apocynaceae	✓
9.	*Capparis acutifolia* Sweet	Capparaceae	
10.	*Derris* sp.	Fabaceae	
11.	*Monoon simiarum* (Buch. – Ham. ex Hook. f. & Thomson) B. Xue & R.M.K. Saunders	Annonaceae	

4. **Area: Panimur Adventure camp (Sampling point 5.2)**

Sl. No.	Scientific name	Family	Presence of the important species
1.	*Ficus semicordata* Buch. – Ham. Sm.	Moraceae	
2.	*Syzygium polypetalum* (Wall.) Merr. & L. M. Perry	Myrtaceae	
3.	*Olax acuminata* Wall. ex. Benth**.**	Olacaceae	
4.	*Eriobotyra angustissima* Hook.f.	Rosaceae	
5.	*Balakata baccata* (Roxb.) Esser	Euphorbiaceae	
6.	*Schefflera* sp.	Araliaceae	
7.	*Dalhousiea bracteata* (Roxb.) Graham ex Benth.	Fabaceae	
8.	*Trema orientale* (L.) Blume	Cannabaceae	
9.	*Hellenia speciosa*(J. Koenig) S.R. Dutta	Costaceae	
10.	*Thysanolaena latifolia* (Roxb.ex Hornem) Honda	Poaceae	
11.	*Syzygium cyanophyllum* (P.C. Kanjilal & D. Das) Raizada	Myrtaceae	✓
12.	*Tarenna pumila* (Hook. f.) Merr.	Rubiaceae	
13.	*Homonoia riparia* Lour.	Euphorbiaceae	
14.	*Pavetta pufii* Barbhuiya, J. Sarma & S. Dey	Rubiaceae	✓ (Reconfirmation required)
15.	*Ixora yunnanensis*	Rubiaceae	✓

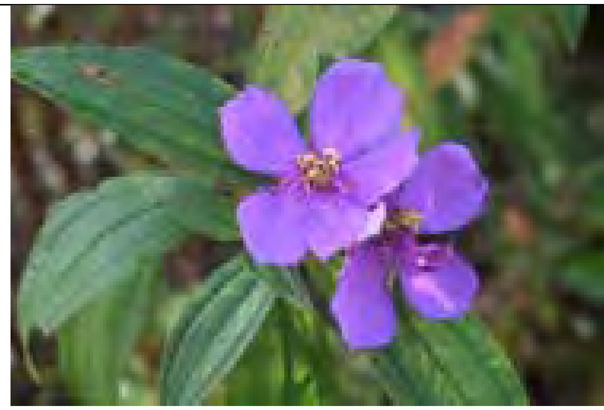
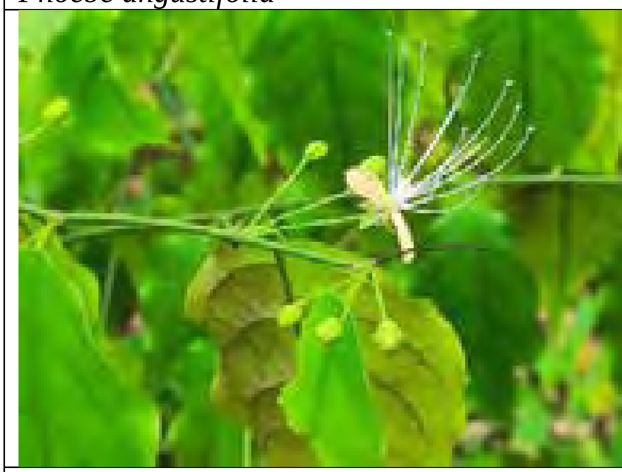
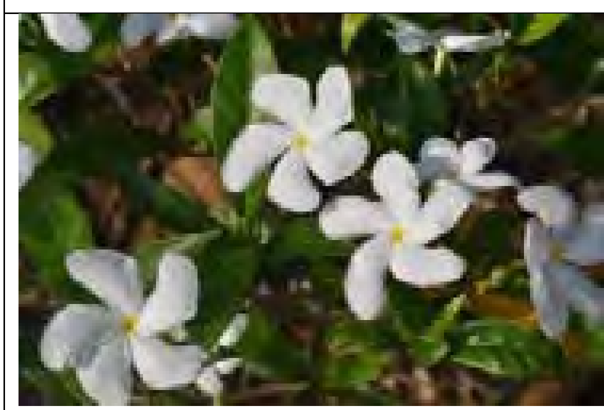
Photographs : Rheophytes

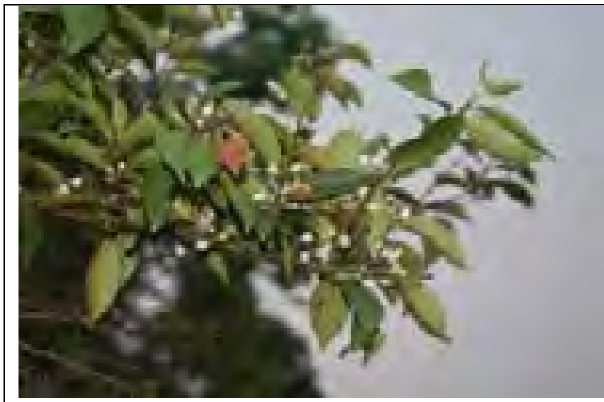
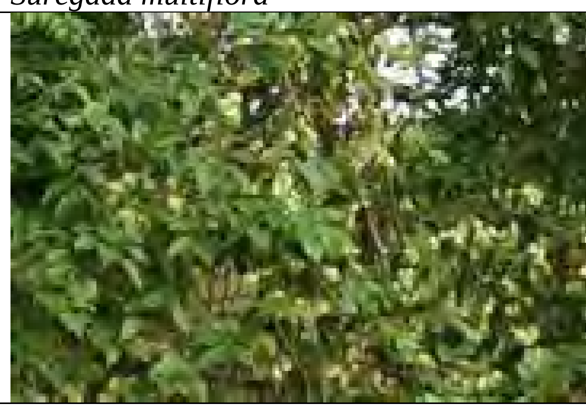
	
Habitat with rheophyte in Kopili River	Characteristic of stem of Rheophyte
	
Survey of Rheophytes	*Carissa kopili*
	
Syzygium polypetalum	*Syzygium cyanophyllum*

	
Carissa kopili	*Ixora sp.*
	
Ixora yunnanensis	*Eriobotyra sp.*
	
Syzygium polypetalum	*Syzygium cyanophyllum*

	
Eriobotyra angustissima	*Phoebe angustifolia*
	
Schefflera sp.	*Tarenna pumila*

Photographs : Other associated species

	
Phoebe angustifolia	*Melastoma malabathricum*
	
	Ocotea sp.
	
Tabernaemontana divaricata	*Jasminum laurifolium*

	
Eugenia braceata	*Hypoxis aurea*
	
Olax acuminata	*Suregada multiflora*
	
	Ulmus lanceifolia

147. Current distribution of the four endemic species (and one species with range expansion) in the project impacted area are shown in the table 15 and provides information on these species based on recent surveys and information available in the literature.

Table 15: Current distribution status in Kopili near LKHEP

Species	Distribution	Recent survey 2024	Phenology	Habitat	Threatened status	Distribution in Kopili River
***Carissa kopilii* (New species)**	Jowai District of Meghalaya (Was earlier misidentified and confirmed later after discovery of *C. kopili*) and from Koka KA in Kopili. The extent of occurrence is estimated to be less than 6000 km^2 (Sarma *et al.*, 2020).	Additional locations found during the survey	The rate of water flow of the river is very high during June - July and gradually slows from August, when flowering begins and lasts up to October. Fruiting takes place from November onward and matures in the month of January (Sarma *et al.*, 2020).	Rock crevices along the riverbed, preferably in well-exposed areas at altitudes ranging from 85-600 m above sea level. Sun loving, and avoids shady places (Sarma *et al.*, 2020)	There is a continuing decline in quality of habitat as the natural flow of water in the river is being disturbed by Kopili Hydro Electric Project. Hence, following IUCN (2012a, 2019), the species is categorized as Vulnerable [criteria: VU B1ab(iii)] (Sarma *et al.*, 2020)	Dam, Garlosa Guest house, Power House
***Syzygium nivae* (New species)**	Only in the Kopili River	Not found during the survey	The rate of water flow of the river is very high during June - July and gradually slows from August, when flowering begins and lasts up to October (Sarma, H.A. Barbhuiya, *et al.*, 2019). Fruit matures in October and November.	Rock crevices at the edges of Kopili riverbed near Koka at altitudes 86-102 m above MSL (Sarma, H.A. Barbhuiya, *et al.*, 2019).	*Syzygium nivae* is provisionally categorized as 'Data Deficient' (DD), as only 50 mature individuals were located during the survey at Koka locality. To ascertain its actual status, the entire course of Kopili River is required to be surveyed (Sarma, H.A. Barbhuiya, *et al.*, 2019).	Koka, Karbi Anglong

Species	Distribution	Recent survey 2024	Phenology	Habitat	Threatened status	Distribution in Kopili River
***Pavetta puffii* (New species)**	Only in the Kopili River	Not found during the survey	Flowering and fruiting occur from April to May.	Rock crevices at the edges of Kopili riverbed near Koka (Sarma, Hussain Ahmed Barbhuiya, *et al.*, 2019a)	*Pavetta puffii* is only known from the type gathering; hence, its conservation status remains 'Data Deficient' (DD) under the IUCN conservation status (IUCN 2012) (Sarma, Hussain Ahmed Barbhuiya, *et al.*, 2019a).	Koka, Karbi Anglong
***Syzygium cyanophyllum* (Range expansion)**	Endemic to Assam: Dehangi (DH); After 103 years in Koka (KA)	Additional locations found during the survey in DH	flowering condition during the months of March and April and its fruit matures in May and June. In January it was also flowering	Rock crevices at the edges of Kopili riverbed near Koka (Sarma, Hussain A. Barbhuiya, *et al.*, 2019)	Following IUCN Red List Categories and Criteria it is categorised as Endangered (Sarma, Hussain A. Barbhuiya, *et al.*, 2019).	Dam, Panimur Adventure camp, Discharge monitoring site
***Ixora yunnanensis* (Range Expansion)**	Yunan province of East asia; range expansion to Koka (KA)	Additional locations found during the survey in DH	Flowering. April–May.	Rock crevices at the edges of Kopili riverbed near Koka (Sarma, Hussain Ahmed Barbhuiya, *et al.*, 2019b)	Not stated	Panimur Adventure camp

2.4.4.2. Critical Habitat Assessment

148. Limited information on these rheophilic plants makes definitive Critical Habitat assessment challenging. However, based on available information, and acting on a precautionary basis, the Project's aquatic Area of Analysis qualifies as Critical Habitat for all four species.

1. Carissa kopilii

149. Sarma *et al.* (2020) described this shrub species from two locations in the bed of the Kopili River, in Assam (West Karbi Anglong District) and Meghalaya (Jowai District). It was found in rock crevices along the riverbed, in well-exposed areas at 85-600 m altitude. The location in Assam is approximately 11 km downstream of the Project dam. As the two known locations for this species are only about 50 km apart, it must currently be considered a restricted-range species. Sarma *et al.* (2020) seem to consider it unlikely that the species occurs outside of the two currently-known States. It is not yet assessed on the IUCN Red List, though is considered by Sarma *et al.* (2020) to be Vulnerable. Rheophytes have been found in the Project area during 2024 surveys, but not all identified to species level. During these surveys, *C. kopilii* was found at the dam site and in the power house area, as well as downstream near the Garlosa Guest House. Since 80% of all currently-known locations for this species fall within the Project's aquatic AoA, ***Carissa kopilii qualifies the Project's aquatic AoA as ADB Critical Habitat*** under Criterion 2.

2. Pavetta puffii

150. Sarma *et al.* (2019a) described this shrub species from a location in the Kopili River, near Koka, West Karbi Anglong District, Assam. It was found in rock crevices along the riverbed, at 86-102 m altitude. As the species is currently only known from a single location, it must currently be considered a restricted-range species. It is not yet assessed on the IUCN Red List, though is considered by Sarma *et al.* (2019a) to be Data Deficient since it is only currently known from one location. Rheophytes have been found in the Project area during 2024 surveys, but not all identified to species level. This species was not confidently identified during 2024 surveys. Since the only known location for this species falls within the Project's aquatic AoA, ***Pavetta puffii qualifies the Project's aquatic AoA as ADB Critical Habitat*** under Criterion 2

3. *Syzygium cyanophyllum*

151. Sarma *et al.* (2019c) rediscovered this shrub species from a location in the Kopili River, near Koka, West Karbi Anglong District, Assam. It was found in rock crevices at the edge of the riverbed, at 83-90 m altitude. It is previously also known from the bed of the Dehangi River in Dima Hasao District, Assam, at about 460 m altitude. As the two known locations for this species are only about 80 km apart, it must currently be considered a restricted-range species. It is not yet assessed on the IUCN Red List, though is considered by Sarma *et al.* (2019c) to be Endangered. Rheophytes have been found in the Project area during 2024 surveys, but not all identified to species level. During these surveys, *S. cyanophyllum* was found in the inundation zone, at the dam site and Panimur Adventure Camp. Since the majority of all currently-known locations for this species fall

within the Project's aquatic AoA, ***Syzygium cyanophyllum qualifies the Project's aquatic AoA as ADB Critical Habitat*** under Criterion 2

4. Syzygium nivae

152. Sarma *et al.* (2019b) described this shrub species from a location in the Kopili River, near Koka, West Karbi Anglong District, Assam. It was found in rock crevices along the riverbed, at 86-102 m altitude. As the species is currently only known from a single location, it must currently be considered a restricted-range species. It is not yet assessed on the IUCN Red List, though is considered by Sarma *et al.* (2019b) to be Data Deficient since it is only currently known from one location. Rheophytes have been found in the Project area during 2024 surveys, but not all identified to species level. This species was not identified during 2024 surveys. Since the only known location for this species falls within the Project's aquatic AoA, ***Syzygium nivae qualifies the Project's aquatic AoA as ADB Critical Habitat*** under Criterion 2.

2.4.4.3. Fluctuation of water level in the Reservoir as per Reservoir Operation Plan

153. The LKHEP scheme is intended to operate under a run of river scenario during monsoon season (June – September) along with reservoir storage. The scheme will operate under a peaking station in non- monsoon season. The reservoir operation plan is presented in the form of a rule curve, which will guide the dam operator about the monthly variation of limiting elevations of the LKHEP reservoir within which the reservoir is to be operated throughout the year. The rule curve is presented in Figure 3. The reservoir has a capacity of 106.29 million cubic metres (MCM) at full reservoir level at a height of 226.00 masl, the minimum drawdown level (MDDL) is 202 m - ensuring a live storage of 77.29 MCM. Environmental releases have been computed at 20 – 30% of the inflow, depending on the seasonal period. The rule curve is developed which fulfils two conflicting criteria i.e. (i) Maximization of Energy & (ii) Minimization of spill from reservoir. Elevation wise dead storage and live storage of LKHEP reservoir is shown in the table 16. It is important to mention here that, although MDDL is at 202 masl, but as per rule curve the water will be lowered upto 205 masl only during operation.

Table 16: Elevation wise Gross Storage and Live Storage of Lower Kopili Reservoir

S. No.	Elevation (masl)	Gross Storage (MCM)	Live Storage (MCM)
1	226.00	106.29	77.29
2	220.00	75.00	46.00
3	215.00	57.50	28.50
4	210.00	44.00	15.00
5	205.00	34.00	5.00
6	202.00	29.00	0.00

2.4.4.4. Impacts of Dam Operation to Rheophytes

154. While details of the altered hydrologic regime are important, ultimately the sensitivity of these rheophyte species and their ability to adapt is the most important factor and will be the key factor determining their survival. Hydroelectric dams are one of the key threats reported for rheophyte species due to their dramatic influence on flow regimes and conversion of lotic (rapidly moving) hydrologic regimes into lentic (still) regimes within the reservoir area after dam construction (Philbrick et al., 2010; Costa et al., 2020). Rheophytes that are endemic to small areas or a single river are at greater risk with dam construction potentially leading to their extinction (Costa et al., 2022).

155. Upon consultation with botany experts, it was concluded that given the specialisation of rheophytes to their particular ecological niches, it is not possible nor appropriate to make generalisations by applying the results of studies for one species to another. The likelihood of survival of the five species in question (out of which 4 are endemic) under these scenarios therefore cannot be determined without specific studies on these species.

156. However, a degree of logic may be applied in that plants that are highly adapted to a particular set of environmental variables are likely to experience reduced chances of survival if those variables are changed. There are a number of possible ecological scenarios that may occur.

1. As the species of interest are the rheophytes, temporary inundation will not impact the species much as they are there for years with the Kopili Project in operation since 1984. But the 4 endemic plants will experience altered depth and frequency of inundation and changes to flow velocity, all of which are likely to impact their stress response and survival.
2. In the down stream water level will be reduced during low flow (Lean period and Non lean and non monsoon period) which coincides with the flowing of the endemic plants. Water level will be increased during monsoon period (June to September) in the down stream. Water level of 1 m (max) will be increases over the normal monsoon water level in the downstream.
3. There are other aspects of reproduction other than flowering and fruiting patterns that may be impacted such as fruit viability and distribution, germination etc due to changed water velocity (if any). The discharge and water velocity will be monitored through the downstream gauge near tail race channel.
4. **Phenology disruption**: Phenology is particularly important for rheophytes as seeds must germinate and grow a sufficient root system to securely anchor the plant to avoid being washed away in high water periods (Yoshimura et al., 2019). Timing and intensity of flowering and fruiting can be affected by several factors including rainfall and moisture (Ramaswami et al., 2019). The literature available for C. kopilii and S. nivae noted that river system experiences high water volumes and flows during June and July (the monsoon) and slows from August when

flowering begins, followed by fruiting. Flowering begins between March – May collectively for *P. puffii, S. cyanophyllum and I. yunnanensis*. It is possible that inundation affected by the monsoon provides environmental cues for these species and these cues may be disrupted by changes to the hydrological regime, affecting the species' ability to reproduce.

5. **Alteration to habitat suitability**: Changes to habitat suitability are expected in relation to the hydrological regime, i.e., the available area of suitable habitats between the bed and the reach of regularly occurring flash floods.
6. Preliminary findings show all the Rheophytes in the submergence area will be submerged. Only *Syzygium cyanophyllum* is an important species which will also be submerged. But this species is also present in the downstream, hence the operation of dam will not extirpate the species from the area.
7. Further to the above, it is likely that a narrower band of suitable habitat will be available upon establishment and operation of the dam, given the variable hydrological regimes that are expected. Should rheophytes be able to establish within new suitable habitat, the distribution and density of species will shift and competition between species may increase.
8. Over the 3 years despite the river's consistently low pH of around 4 - 6 (in all the sampling stations upto the confluence of Amring river) indicating acidity, and frequent heavy flooding during monsoon, the resilience of the rheophytes remains remarkable. As per record the water of reservoir and Kopili River adjacent to the Meghalaya state was becoming acidic for mixing of effluents from open-cast mining in Meghalaya since 2004.
9. **Adaptation:** - Following the implementation of the new hydrological regime, rheophytes may begin to inhabit "newly available" habitats. However, questions remain as to whether new suitable habitats will be available, particularly rock crevices along the edge of the river that appear to be the preferred habitat for all five species. Furthermore, their ability to colonise these areas depends on their ability to adapt quickly enough once their original sites have become unsuitable. Detailed studies concerning the establishment of rheophytes are lacking altogether (Puff and Chayamarit, 2011[36])

157. Rheophytes in the dead storage zone are expected to experience complete inundation. For LKHEP total inundation will be upto 205 masl. These species are adapted to varying levels of inundation, but prolonged submergence is rare and can be lethal (Puff and Chayamarit, 2011; Costa et al., 2022). Thus, rheophytes are not expected to survive in permanent inundation area / zone.

158. The live storage zone (205 m to 226 m) will experience fluctuations in water level and importantly, a reduction in flow velocity. Run of river scenarios during the monsoon

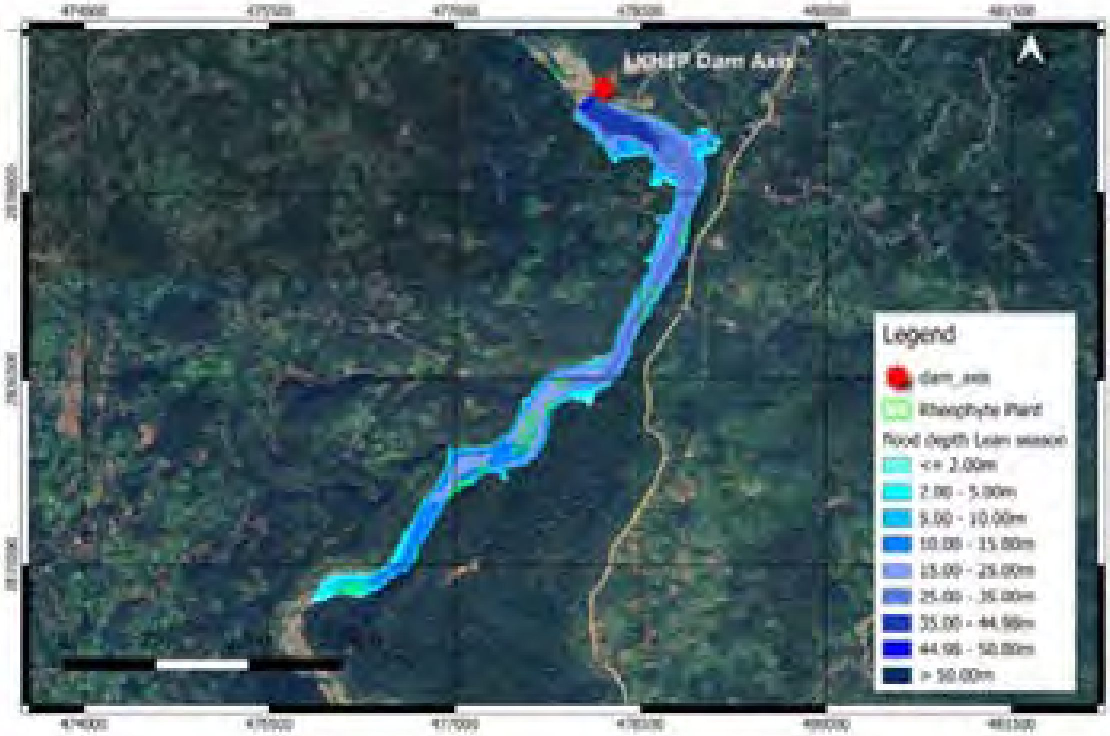
[36] Puff, C. and Chayamarit, K. (2011) 'Living under water for up to four months of the year: observations on the rheophytes of the Mekong River in the Pha Taem National Park area (Thailand/Laos border)', *Thai Forest Bulletin (Botany)*, 39, pp. 173–205.

season are assumed to result in some fluctuation in water levels, while peaking will occur during non-monsoon seasons. Larger water level fluctuations can be expected during peaking and water levels will fluctuate based on electricity demand.

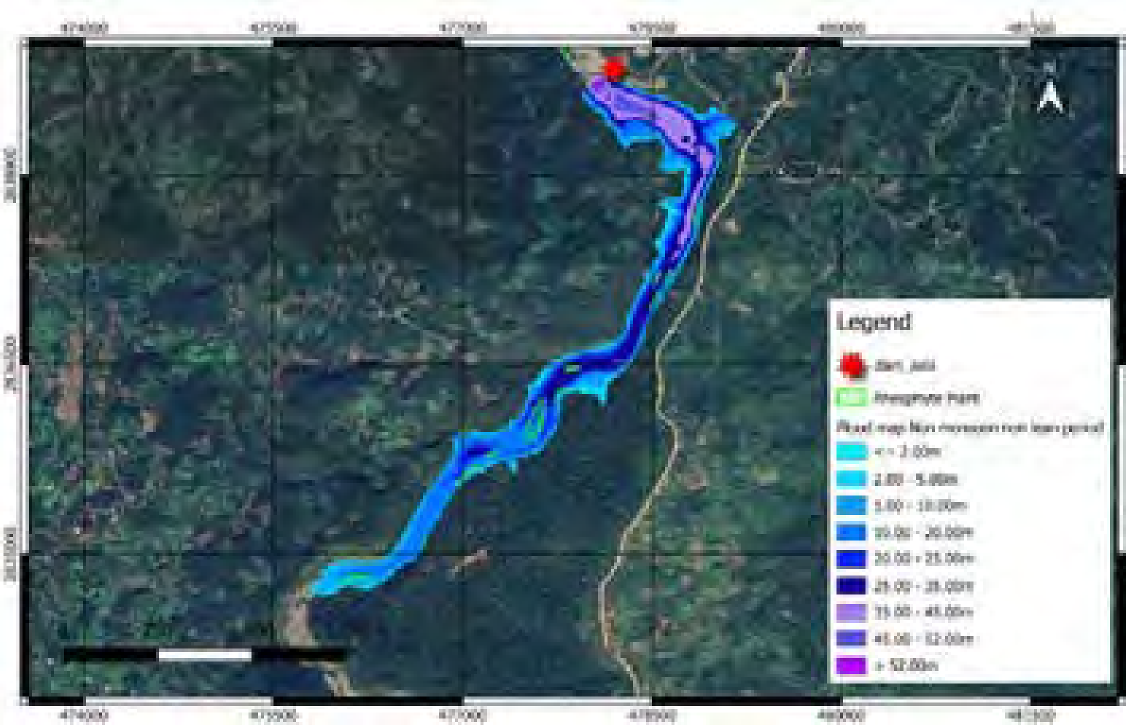
159. As per the above two tables (6,16) the lowest water level will be 205 m. It means that all the rheophytes will be submerged through out the year. The species *Syzygium cyanophyllum* will be impacted due to LKHEP in the reservoir area. Area inundation maps are presented below during different seasons (Map 27-30). Inundation is expected throughout the year as the water level of the reservoir will not go down below 205 m. Rehophytes inundation during different months are shown in the following maps. Diagrammatic representation of the inundation of rheophytes in the reservoir (Figure 43).

Map 27: Distribution of Rheophytes in the submergence area

Map 28: Distribution of Rheophytes in the submergence area during Lean Months (December to March)



Map 29: Distribution of Rheophytes in the submergence area during Non Lean Non Monsoon Months (April, May, October, November)



Map 30: Distribution of Rheophytes in the submergence area during Monsoon Months (June to September)

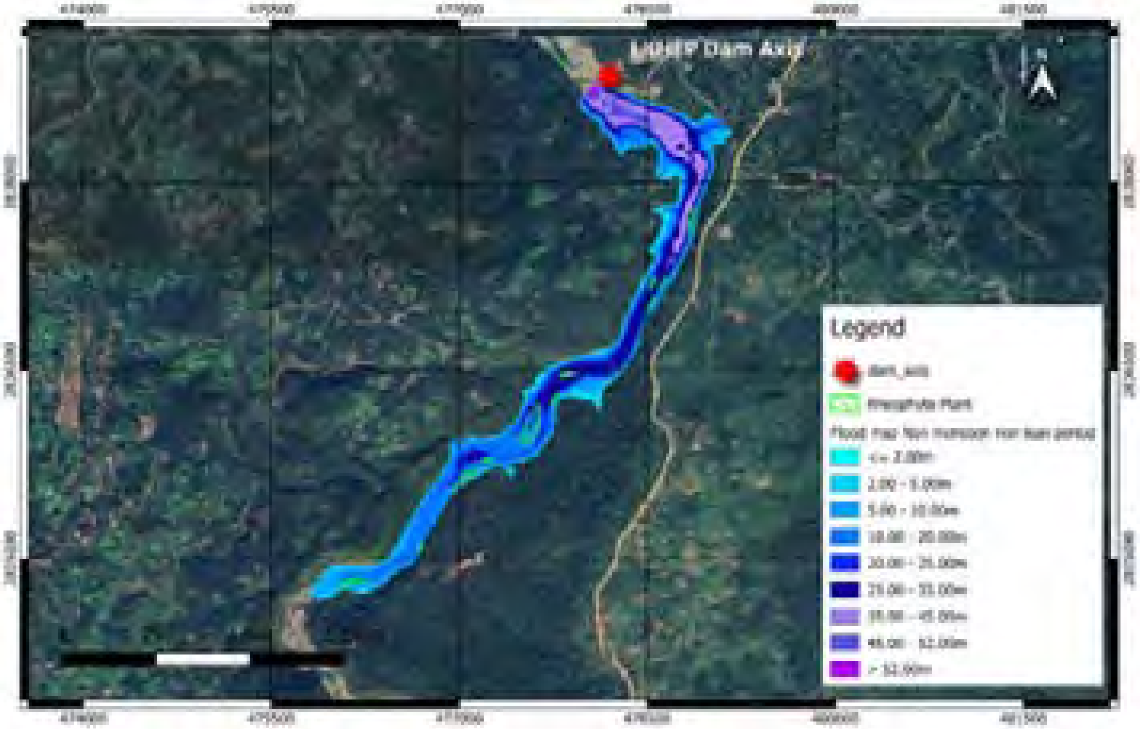
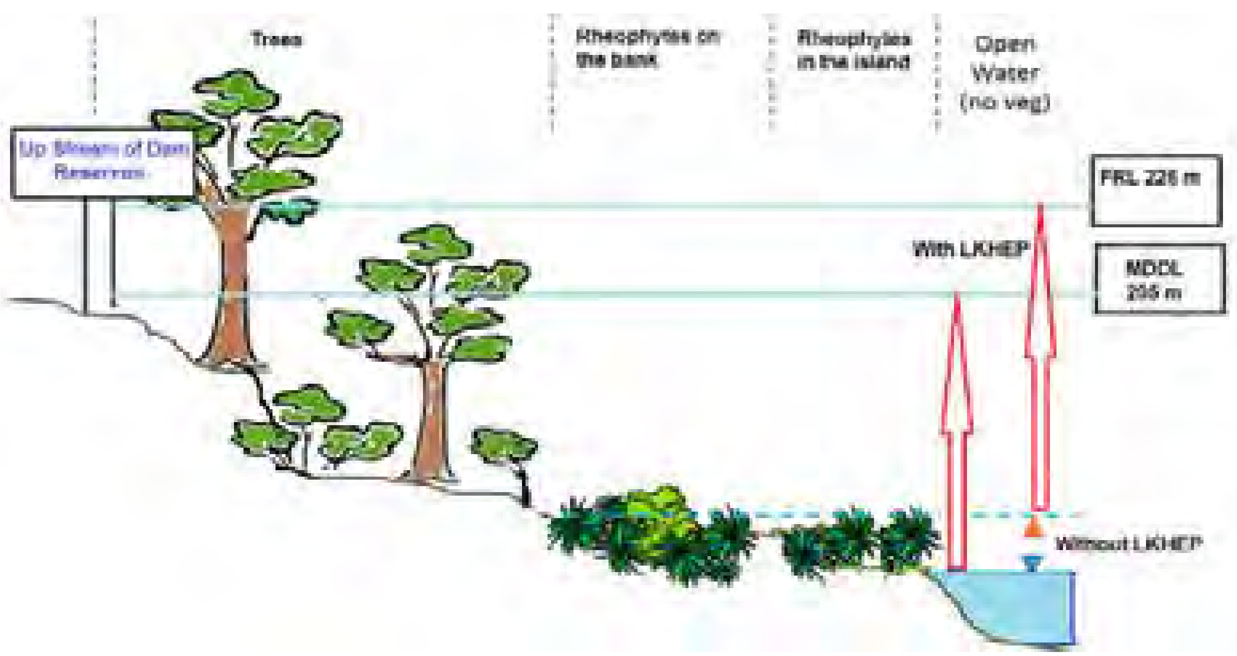


Figure 43: Diagrammatic representation of the inundation of rheophytes in the reservoir



160. As per the Rule curve parts of the rheophytic plants in 4 patches in the upstream will be above water from February to June. But rest 7 patches will be under water throughout the year (Table 17). Species confirmation in the patches numbered 8 to 11 will be crucial for preparation of the conservation management plan for *Syzygium cyanophyllum*

Table 17: Distribution of the rheophytes in submergence area and their inundation as per Rule curve

Patch No from DAM	Size of the patches (Ha)	Important Species	Month	Water level of the reservoir (m) amsl 205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	FRL 226
1	0.1	*Syzygium cyanophyllum*	Jan																						
2	0.1	*Syzygium cyanophyllum*	Feb																						
3	0.1	Species confirmation will be done after the detail survey	Mar																						
4	0.11		Apr																						
5	0.17		May																						
6	0.1		June																						
7	2.49		July																						
8	0.13		Aug																						
9	0.25		Sept																						
10	0.1		Oct																						
11	0.3		Nov																						
			Dec																						
	3.95	**Total**																							
	Percentage of total inundation of the patched with Rheophytes at different water level			80.25	80.25	85.00	85.00	90.00	90.00	95.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	Partial innundation of the patch number			8-11	8-11	8-11	8-11	8-11	8-11	8-11															

161. The reduction in flow velocity is considered the key issue affecting survival in this instance. Without data specifically relating to the species in question, it is not possible to determine with certainty what the outcome will be, however a degree of logic may be applied. The uniting characteristic of rheophytes is their adaptations to survive in swiftly flowing water. Reduced flow velocity may negatively impact their survival due to decreased oxygenation and sediment buildup on leaves, hindering photosynthesis. Given the high degree of adaptation to fast flowing waters, it is reasonable to consider that changes to this parameter will have a substantial negative impact and may lead to mortality of the rheophytes within this zone (patch 1-7).

2.4.4.5. Downstream impacts on the Rheophytes

162. The downstream environment will be affected by changes in water level frequency and duration during both run of river and daily peaking power conditions. Daily peaking power is expected to result in relatively abrupt fluctuating flow conditions downstream leading to variable inundation levels and frequency that will be influenced by power demand. The dam is expected to operate as a peaking system during non-monsoon seasons (Table -18). Some degree of inundation is expected from the dam to the powerhouse during the lean and high flow periods (during monsoon), and from the powerhouse to the Amring River during high flow periods (monsoon). The planned ramp-up from minimum flows to such high peaking flows is tentatively proposed to only occur within two 16-second periods, separated by 240 seconds. Changes to the frequency and duration of rheophyte inundation and flow rate are expected to be of relevance.

Table 18: Daily peaking power operation during different months (Based on the 10 daily flow)

Duration of innundation per day during different seasons													
Monsoon					Non Monsoon Non Lean					Lean			
June to Sept					Apr, May, Oct, Nov					Dec to Mar			
	MPH		APH			MPH		APH		MPH		APH	
Month	Hr	m3/s	Hr	m3/s	Month	Hr	m3/s	Hr	m3/s	Hr	m3/s	Hr	m3/s
June	1-17	112.71	24	27.43	April	2.71	112.71	24	16.84	4-5	112.71	24	5.35
Jul	13-15				May	10-21							
Sept	18-24				Oct	10-21							
Aug	9-24				Nov	7-8							

163. Some inundation is expected from the dam to the powerhouse that is the dewatered section and will be served by the e-flow. Water velocity coming out of the auxiliary powerhouse can be higher than normal but is expected to get dissipated due to the plunge pool. Section from powerhouse towards downstream is anticipated to face the impacts of inundation and velocity to a greater extent. Based on the position of rheophytes on the maps, inundation is expected to be minimal (Table - 19).

Table 19: Distribution of the Rheophytes in the downstream and their inundation during different season.

Patch No from DAM (D/s)	Size of the patches (Ha and sqm)	Size of the patches (Ha)	Height of the plants (m)	Important Species	HFL	Without LKHEP: Velocity (m/s)	Without LKHEP: Inundation of area during different seasons (in %): Monsoon	Without LKHEP: Inundation of area during different seasons (in %): Non Monsoon Non Lean	Without LKHEP: Inundation of area during different seasons (in %): Lean	Highest water level during operation (m)	After LKHEP: Velocity (m/s)	After LKHEP: Inundation of area during different seasons (in %): Monsoon	After LKHEP: Inundation of area during different seasons (in %): Non Monsoon Non Lean	After LKHEP: Inundation of area during different seasons (in %): Lean
Dam to Power House (TRC)					Dam at 90 m d/s 185.987 m	0.25	June to Sept	Apr, May, Oct, Nov	Dec to Mar		2.92 (end of APH)	June to Sept	Apr, May, Oct, Nov	Dec to Mar
12	274 sqm	0.027	1	*Carissa kopilii*		0.2-0.3	100	40	10			100	40	8
			2	*Syzygium cyanophyllum*		0.2-0.3	100	40	10			100	40	8
12.1	137 sqm	0.014	1	*Carissa kopilii*		0.2-0.3	100	40	10			100	40	8
			1	*Syzygium cyanophyllum*		0.2-0.3	100	40	10			100	40	8
13	0.1	0.1	1	*Carissa kopilii*		0.3-0.89	70	30	0			75	25	0
14	0.23	0.23		Species to be identified during Detail survey		0.3-0.89	100	40	0			75	25	0
15	139 sqm	0.014				0.3-0.89	50	10	0			60	15	0
Power House to Amring River					118.715 m	0.6				104; during Flood 111.66	3.864 (end of TRC)			
16	0.1	0.1		Species to be identified during Detail survey		0.23-0.87	50	10	0			60	15	0
17	106 sqm	0.011				0.23-0.87	50	10	0			60	15	0
18	251 sqm	0.025				0.23-0.87	50	10	0			60	15	0
19	0.25	0.25	1	*Carissa kopilii*			50	10	0			60	15	0
20	0.11	0.11		Species to be identified during Detail survey			50	10	0			60	15	0
21	279 sqm	0.028					50	10	0			60	15	0
22	258 sqm	0.026					90	10	0			95	15	0
23	0.1	0.1					70	10	0			70	10	0
24	0.1	0.1					30	5	0			40	8	0
25	0.1	0.1					30	5	0			40	8	0
26	0.3	0.3	3	*Syzygium cyanophyllum*			30	5	0			40	8	0
			1	*Ixora yunnanensis*			30	5	0			40	8	0
			1	*Pavetta pufii (?)*			30	5	0			40	8	0
27	0.45	0.45		Species to be identified during Detail survey			30	5	0			40	8	0
28	0.3	0.3					30	5	0			40	8	0
29	0.1	0.1					30	5	0			40	8	0
	Total	**2.384**												

Note : 1. The submergence % factors both area and height of the plant

2. This table will be revised based on the detailed study including availability of velocity data.

164. In the downstream partial inundation is observed between Dam and Power House area during both Lean period and during high flow periods (during monsoon) (Map 31, Map 32). Between power house to Amring river the plants will be periodically inundated during lean, and monsoon period (Map 33, Map 34). Height of the rheophytes species varies from 1 m to 3.5 m. The maps representing the different depth of water indicates the inundation status of the rheophyte patches during different season (Figure 44).

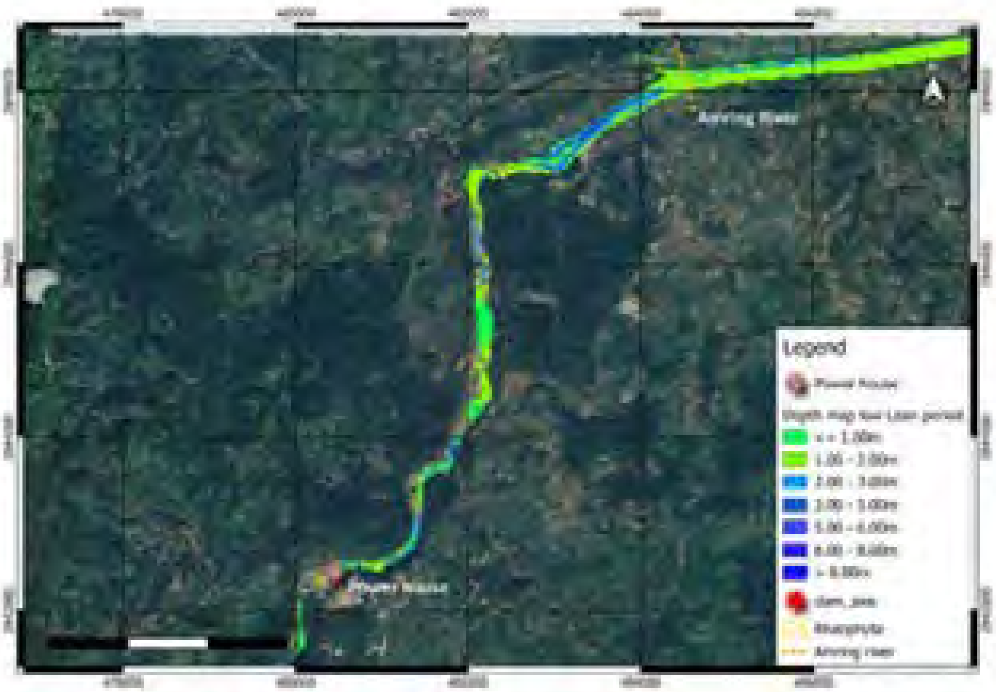
165. The project is identified as critical habitat for 4 species *(Carissa kopilii , Syzygium nivae, Pavetta puffii, Syzygium cyanophyllum)* in addition to earlier assessed in Interim EIA addendum. Out of the toral area of 6.33 Ha (3.95 Ha u/s and 2.38 Ha d/s) around 12.32 % area with rheophytes will be inundated permanently for all the seasons and

remaining 87.67 % area will not be inundated or partially inundated for few months during monsoon.

Map 31 : Inundation area and distribution of Rheophytes during Lean period between Dam and Power House

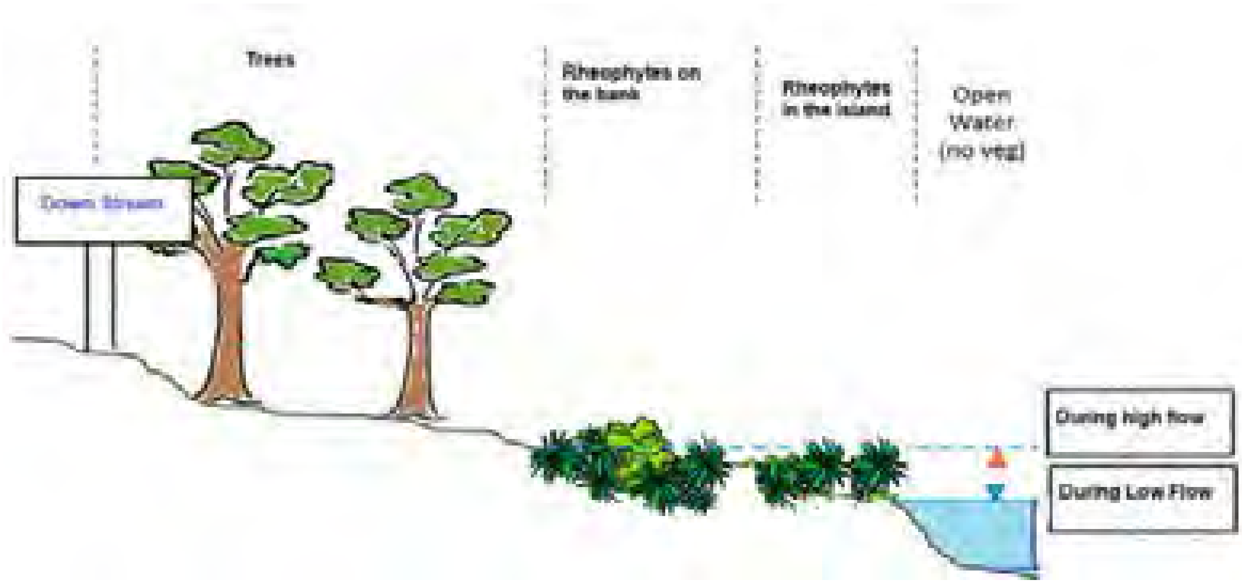
Map 32 : Inundation area and distribution of Rheophytes during Monsoon period between Dam and Power House

Map 33 : Inundation area and distribution of Rheophytes during Lean period between Power House and upto the confluence of Amring River



Map 34 : Inundation area and distribution of Rheophytes during Monsoon period between Power House and upto the confluence of Amring River

Figure 44: Typical representation of the inundation of rheophytes in the downstream



2.4.4.6. Impact of flow velocity on the rheophytes :

166. Changes in the flow velocity is likely to impact plants stress response and survival. Velocity in outlet of Tail Race Channel (Junction of TRC & Kopili River) is 3.864 m/sec when both units are running at rated discharge i.e. 112.71 m3/s. To maintain the laminar flow in the river and to avoid the turbulence the tail race channel has been designed 'L' type (Figure 45). During low water level in Kopili river (During Lean period), certainly there will be some local flow disturbance when tail race water is released from main powerhouse with velocity of 3.864 m/s. However, once the water level is raised, the impact of flow disturbance will be very minimal. Water level fluctuation was observed up to 95 km and beyond that lesser fluctuation in the river during high and low flow conditions. But rheophytes are distributed up to 20 km downstream of the dam only. During lean season (Dec - Mar) the e flow in 5.35 m^3/s, during non monsoon non lean period (Apr, May, Oct, Nov) the e flow is 16.84 m^3/s and during Monsoon (June- Sept) the e flow is 33.97 m^3/s. In the dam area the e flow velocity from Auxiliary Power House will be 2.92 m/s.

167. Since the impact of altered flow velocity on the rheophytes were not studied, it is recommended to monitor rheophytes species during 1 year of operation, so that impacts can be documented / known.

Figure 45 : Layout of Tail Race Channel to maintain the laminar flow.

2.4.4.7. Mitigation and management measures

168. The Kopili River has special significance for endemic or restricted-range rheophyte species and is therefore designated as critical habitat under the ADB Safeguard Policy Statement (ADB SPS), (Asian Development Bank, 2009). The ADB Safeguard Policy Statement requires '*measures to avoid, minimize, or mitigate potentially adverse impacts and risks*', as outlined in Section above. Nonetheless, some residual impacts might not be fully mitigated, and – on a precautionary basis – it is possible that this Project may have significant residual impacts on Critical Habitat-qualifying rheophilic plants. In such cases, ADB requires '*compensatory measures, such as biodiversity offsets, to achieve no net loss or a net gain of the affected biodiversity*'. These compensatory measures should ensure that, overall, the high biodiversity value of the Critical Habitat is maintained. Mitigation measures provided here are based on the current findings and impact assessment based on draft reservoir operation plan. This will have to be finalised based on the hourly flow data that will be available by July 2025 and final reservoir plan to be prepared. Optimization of reservoir operations plan will be based on the final findings and accordingly the EMP will be updated.

Avoidance

169. At this point of time avoidance is not possible as this involves alternative locations for the project.

Relocation

170. The relocation of endemic rheophytes is likely to be problematic and often proves unsuccessful (Hoyos-Gómez and Bernal, 2018[37]). All of the five rheophytes in question grow within rock crevices and in the first instance, extraction of the plant without serious damage is likely to be difficult. However, should this be achieved, suitable alternative habitats would need to be identified and populations successfully established. Establishment of populations in other river systems can result in high mortality rates (Wiesbauer et al., 2009; Costa et al., 2020[38]). So, relocation might not be feasible.

Propagation

171. Propagation requires growing new plants from seeds or cuttings. In the first instance, this would require particular knowledge of the plant's lifecycle and ecological requirements followed by the ability to replicate these conditions. Given the species' apparent preference for rock crevices and requirement for swift water, this could be extremely difficult. However, if the plant were able to be cultivated, it would need to be

[37] Hoyos-Gómez, S. E. and Bernal, R. (2018) 'Rheophytes of the samaná norte river, colombia: a hydroelectric project threatens an endemic flora', Tropical Conservation Science. Sage Publications Sage CA: Los Angeles, CA, 11, p. 1940082918756816.

[38] Costa, L. M. S., Goetze, M., Rodrigues, A. V., Seger, G. D. dos S. and Bered, F. (2020) 'Global rheophytes data set: angiosperms and gymnosperms', Ecology, 101(8). doi: 10.1002/ecy.3056.

relocated to a suitable alternative habitat. Under CAT Plan, afforestation will be carried out through the Forest Department, in open space, degraded surface, high soil erosion area, and in gentle and moderate slope. Gap plantation with 3 years maintenance also be done. In afforestation rheophytes will also be incorporated and for that Forest Department to be sensitized about the important species found in this river basin.

NO NET LOSS/NET GAIN APPROACH -**In situ conservation and offsetting**

172. As these taxa are expected to be difficult to cultivate, are unlikely to survive in the long term out of their natural environment and have small distribution area, in situ conservation would be the most suitable measure, associated with continuous monitoring (Costa et al., 2020). The best, and possibly the only viable option for the conservation of these species would be to conduct intensive surveys to identify any existing populations that are outside of the project's area of influence and consider their suitability for conservation and offsetting.

173. Should there be no alternative populations, in situ conservation of existing populations within the area of influence is only apparent the remaining option. This should involve a comprehensive study of the five species in question and modification of the hydrological regime in order to meet their habitat requirements.

174. Drawing on international good practice, the choice of an appropriate compensation measure to reach no net loss or net gain should – in particular – be comparable, additional and lasting (e.g., Gardner *et al.* 2013[39]). "Additional" means that gains produced by the compensation measure would not have happened anyway, in the absence of the Project. "Lasting" means that gains should last as long as residual impacts, in the case of this Project into the long-term. The compensation measure should ideally also be practical, i.e. cost-effective and relatively easy to implement – such as through a contract to one entity, rather than through complex multi-institutional partnerships.

175. "Comparable" means that the compensation measure should produce similar biodiversity gains to residual impacts (in scale, type of biodiversity, etc.), equating – for this document – to gains in the extent and/or number of Critical Habitat-qualifying rheophilic plants impacted by the Project, ideally in or near the Project area.

176. Steps necessary to assess the need for an offset and, if necessary, undertake one are outlined below:

177. Step 1. Assess whether any of the apparently Critical Habitat-qualifying rheophilic plants have significantly broader distributions than currently known.

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[39] TOBY A. GARDNER, AMREI VON HASE, SUSIE BROWNLIE,§ JONATHAN M. M. EKSTROM, JOHN D. PILGRIM, CONRAD E. SAVY, R. T. THEO STEPHENS, JO TREWEEK,§§ GRAHAM T. USSHER, GERRI WARD, AND KERRY TEN KATE. Biodiversity Offsets and the Challenge of Achieving No Net Loss. Conservation Biology, Volume 00, No. 0, 1–11 C 2013 Society for Conservation Biology DOI: 10.1111/cobi.12118

Consultation with experts involved in description of, or previous surveys for, these four species should identify any river stretches beyond the Kopili which may potentially hold these species but have not yet been surveyed. Surveys in those locations could potentially reveal much wider distributions for these species, thus reducing the relative significance of Project impacts. If species are found to be very widespread, they would no longer qualify the Project EAAA as Critical Habitat and thus require no specific offset actions.

178. Step 2. Assess the scale of direct impacts to Critical Habitat-qualifying rheophilic plants under the Project footprint (including the reservoir).
161. This will require surveys by expert botanists at appropriate seasons for identification (during flowering seasons for each species), at least throughout the entire reservoir area. It is not necessary to count each individual plant which will be lost – estimates can be extrapolated from mapped areas of rheophilic vegetation and counts of individuals within sample plots. However, it will be necessary to ensure some of the Critical Habitat-qualifying rheophilic plant species are not missed in the Project footprint.

*179. Step 3. Assess the scale of downstream impacts to Critical Habitat-qualifying rheophilic plants from the Project's power generation plans.*This will require environmental/ecological flow modelling.

180. Step 4. Consult an expert botanist on the findings of Steps 1-3 (above) to identify whether Project impacts are significant.
This requires botanical and ecological expertise, to assess – on a precautionary basis – if impacts might be relevant at the population level for each species. As a rule of thumb, however, loss of 5% of known populations would likely be considered significant, whereas smaller losses may not be.

181. Step 5. Modify the Project power generation plan to avoid any significant impacts on Critical Habitat-qualifying rheophilic plants
The challenge of offsetting any such impacts is so high (see Step 8) that the most realistic approach is to avoid them in the first place, or the Project is unlikely to be able to meet ADB safeguard requirements.

182, Step 6. Where significant impacts are possible for any Critical Habitat-qualifying rheophilic plant species, assess offset options.
Offset options for these species would comprise either (i) areas in which these plants have previously been lost/reduced (for non-Project reasons), and where they can be reintroduced/ expanded because threats have been/can be removed, or (ii) areas in which threats to these plants are clear, imminent and predictable, and could be prevented. The scale of an offset will depend on the type of offset and the specific context of each site – offsets do not require a simple 1:1 ratio of area. In option (i), the area of offset will depend upon the recovery/growth/expansion rate feasible for plants over the life of offset. For example, if plants are being reintroduced to an area and can only re-establish rheophilic vegetation at 50% of the quality of a natural vegetation community during the life of the offset, at least a 2:1 area ratio would be necessary. For option (ii), in a similar way, the

offset size will depend upon the predictable rate of loss expected during the life of offset. For example, if habitat is expected to be degraded by 25% without the offset, during its life, at least a 4:1 area ratio would be necessary.

183. Step 7. If offset options exist, implement offsets.
This will involve (i) restoration and/or protection work (see Step 6, above). The success of both of these will depend upon security of tenure of the areas, so the Project will need to either purchase any areas where offsets take place, or negotiate long-term leases on any such areas.

184. Step 8. Assess whether the Project has achieved No Net Loss for any significantly impacted Critical Habitat-qualifying rheophilic plant species
As these species mainly occur in rocky areas of the riverbed itself it is not anticipated that either of the offset options (Step 4) are very likely.

170. Table 20 identifies mitigation measures identified which are also necessary to reduce this Project's specific residual impacts on Critical Habitat-qualifying rheophilic species to levels in line with the ADB Safeguard Policy Statement (ADB 2009), based on a precautionary approach. Several general or standard mitigation/enhancement measures have already been outlined in the Project EIA (2018). Table 20 identifies where these general/standard mitigation measures already fully or partially meet mitigation needs.

185. A provision for in-situ and offset management have been provided in the updated EMP. Further survey and assessment in August and September, 2024, mitigation measures will be prepared and updated to ensure that the critical habitats requirements as per ADB SPS, 2009 are met.

Table 20: Appropriate mitigation and management measures for Critical Habitat-qualifying rheophilic plants, reviewed against planned Project mitigation (APGCL 2018[40], 2021)

Project Phase	Project impact	Proposed mitigation measure as per interim addendum	Updated mitigation measure
C, O	Loss of rheophilic vegetation under Project footprint (including reservoir).	Not identified earlier so no mitigation measures were planned.	Offset and in-situ management will be planned as per the detail assessment. Conduct intensive surveys to :- 1. cover all the patches for identification of the species of endemic rheophytes. 2. identify any existing populations that are outside of the project's area of influence and consider their suitability for conservation. Identification of offset locations. 3. Extent of occurrence of the species. 4. Selection of propagation method. In situ conservation of existing populations within the area of influence should involve a comprehensive study of the five species in question and modification of the hydrological regime in order to meet their habitat requirements In situ conservation :- (during operation) 1. Survival rate monitoring of the existing plants. In situ conservation during (construction)

[40] APGCL (2018a) Environmental Impact Assessment (Draft). IND: Assam Power Sector Investment Program – Tranche 3. 120 MW Lower Kopili Hydroelectric Project. Assam Power Generation Corporation Limited (APGCL), Guwahati, Assam

Project Phase	Project impact	Proposed mitigation measure as per interim addendum	Updated mitigation measure
			As per best practice with precaution, if habitat is expected to be degraded by 25% without the offset, during its life, at least plantation of 4:1 area ratio would be necessary.
C	Degradation/ mortality of rheophilic vegetation due to introduction of invasive alien species.	Take care to avoid introduction of new invasive species to, and spread of existing invasive species within, the Project area through: - washing of vehicles, equipment and supplies before entry to the Project area; - monitoring for invasive species; and - control/eradication of invasive species where found.	Mitigation measures same as in EMP of Interim Addendum.
C	Degradation of rheophilic vegetation from accidentally spilled fuel/oil/chemicals or surface runoff.	Use coffer dams and silt screens to prevent migration of silt during construction within the river.	Mitigation measures same as in EMP of Interim Addendum.
		Dewater and clean coffer dams to prevent siltation, by pumping from cofferdams to a settling basin or a containment unit.	Mitigation measures same as in EMP of Interim Addendum.
		Appropriately secure construction materials and chemicals during wet weather to avoid accidental release to the natural environment.	Mitigation measures same as in EMP of Interim Addendum.
		Stockpile materials and waste (including spoil) so as to avoid erosion and washing off into the river; establish drainage trenches to divert surface runoff from the site.	Mitigation measures same as in EMP of Interim Addendum.
		Ensure no waste materials are dumped in the river, including re-enforced concrete debris.	Mitigation measures same as in EMP of Interim Addendum.
		Prevent dumping of waste from concrete mixers in the river.	Mitigation measures same as in EMP of Interim Addendum.
		Prevent refuelling of all vehicles and machinery within 50 m of any watercourse, drain or channel leading to a water course.	Mitigation measures same as in EMP of Interim Addendum.

Project Phase	Project impact	Proposed mitigation measure as per interim addendum	Updated mitigation measure
		Locate temporary fuel tanks at least 50 m away from any watercourse, drain, or channel leading to a water course. Place tanks in covered areas with berms or dikes installed to intercept spills, if any. Immediately localize and clean up any spills with absorbent materials.	Mitigation measures same as in EMP of Interim Addendum.
		Ensure oil, chemical and solid waste are stored, handled and disposed of by appropriately licensed waste management contractors.	Mitigation measures same as in EMP of Interim Addendum.
C, O	Degradation of downstream rheophilic vegetation due to peaks and fluctuations in water flow, and consequent fluctuations in sediment and~~,~~ scouring, and armouring.	Ensure no periods of zero flow during construction or operation.	Mitigation measures same as in EMP of Interim Addendum.
		Put in place a peaking power generation plan that ensures both that peak flows are sufficiently low, and that they are ramped up to sufficiently slowly, such that (i) aquatic species, particularly those of conservation concern, can seek refuge in lower-flowing parts of the river for the duration of peaking flows; (ii) scouring of the river bed and resulting armouring is minimised; (iii) there are not surging peaking "waves" of water downstream which cannot be mitigated by downstream inflows from tributaries; and (iv) downstream impacts do not reach aquatic Critical Habitat.	Mitigation measures same as in EMP of Interim Addendum. This measured will be finalised as applicable after final assessment.

Notes: Project Phase = C-Construction, O-Operation.

186. Mitigation measures will be designed to achieve at least no net loss of biodiversity. At this stage, the project's ability to meet the ADB SPS requirements for projects within critical habitat depend on the ability to identify populations outside of the project's area of influence or successfully conserve existing rheophytes within the area of influence. Extensive survey will be carried out in Aug-Sept 2024.

2,4,4,8. Conclusion

187. In summary, it is not possible to predict the survival of the five endemic rheophyte species outside of the dead storage zone with any degree of certainty. This is due to their high degree of specialisation and adaptation to the particular environmental niches in which they exist, combined with the lack of knowledge for these species in particular. However, a degree of logic may be applied that suggests that plants adapted to a particular set of environmental circumstances are likely to experience a reduced probability of survival if those circumstances are changed.

188. The suggested next steps for the project are:

- Conduct intensive searches to identify populations outside of the project's area of influence and if found, reassess critical habitat status if necessary and assess the suitability of these areas for conservation and offsetting. Discovery of other populations may also provide information regarding environments that the species are able to inhabit.

- Should no alternative populations be identified, Good International Practice for hydropower development states that a high level eflows assessment is necessary (World Bank Group, 2018; European Investment Bank, 2019). This involves conducting studies on the species in question to determine the ecological circumstances that are required for their survival. This will aid in determining their likelihood of survival under various hydrological regimes and circumstances.

- If rheophyte survival under a hydropower regime is considered achievable, a suitable environmental flows regime can then be developed.

2.4.5. Plankton

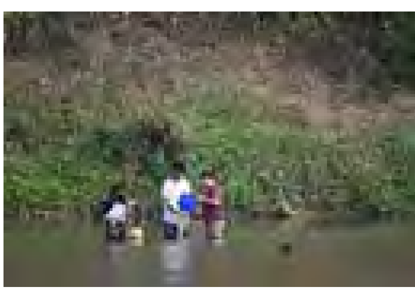
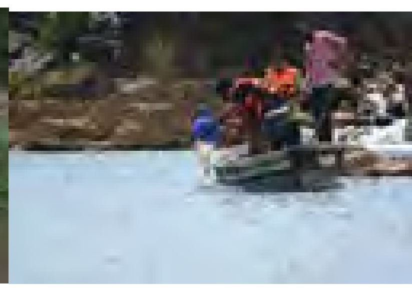
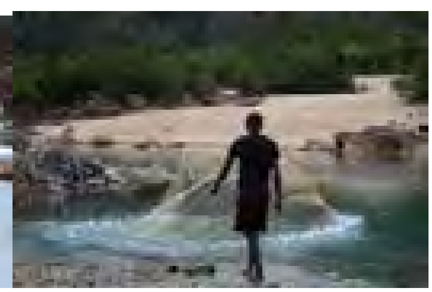
2.4.5.1. Plankton density

189. Plankton is an integral part of aquatic biodiversity and plays a vital role in the functioning of riverine ecosystem. This study was conducted in the river Kopili to evaluate the relative importance of physical, chemical, and nutritional characteristics of water quality on the spatiotemporal distributions of diversity and stability of plankton communities. Phytoplankton density is expressed as Cells/L and Zooplankton density is expressed as Nos/L. Although it is known that the pH of the river around the LKHEP dam is <5. Station wise plankton diversity is shown in the table 21. Plankton samples were collected in duplicate by filtering 100 Liters of river water using a 28 mm mesh nylobolt plankton net as described by Santhanam *et al*. (1987[41]). The collected plankton samples were preserved in 3-4 % formalin in separate plankton tubes. In the laboratory, from the known volume plankton sample counting was done by using the Sedgwick Rafter Plankton counting cell (Sharma and Saini, 2005). Plankton was identified at genera level using the identifying keys of Edmondson (1959), Needham & Needham (1966) and the ICAR monograph series on algae (Ramanathan, 1964; Philipose, 1967). Plankton biomass in terms of density was determined using plankton density (UL^{-1}) a Sedgwick Rafter Cell as per the methodology of Sharma and Saini (2005) using the following equation:

$$U\ L^{-1} = (N \times n) / L$$

Where ,

N= Number of plankton/ml
n= Volume of plankton sample
L= Total volume of water filtered in litres

- [41] Santhanam, R.; Ramanathan, N.; Venkataramanujam, K.V. and Jegatheesan, G. (1987). Phytoplankton of the Indian seas. As aspects of Marine Botany. Daya Publishing House,Delhi, 127p.

Table 21: Plankton density across different study stations

Type	Plankton Genus	Station 1	Station 2	Station 3	Station 4	Station 5	station 6	Station 7 Plankton density (UL^{-1})	Station 8 (Pond) (Longku Nala) Plankton density (UL^{-1})
Phytoplankton[42] (Cells/L)	*Scenedesmus sp*	-	-	-	-	-	-	1.7	0.6
	Microcystis sp	-	-	-	-	-	-	1.2	0.9
	Euglena sp	-	-	-	-	-	-	3.5	3.7
	Asterionella sp	-	-	-	-	-	-	3.1	4.6
	Desmidium sp	-	-	-	-	-	-	1.4	1.1
	Cosmerium sp	-	-	-	-	-	-	0.7	0.2
	Frustulia sp	-	-	-	-	-	-	2.8	1.7
	Mougetia sp	-	-	-	-	-	-	2.1	4
	Cymbella sp	-	-	-	-	-	-	1.6	2
	Cyclotella sp	-	-	-	-	-	-	0.9	0.4
	Spryogyra sp	-	-	-	-	-	-	1.5	3.3
	Closterium sp	-	-	-	-	-	-	0.3	0.1
	Zygnema sp	-	-	-	-	-	-	2.4	2.8
	Phacus sp	-	-	-	-	-	-	4.1	2.9
	Nostoc sp	-	-	-	-	-	-	0.7	1.5
	Navicula sp	-	-	-	-	-	-	3.5	5.1
	Pediastrum sp	-	-	-	-	-	-	0.6	0.8
	Nitzchia sp	-	-	-	-	-	-	-	0.8
Zooplankton[43] (Nos/L)	*Diaptomus sp*	-	-	-	-	-	-	0.9	0.4
	Bosmina sp	-	-	-	-	-	-	0.3	0.2
	Alona sp	-	-	-	-	-	-	0.2	-
	Cyclops sp	-	-	-	-	-	-	1.1	2.4
	Copepod Nauplii	-	-	-	-	-	-	1.4	3.1

[42] Phytoplankton : "Phytoplankton are unicellular organisms that drift with the currents, carry out oxygenic photosynthesis, and live in the upper illuminated waters of all aquatic ecosystems."
Marañón, E., Steele, J., Thorpe, A., & Turekian, K. (2009). Phytoplankton size structure. Elements of physical oceanography: A derivative of the encyclopedia of ocean sciences, 85

[43] Zooplankton : "Zooplankton include all animals in the water column that float, drift, or swim weakly (i.e., they are at the mercy of currents)."
Thorp, J. H., & Covich, A. P. (2001). An overview of freshwater habitats. Ecology and classification of North American freshwater invertebrates, 19-41.

2.4.5.2.Biodiversity Indices : Shannon-Wiener Index and Simpson Diversity Index

190. The Shannon-Wiener Index is a measure of biodiversity that takes into account both the richness (number of different species) and evenness (distribution of individuals among those species) of a community ranges from 0-5. A higher Shannon-Wiener Index value indicates greater diversity within the community. In present study, the Shannon-Wiener Index of plankton at station 7 is 2.86, while the pond has a Shannon-Wiener Index of 2.77. This suggests that the plankton community at station 7 has slightly higher biodiversity compared to the pond (Station 8).

191. The Simpson Diversity Index ranges from 0 to 1, with 0 indicating infinite diversity (infinite number of equally abundant species) and 1 indicating no diversity (only one species present).In the provided example, the Simpson Index of plankton at station 7 is 0.04, and in the pond, it is 0.05. Both values are close to 0, indicating relatively high diversity in both locations. Comparatively, the Simpson Index of the pond (0.05) suggests slightly lower diversity than that of station 7 (0.04), although both values still fall within the range close to 0, signifying diverse plankton communities. Therefore, despite the slight difference between the two locations, both exhibits relatively high diversity of plankton species. Since plankton were not found in the upstream stations 1-6, the plankton diversity were not calculated for these stations. Acidic Water pH and low alkalinity values may be the critical factors contributing to the absence of plankton population in this stations. Water quality was tested and the results are provided in the report. In case of station 7 as the station is the confluence of river Kopili and Diyung. The dilution of the river water contributed towards replenishment of Water quality leading to higher plankton diversity.

2.4.5.3. Periphyton

192. Periphyton[44] is an entire community of organisms, including blue-green algae, fungi, microbes, bacteria, plant detritus, and animals that together compose the foundation of an entire ecosystem. 18 species were found in station 7 (Table 22).

Table 22: Periphyton Diversity across different Station
(Samples were collected from all the stations 1-7 and the pond but we have not encountered any plankton cells from station 1-6)

Type	Plankton Genus	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7
Phytoplankton	*Scenedesmus sp*	-	-	-	-	-	-	+

[44] Periphyton : “Periphyton is the material growing on submerged surfaces in freshwaters. It is dominated by microalgae that often form long filaments or sheets that can cover the sediments, plants, or other objects in water.”

Type	Plankton Genus	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7
	Microcystis sp	-	-	-	-	-	-	+
	Euglena sp	-	-	-	-	-	-	+
	Asterionella sp	-	-	-	-	-	-	+
	Desmidium sp	-	-	-	-	-	-	+
	Cosmerium sp	-	-	-	-	-	-	+
	Frustulia sp	-	-	-	-	-	-	+
	Mougetia sp	-	-	-	-	-	-	+
	Cymbella sp	-	-	-	-	-	-	+
	Cyclotella sp	-	-	-	-	-	-	+
	Spryogyra sp	-	-	-	-	-	-	+
	Closterium sp	-	-	-	-	-	-	+
	Zygnema sp	-	-	-	-	-	-	+
	Phacus sp	-	-	-	-	-	-	+
	Nostoc sp	-	-	-	-	-	-	+
	Navicula sp	-	-	-	-	-	-	+
	Pediastrum sp	-	-	-	-	-	-	+
	Nitzchia sp	-	-	-	-	-	-	+

2.4.5.4. Benthos

193. No benthos[45] species were found in all the stations during study period. For collection of benthos, a metallic tube of 50 cm length and 3 cm diameter was used in every station during sampling.

2.4.6. Fish Composition and Distribution

194. Fish specimens were collected from 7 selected stations of Kopili river & one catchment area pond during the study using gill nets and cast nets of mesh size 0.5 cm and 2 cm. A total number of 30 hauls per station was performed during every sampling programme for catching fish specimens. Proper care was taken after the collection of fish specimens to avoid damage. Fish samples were collected based on the guidelines of the National Biodiversity Authority, Govt. of India. Each collected sample was photographed and preserved in 10% formalin and deposited in the laboratory of the Department of

[45] Benthos : "Benthos is an encompassing term used to classify organisms found on, in, or in close contact with the bottom region of bodies of water."
Walag, A. M. P. (2022). Understanding the World of benthos: an introduction to benthology. In Ecology and Biodiversity of Benthos (pp. 1-19). Elsevier.

Aquatic Environment Management, College of Fisheries, Assam Agriculture University, Raha, where each species was given a unique code number after identification. Identification was carried out based on their morphometric and meristic counts using standard keys (Talwar & Jhingran, 1991[46]; Jayaram, 1999[47]; Viswanath, 2002[48] & Kottelat, 2013[49]). Measurements were taken on the left side of the specimen with the help of a digital caliper and meristic counts were recorded under a PC-based stereo-zoom microscope. Electrofishing is not permitted in the river. The present conservation status of each identified species was obtained using the website: www.iucnredlist.org (IUCN, 2021[50]). Valid scientific names were confirmed from Eschmeyer's Catalogue of Fishes and Fish Base (Froese & Pauly, 2019[51]). During the present study, no fish species was recorded from stations 1,2,3,4 & 5. During the present investigation, 18 fish species belonging to 3 orders, 4 families, 15 genera were recorded from the study stretch. During the study, 2 fish species were recoded from station 6 while 16 fish species were recorded from station 7 (Table 23). One fish species was recorded from the Reservoir area (after LKHEP) on Longku Nala Dyke area. Species wise catch size is shown in the table 24.

Table 23: Station Wise Identification of Fish Species with Tropic Level status

Sl. no	Name of the Fish species & IUCN (2021) conservation status	Trophic Level	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7	Station 8 Pond
1	*Puntius Sophore* (LC)	2.6 ±0.1 ()	-	-	-	-	-	-	+	-
2	*Labeo rohita* (LC)	2.2 ±0.12	-	-	-	-	-	-	+	-
3	*Clupisoma garua* (LC)	3.7 ±0.59	-	-	-	-	-	-	+	-
4	*Cabdio morar* (LC)	3.3 ±0.4	-	-	-	-	-	-	+	-
5	*Opsarius bendelisis* (LC)	3.5 ±0.5	-	-	-	-	-	-	+	-

46 Talwar, P.K. and Jhingran, A.G. (1991) Inland Fishes of India and Adjacent Countries. Oxford-IBH Publishing Co. Pvt. Ltd., New Delhi, 1158 p.

47 Jayaram, K.C. (1999). The fresh water fishes of the Indian Region, Narendra Publisting house. Delhi-551.

48 W Vishwanath, 2002. Fishes of North East India: A field guide to species identification., Manipur University and NATP 198.

49 Kottelat, M. (2013). The fishes of the inland waters of Southeast Asia: a catalog and core bibliography of the fishes known to occur in freshwaters, mangroves and estuaries. Raffles Bulletin of Zoology.

50 IUCN (2021). Pethia stoliczkana. In: IUCN red list of threatened species. Version 2021. www.iucnredlist.org

51 Froese, R. and Pauly, D. (2019). FishBase-World Wide Web electronic publication, http://www.fishbase.org

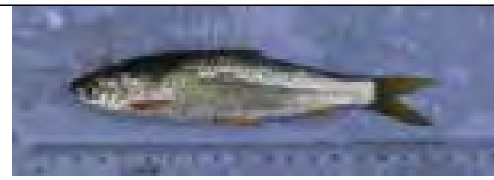
Sl. no	Name of the Fish species & IUCN (2021) conservation status	Trophic Level	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6	Station 7	Station 8 Pond
6	*Cirrhinus reba* (LC)	2.5 ±0.2	-	-	-	-	-	+	+	-
7	*Glossogbius giuris* (LC)	2.5 ±0.2	-	-	-	-	-	-	+	-
8	*Opsarius tileo* (LC)	3.6 ±0.5	-	-	-	-	-	-	+	-
9	*Osteobrama cotia* (LC)	2.9 ±0.3	-	-	-	-	-	-	+	-
10	*Labeo pangusia* (NT)	2.0 ±0.00	-	-	-	-	-	-	+	-
11	*Bangana dero* (LC)	2.0 ±0.00	-	-	-	-	-	-	+	-
12	*Sperta aor* (LC)	3.6 ±0.53	-	-	-	-	-	-	+	-
13	*Mystus cavasius* (LC)	3.4 ±0.4	-	-	-	-	-	-	+	-
14	*Mystus bleekeri* (LC)	3.3 ±0.4	-	-	-	-	-	-	+	-
15	*Botia rostrata* (VU)	3.2 ±0.4	-	-	-	-	-	-	+	-
16	*Pethia conchonius* (LC)	2.9 ±0.33	-	-	-	-	-	-	+	-
17	*Barilius barila* (LC)	3.2 ±0.4	-	-	-	-	-	+	_	-
18	*Danio rerio* (LC)	3.1 ±0.1	-	-	-	-	-	-	-	+

Note:

1. + Present; - Absent
2. LC- Least Concern; VU – Vulnerable; NT – Near Threatened
3. No separate status report available for India.
4. Trophic Level referred from fishbase.org

Fish Photographs

	
Puntius sophore	*Labeo rohita*

	
Clupeisoma garua	*Cabdio morar*
	
Opsarius bendelisis	*Cirrhinus reba*
	
Glossogobius giuris	*Opsarius tileo*
	
Osteobrama cotio	Labeo pangusia
	
Bangana dero	*Mystus cavasius*
	

Mystus bleekeri	*Sperta aor*
	
Botia rostrata	*Danio rerio*
	
Pethia conconius	*Barilius barila*

195. According to available literature (Hora, 1992[52]; Das & Hasan, 2008), Cyprinid fishes display potamodrmous migration. Potamodromous fish/cyprinids usually migrate only a few kilometres to suitable spawning grounds in medium sized rivers, which are characterised by high discharge fluctuations during spring and summer[53],[54]. They migrate upstream during monsoon for reproduction. They live in upper reaches for a period and then return to the lower reaches (foothills) for food and shelter. The present study was conducted for a period of 4 months from February 2024 to May 2024. A complete seasonal study can confirm their migration pattern. Some of the unfavorable critical river water quality parameters like pH , Alkalinity may be the reason of their absence in stations 1-5. Due to the unfavorable water quality parameters of River Kopili fishes are either migrating to the river Diyung or further downstream. Based on the present study some of the potamodramous migratory fish species available in the study stretch of River Kopili are : *Labeo* spp*., Barilius* spp*.* and *Opsarius* spp (Table 25)*. Labeo pangusia* is Near Threatened and *Botia rostrata* Vulnarable as per IUCN. Two species were found at Amring confluence which were probably from Amring river however the pH of Kopili doesnot support conducive environment for the fishes. Rest all the fish species are found after confluence of Diyung river (Sampling station 7) where the water level fluctuation is less and will have no impact on the survival of the fish species.

[52] Hora, S. L(1992). Structural modification in the fish of mountain torrents. Rec Ind Mus , 24:31
[53] Jungwirth, M., Schmutz, S. & Weiss, S. Fish Migration and Fish Bypasses. 438 (Blackwell Science Ltd, 1998).
[54] Thalinger, B., Wolf, E., Traugott, M. et al. Monitoring spawning migrations of potamodromous fish species via eDNA. Sci Rep 9, 15388 (2019). https://doi.org/10.1038/s41598-019-51398-0

Fish sampling

Table 24: Length and Weight of Collected Fish species

(Note : Trophic Level data was collected from fishbase.org . Length and weight data were collected to provide an idea about the size of the fish species)

Sl. no	Name of the Fish species & IUCN (2021) conservation status	Trophic Level	No of individuals	Length (Cm)	Weight (gm)
1	*Puntius sophore* (LC)	2.6 ±0.1 ()	7	10.1 11 13.86 10.1	15.57 20.502 10.5 16.315

Sl. no	Name of the Fish species & IUCN (2021) conservation status	Trophic Level	No of individuals	Length (Cm)	Weight (gm)
				9.8 9.4 11	17.90 13.142 27.71
2	*Labeo rohita* (LC)	2.2 ±0.12	4	20.6 15.2 19.5 18.2	108.81 43.005 79.186 71.512
3	*Clupisoma garua* (LC)	3.7 ±0.59	1	12.8	15.86
4	*Cabdio morar* (LC)	3.3 ±0.4	61	13.2 13.2 9.3 9.6 7.5 7.7 8 7 6.1 7.2 10.4 7.2 8.7 6.5 6.9 7.4 8 8.5 6.5 7.5 7.7 5.6 5.6 7 7.1 7.6 8.2 7.4 9.1 6.8 8.3 7.5 6 8 7.3	21.804 24.519 12.651 7.61 3.58 3.75 4.66 3.57 2.57 3.44 6.04 3.76 5.88 2.89 2.81 3.97 3.83 4.62 2.5 3.13 4.04 1.35 1.59 3.28 3.18 3.34 4.42 3.01 5.94 2.95 4.24 3.89 2.08 3.77 3.45

Sl. no	Name of the Fish species & IUCN (2021) conservation status	Trophic Level	No of individuals	Length (Cm)	Weight (gm)
				9 7.1 8.1 8.3 8.6 7.4 8.1 6.5 7 7 8.3 8.2 7.4 7.1 7.2 7 6.2 7.5 8.2 7 7 7.2 6.6 7 6.6 6.8	7.24 3.49 5.07 4.57 5.11 3.02 3.92 2.45 3.84 3.57 4.79 4.58 3.27 3.47 3.17 2.33 2.68 3.85 4.74 2.95 3.26 3.87 3.12 3.07 3.20 2.93
5	*Opsarius bendelisis* (LC)	3.5 ±0.5		6.5 5.9	4.3 3.9
6	*Cirrhinus reba* (LC)	2.5 ±0.2	3	13.4 12.5 14.46	20.730 17.785 42.773
7	*Glossogbius giuris* (LC)	2.5 ±0.2	5	14.5 15.3 13 13.4 11.3	28.582 27.45 20.154 18.668 13.299
8	*Opsarius tileo* (LC)	3.6 ±0.5	1	7.5	20
9	*Osteobrama cotia* (LC)	2.9 ±0.3	22	8 8.6 8.2 8.6 8.7 8.1	7.25 7.703 7.509 6.609 7.066 7.633

Sl. no	Name of the Fish species & IUCN (2021) conservation status	Trophic Level	No of individuals	Length (Cm)	Weight (gm)
				8.2 8.9 9.3 7.8 8.6 8.8 8.6 9.4 7.6 8.7 8.8 8.5 7.9 8.4 7.8 8.3	5.437 8.521 8.446 5.183 8.493 8.21 7.131 9.45 5.716 7.6 8.252 6.95 5.34 6.66 8.843 6.571
10	*Labeo pangusia* (NT)	2.0 ±0.00	2	21.7 18	123.6 68
11	*Bangana dero* (LC)	2.0 ±0.00	11	16.8 16.1 16.5 15 16 17 14.1 14.8 16.2 14.6 16.3	53.49 52.441 46.295 33.45 43.55 47.565 28.08 29.226 50.601 31.04 39.391
12	*Sperta aor* (LC)	3.6 ±0.53	1	25	100
13	*Mystus cavasius* (LC)	3.4 ±0.4	9	25.6 14.7 15.2 15 18.1 15.3 14.4 15.2 15.7	83.523 26.954 24.196 23.96 44.09 26.358 26.088 29.275 30.144
14	*Mystus bleekeri* (LC)	3.3 ±0.4	4	26.1 24.6 13.6 15.4	100 80.804 24.609 28.04

Sl. no	Name of the Fish species & IUCN (2021) conservation status	Trophic Level	No of individuals	Length (Cm)	Weight (gm)
15	*Botia rostrata* (LC)	3.2 ±0.4	1	10.1	13.91
16	*Pethia conchonius* (LC)	2.9 ±0.33	3	5 4.8 5.1	3 2.88 3
17	*Barilus barila* (LC)	3.2 ±0.4	4	6.5 6.5 8.7 6.5	3.205 2.68 7.78 2.68
18	*Danio rerio* (LC)	3.1 ±0.1	2	4.5 4.3	4 3.2

Table 25: Fish fauna recorded during the study with their Order, Family, Common name, migratory nature and Conservation status

Sl. No.	Order	Family	Species	Common name	IUCN 2021	Migratory nature
1.	Cypriniformes	Cyprinidae	*Puntius sophore*	Soft fin swamp barb	LC	Reports available on their migration (Hora, 1992; Das & Hasan, 2008)
2.			*Pethia conchonus*	Rosy barb	LC	
3.			*Labeo rohita*	Rohu labeo	LC	
4.			*Labeo pangusia*	Pangusia labeo	NT	
5.			*Bangana dero*	Kalabans	LC	
6.			*Cabdio morar*	Morar	LC	
7.			*Opsarius bendelisis*	Hamilton's barila	LC	
8.			*Opsarius tileo*	Tileo baril	LC	
9.			*Barilus barila*	Bared trout	LC	
10.			*Cirrhinus reba*	Reba carp	LC	
11.			*Danio rerio*	Zebra fish	LC	
12.			*Osteobrama cotio*	Hafo	LC	

13.			*Botia rostrata*	Gangetic loach	VU	
14.	Siluriformes	Bagridae	*Mystus cavasius*	Gangetic Mystus	LC	Not reported
15.			*Mystus bleekeri*	Day's mystus	LC	-do-
16.			*Sperata aor*	Long-whiskered catfish	LC	-do-
17.		Sisoridae	*Clupeisoma garua*	Bachcha	LC	-do-
18.	Perciformes	Gobiidae	*Glossogobius giuris*	Tank goby/Bare eye goby	LC	-do-

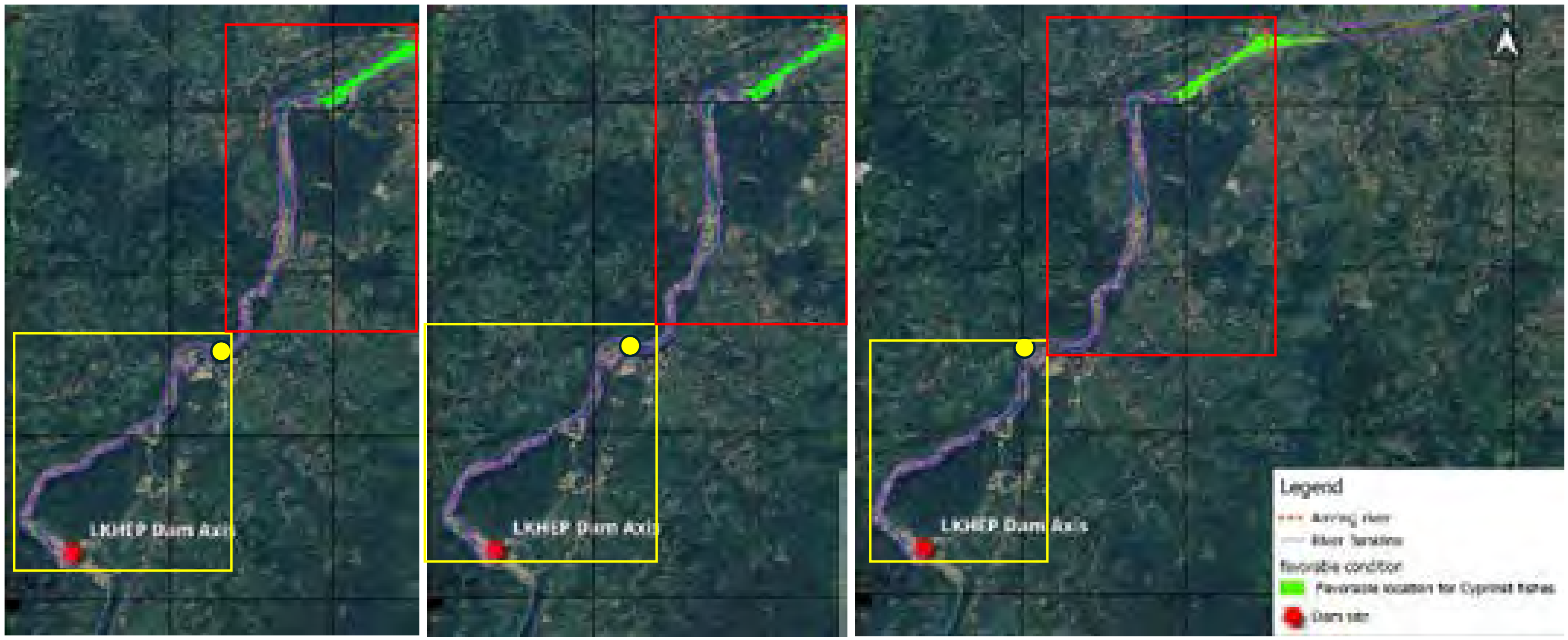
2.4.6.1. Assessment of Migratory fish and fish pass:

196. Cyprinids are the only species which shows limited migration in the river as per the literature. Considering the minimum requirement of water depth and velocity of *Tor tor* (endangered Cyprinid species) required for migration during both adult and juvenile stage, the following suitable habitats were identified in the d/s of the river Kopili. Adults of the golden mahseer (Tor putitora, the studied species) were mostly found in deep waters (> 2 m) with cool temperature (18-23ºC) and low water velocity (0-0.4m/s). Low water velocity are preferred by the adult cyprinid species. Fingerlings were mostly seen at depth ranges (0.1-0.6m) with velocity (0-1.2m/s) where dominant substratum was gravel and sand. Similarly, depth range between (0.3-1.8m), moderate velocity (0.3 -1.2m/s) and habitats with cobbles, bed rock and gravel as substrate were used by the juveniles. (Source: Johnson et al., 2017[55]).

197. As a precautionary measure this assessment was carried out. Based on the water depth and water velocity this assessment was carried out without considering the water quality i.e., pH. The pH of the river do not support any aquatic life in the Kopili River u/s of Diyung river confluence. (Map 32 and Map 33) All the suitable habitat of the cyprinid species are in patches and there is no connectivity or contiguity.

[55] Ecological flow requirement for fishes of Godavari River: flow estimation using the PHABSIM method JA Johnson, K Sivakumar, J Rosenfeld - Current Science, 2017 – JSTOR.

Map 35: Suitable Habitat for Cyprinid (Dam to Powerhouse , Powerhouse to congluence of Amring River)



Lean Period Non-Lean and Non-Monsoon Monsoon Main Power House

198. There is suitable habitat based on water depth and flow after the tailrace channel. But the area between the powerhouse and Diyung river has lower pH which is not suitable for the survival of the Cyprinid species. (Map 29)

199. Fish pass is not planned so far for the LKHEP due the acidic nature of water and lack of further upstream connectivity. The present study also does not confirm presence of any migratory fish species but it will be conclusive only after completion of the fish study for the one year covering all the seasons.

Map 36: Suitable Habitat for Cyprinid during lean period (Confluence of Amring river to Confluence of Diyung river)

Lean Period

Non Lean Non Monsoon Period

Monsoon period

2.4.7. Sediment Characterization

200. **Texture, pH, nutrient Level:** Texture of the sediment of all study stations were found to be sandy in the table below. The chemical characteristic of the sediment is shown in table 26. The sediment organic carbon content of the study stations was found to be medium to low while the sediment nitrogen & phosphate content was found to be low (Table 27). The sediment phosphorus values of the study stations were found to be high.

Table 26: Sediment pH and nutrients

Stations	pH	Organic Carbon (%)	Av. N_2 (Kg/ha)	Av. P_2O_5 (Kg/ha)	Av. K_2O (Kg/ha)
1	6.3	0.12	39.82	117.98	80.64
2	6.2	0.48	159.31	84.63	60.48
3	5.1	0.75	252.24	135.93	87.36
4	6.3	0.16	53.10	89.76	43.68
5	6.1	0.43	146.03	79.50	40.32
6	6.0	0.52	172.58	67.96	50.40
7	7.1	0.40	132.76	84.63	70.56

Table 27: Sediment Texture within stations

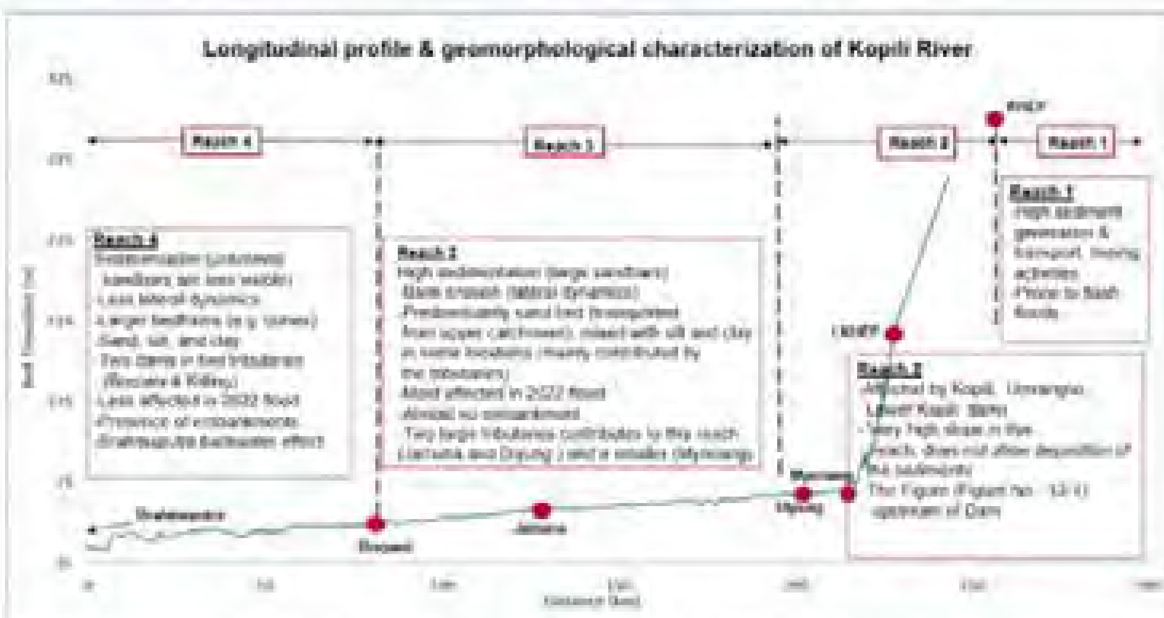
Stations	Sand (%)	Silt (%)	Clay (%)	Texture
1	89.60	1.42	8.98	Sandy
2	89.62	1.50	8.88	Sandy
3	89.64	1.28	9.08	Sandy
4	89.74	1.28	8.98	Sandy
5	89.86	0.96	9.18	Sandy
6	89.66	1.06	9.28	Sandy
7	89.62	1.30	9.08	Sandy

2.4.7.1. Fluvial geomorphology

201. From a fluvial geomorphological perspective, and utilizing the riverbed slope feature, as depicted in Figure 46, as a key criterion, as well as considering the location of the dams along the Kopili River, we can categorize or delineate the Kopili River into four distinct reaches as outlined below.

Water in Kopili river upstream of LKHEP dam showing very little sedimentation

Figure 46 Longitudinal profile of the Kopili River (along the thalweg) depicting the location of LKHEP, major confluence in the lower reach, and characteristic reaches based on sediment transport and morphological features.



202. This segment of river lies between KHEP to the confluence of Diyung river with Kopili river. The reach is affected by the operation of Kopili (Khangdong), Umrangso reservoirs, and LKHEP. Due to steepness and high transport capacity, sediment transported through this reach does not deposit within this reach Figure 44 shows a view of water flowing in Kopili river upstream of LKHEP dam. Clean water in thus figure exhibits a very little sediment in the river. However, transportation of sediments through the LKHEP to Mynriang stretch is evident that can impact the rheophytes with increased velocity of

water in post LKHEP scenario as has been also mentioned in the sections on rheophytes above.

2.4.8. Findings of the Aquatic Study

2.4.8.1. Downstream

2.4.8.1.1. Impact zone due to water quality

203. In the aquatic ecosystem, interaction occurs between biotic and abiotic factors are prevalent, Abiotic factors comprising physical and chemical components which has create an adverse effect on the aquatic community in their growth, abundance, community structures and distribution patterns etc. in a river ecosystem. To evaluate the potential impact of water of a river, ecological parameters like phytoplankton, zooplankton and fishes are the key tools for understanding Based on the population dynamics and distribution patterns, it is easier to identify the impact zone of a river stretch. Based on the 4 months data (Physical, chemical and biological parameters) of the present investigation. Station 7 i.e. post confluence of River Diyung and Kopili, can be regarded as non-impact zone. In the impact zone of the study stretch of river Kopili i.e. from station 1 to 6, (Map 38) many of the critical water quality parameters (pH, Total Hardness and Total Alkalinity) were found to be not congenial for aquatic life as a result of which no fishes, plankton and periphyton were recorded in this zone. However, in the station 7 after dilution of Kopili River water by River Diyung, the parameters were found to be suitable for aquatic organisms (Map 37). During the present study in the non-impact zone, we have recorded 16 fish species, 19 phytoplankton Genera and 5 zooplanktonic forms. Water level fluctuation from Dam to Diyung river during operation of the plant is shown in the figure 2. Graphical representation of the impact zone and non-impact zone is shown in the Figure 47. These impacts are due to existing water quality issues and this is the environmental baseline describing the existing environment prior to project implementation.

Map 37: Impact (Red Line) and Non-Impact Zone of the study stretch of River Kopili

Figure 47: Impact and Non-Impact Zone of River Kopili with Graphical Illustration

= Indicates Toxic to aquatic organisms specially fishes.

2.4.9.1.2. Breeding, nesting and feeding ground

204. Based on the 4 months data of the present investigation. Station 1 to 6 do not provide optimum conditions for breeding, nesting and feeding of fishes. However, since in station 7 we have recorded 16 fish species. Thus, this station may serve as a breeding, nesting and feeding ground of ichthyofauna.

2.4.9.1.3. Gangetic Dolphin occurrence

205. Based on the present study and after consultation of previous literature (Nath et al., 2023) there is no record of occurrence of Gangetic Dolphin (*Platanista gangetica) i*n the River Kopili.

2.4.9.1.3.1. Additional Information on the distribution of Dolphin

206. As per the existing literature, Ganges River Dolphin *Platanista gangetica* was not recorded from the river Kopili. During Initial Environmental Examination for Climate Resilient Brahmaputra Integrated Flood and Riverbank Erosion Risk Management Project in Assam (Morigaon Subproject, Morigaon District) and based on biodiversity report prepared by LASA[56], Ganges River Dolphin has been reported from consultee within 100m - 1 km from the riverbanks, but primarily in the main channels of the Brahmaputra River. The primary surveys were carried out summer period (March – April 2023), and couldn't sight any Ganges River Dolphin in the subproject areas. The presence of this species was noted through secondary data sources (i.e. consultations with locals and fishermen). The secondary data doesn't conclusively establish the presence of ≥ 0.5% of the global population AND ≥ 5 reproductive units of the Dolphins in the subproject areas (Criteria 1a and 1c for critical habitat, IFC). Moreover, during the downstream impact assessment carried out by the College of Fisheries, Raha, dolphin was not recorded in the river Kopili. The Ganges River dolphin (Platanista gangetica) has been categorised as 'Endangered' by the International Union for Conservation of Nature (IUCN)'s latest Red List Assessment of the species. The species' status remains the same as it was in previous assessments, given the continuing threats to its persistence and survival from a range of human impacts on the rivers of the Indian sub-continent where it occurs. The latest Red List assessment was published online in July 2022[57]. It estimates nearly 5,000 adult and juvenile dolphins to be extant today – a number higher than previous assessments from rivers of India, Nepal, and Bangladesh.

2.4.9.1.4. Habitat Restoration

207. Analysis of the water quality data generated during the current study clearly indicated that the habitat of River Kopili from Station 1 to 6 in not congenial for aquatic organisms

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[56] LASA Biodiversity Assessment & Ecology Survey Report, 2023

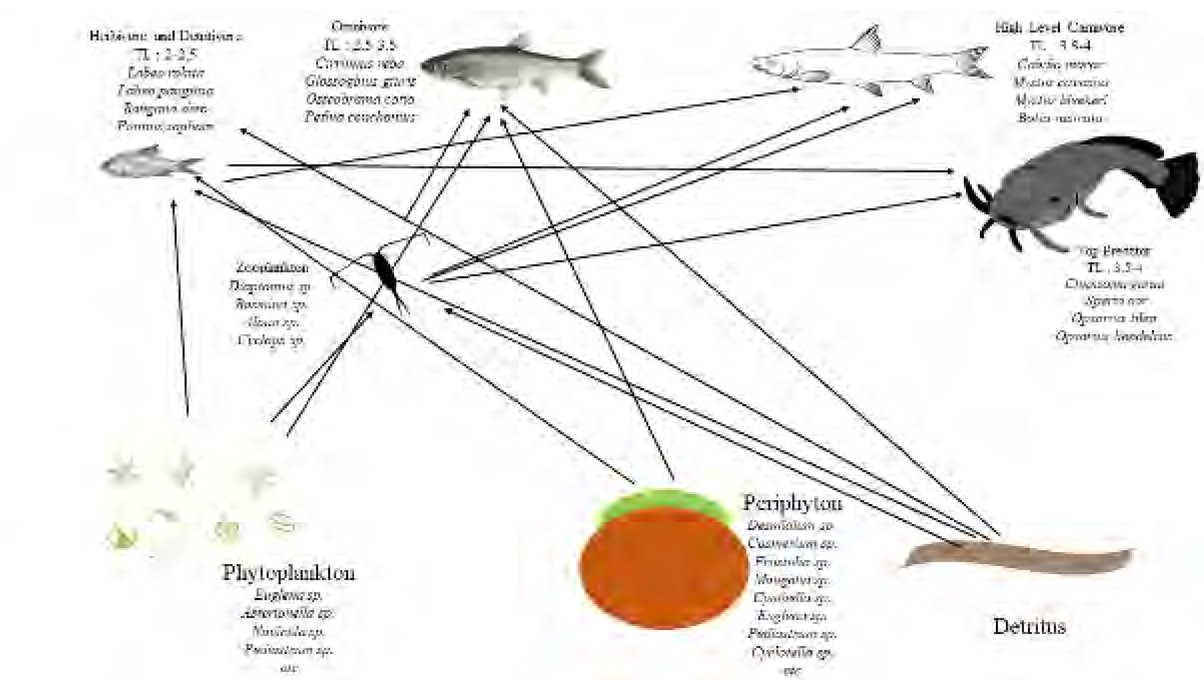
[57] Kelkar, N., Smith, B.D., Alom, M.Z., Dey, S., Paudel, S. & Braulik, G.T. 2022. *Platanista gangetica*. *The IUCN Red List of Threatened Species* 2022:
e.T41756A50383346. https://dx.doi.org/10.2305/IUCN.UK.2022-.RLTS.T41756A50383346.en. Accessed on 24 June 2024.

specially fishes. After confluence of the River Diyung with Kopili at Station 7, the water quality parameters found to be restored towards congenial range for fishes. This restored habitat from Station 7 onwards should be managed and conserved in consultation with professionals. There is variation of 0.24 m to 0.37 m either decrease (during lean period) or increase (during monsoon) in the confluence of Amring river to Diyung River in post dam period.

2.4.9.1.5. Food Web Diagram

208. Food web diagram could not be generated from station 1 to 6 due to absence of primary producer , secondary producer and consumers which are indispensable for a food chain leading to a food web. Based on the findings of our 4 months study, foodweb diagram for station 7 was prepared (Figure 48). This is a simplified representation as food webs are often highly complex.

Figure 48: River Kopili Food Web in station 7



2.4.8.2. Backwater Impact

209. Reservoirs, while serving important functions like water storage, flood control, and energy generation, can have significant impacts on aquatic ecology. Here are some key ways reservoirs can affect aquatic ecosystems and the assessment of impact for the LKHEP (Table 28).

Table 28: Back water impact assessment in LKHEP scenario

	Impacts	LKHEP scenario	Sensitivity of the receptor	Magnitude of impact	Categorization of Impact
1	**Alteration of Flow Regimes**: Reservoirs change the natural flow patterns of rivers, altering the timing, duration, and magnitude of high and low flows. This affects the habitats of aquatic organisms adapted to specific flow regimes. For instance, species that rely on seasonal flooding for spawning or feeding may be disrupted.	Due to the low pH in this section in LKHEP there is no aquatic life. Hence there will be no impact spawning or feeding ground as they are not existent. Creation of the reservoir will impact rheophyte vegetation which is semi-aquatic. Altered flow regimes may affect communities and the habitats that support them downstream. Again the pH of the river upto Diyung river donot support any aquatic life. Altered water level in the downstream will be below the normal HFL.	High	High	**High**
2	**Water Quality Changes**: Reservoirs can change water temperature, turbidity, and nutrient levels. The creation of reservoirs can lead to stratification of water columns, affecting oxygen levels and nutrient distribution. This can impact the composition of aquatic communities and lead to algal blooms, which can further degrade water quality and harm aquatic life.	Due to the low pH in this section in LKHEP there is no impact.	High	High	**High**

	Impacts	LKHEP scenario	Sensitivity of the receptor	Magnitude of impact	Categorization of Impact
3	**Habitat Loss and Fragmentation**: The inundation of land during reservoir construction leads to the loss of terrestrial habitats and fragmentation of aquatic habitats. This can disrupt migration patterns of fish and other aquatic organisms, isolate populations, and reduce genetic diversity.	There will be reduction in the habitat of terrestrial species due to the creation of reservoir. But 1:3 area is being restored and new areas of Reserve Forests has been created through CAMPA fund. As there is no fish in the project area an upstream hence no impact is envisaged on aquatic ecology. There will not be any habitat loss and barriers to movement for terrestrial and aquatic species due to LKHEP as the pH of the upstream areas are more acidic 2 to 4.	High	High	**High**

	Impacts	LKHEP scenario	Sensitivity of the receptor	Magnitude of impact	Categorization of Impact
4	**Sedimentation**: Reservoirs trap sediments, altering downstream sediment transport dynamics. This can lead to erosion downstream, affecting habitat quality for benthic organisms and altering channel morphology.	However, changes to sediment loads can have a marked effect on geomorphology, habitats and species downstream. Also rheophytes are particularly sensitive to the changed sediments in the downstream. Minimum sediment load of 1 mm/Sq Km/Year has been estimated during DPR and the study carried out by RMSI. Sedimentation rate 0.1 Ha-m/km^2/year as per DPR and MOC of CEA. Due to less sedimentation in the reservoir it will not affect hydropower production due to loss of reservoir storage and/or damage to the facility's mechanical components. Safety of dams will not be at stake due to less sedimentation and will not impact the environment.	Moderate	Moderate	**Moderate**

	Impacts	LKHEP scenario	Sensitivity of the receptor	Magnitude of impact	Categorization of Impact
5	**Species Composition Changes**: Reservoirs may favor certain species over others, leading to changes in species composition and biodiversity. For example, reservoirs often support populations of non-native species that can outcompete native species, leading to declines in native biodiversity.	Reservoir generally alter species composition downstream particularly terrestrial environments, including rheophytes. Rheophytes in Kopili shows resistance to acidity of water. Due to acidic nature no aquatic life persists.	Low	Low	**Low**
6	**Hydrological Connectivity**: Reservoirs can disrupt hydrological connectivity between rivers and floodplains, affecting nutrient cycling, sediment transport, and the migration of aquatic organisms. Loss of connectivity can have cascading effects on the entire riverine ecosystem.	As the water is acidic both in upstream and downstream migration of aquatic organisms does not arise.	Low	Low	**Low**

	Impacts	LKHEP scenario	Sensitivity of the receptor	Magnitude of impact	Categorization of Impact
7	**Water Withdrawal and Release**: Reservoir operations, such as water withdrawal for hydropower generation, can further alter flow regimes downstream. Sudden releases of water from reservoirs can cause downstream flooding or dewatering events, impacting aquatic habitats and organisms.	Influence of water level has been observed up to around 95 Km downstream from the LKHEP Dam (Figure 2). After that point there is no significant change in the water level. Low flow events after LKHEP varied between 0.03 m to 0.45 m in different sections of the river. Similarly, during monsoon, the water level will be reduced between 0.03 m to 1.5 m. Major changes are observed in the Dam to the confluence of the Amring River only. So downstream of LKHEP has been considered up to 95 Km. As there is no aquatic life till Diyung river peeking power operation will not impact any aquatic life as such. As a precautionary measure during the August September, 2024, study for the rheophytes, baseline aquatic life upto 95 km will also be considered.	High (Conservative approach)	High (Conservative approach)	**High**

	Impacts	LKHEP scenario	Sensitivity of the receptor	Magnitude of impact	Categorization of Impact
8	**Changes in Riparian Zones**: Reservoir construction alters riparian zones, which are critical transition areas between terrestrial and aquatic ecosystems. Changes in riparian vegetation can affect habitat quality, bank stability, and nutrient cycling, impacting aquatic communities.	Changes in riparian vegetation will affect Terrestrial habitat quality in LKHEP including the riparian vegetation. Back water impact on the Plant species has already been discussed in section 2.4.4.1. Terrestrial plants were already evaluated during the Forest Clearance.	High (Detail study in Aug-Sept will give more insight)	High	**High**
9	Warm climate reservoirs generate methane, a greenhouse gas when the reservoirs are stratified, in which the bottom layers are anoxic (i.e. they lack oxygen), leading to degradation of biomass through anaerobic processes.	Utmost care will be taken for the removal of the trees, and bushes for the submergence area of LKHEP before impounding in presence of the Forest Department.	Moderate	Moderate	**Moderate**

210. Overall, the impacts of reservoirs on aquatic ecology are complex and can vary depending on factors such as reservoir size, location, and management practices. Understanding these impacts is crucial for effective reservoir management and conservation of aquatic ecosystems.

3. Impact on Pabitora WLS in the downstream

211. Pobitora Wildlife Sanctuary is a protected area dominated by alluvial grasslands and wetlands in the south bank of the river Brahmaputra in the state of Assam. This wildlife sanctuary was finally notified on 17th March 1998 with a total area of 38.81 sq.kms and is located approximately 50kms. east of Guwahati, the capital city of Assam. The WLS is surrounded by more than 30 revenue villages and most of these villages are located in the Morigaon district of Assam and a very small portion of these villages are located in the Kamrup Metropolitan district of Assam. The sanctuary is a critical habitat for the one-horned Rhino, a protected species under Schedule 1 of the Wildlife Protection Act 1972. According to a census in 2022, the rhino population in the sanctuary is 107 including 30 male rhinos, 50 female rhinos, and 27 calves. This PA has a good combination of grasslands and wetlands seasonally affected by flood waters helping maintain the quality to support a relatively large rhino population and other herbivores.

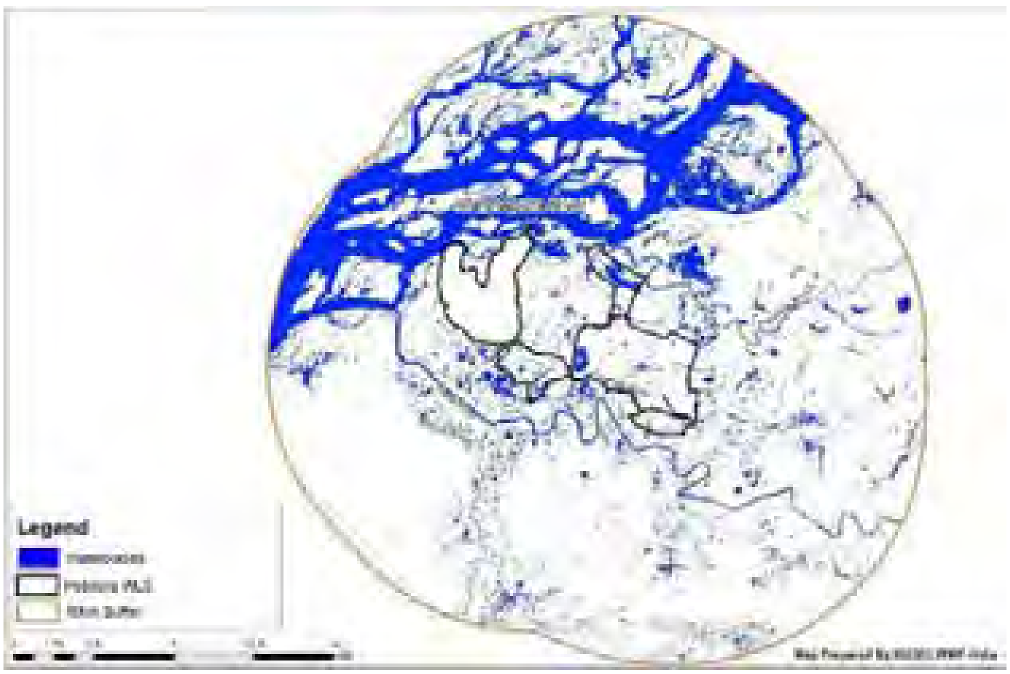
212. The Pobitora Wildlife Sanctuary (WLS) falls within 26°12′– 26°15′N latitude and 91°57′–92°5′E longitude (Map 39). The area is generally flat with a gentle east-to-west inclination, excluding the Bura-Mayong hill to the north. The sanctuary is located in the floodplains of rivers Brahmaputra and is serviced by the flows of the two south bank tributaries of the Brahmaputra i.e., - Kolong and Pokoria. Being low-lying, the region is subject to annual flooding with water present year-round in lakes and swamps (Map 40). This makes Pobitora WLS an ideal area for rhinos as well as migratory waterfowl. The average annual rainfall is between 2000–2300 mm and the average winter temperature is 8°C and it rises up to 37°C in summer. Relative humidity ranges from 60% in March to 95% in July.

213. The sanctuary area can be broadly categorized as- the grasslands, the woodlands and the waterbodies. The vegetation of the sanctuary can be classified into four types: Eastern wet alluvial grassland; Barringtonia freshwater swamp, forest; Low alluvial savannah wood land (Salmania-Albizzia) and Northern secondary moist mixed deciduous forest.

Map 38: 3D map of Pabitora WLS

214. In addition to the Greater One Horned Rhinoceros, Pobitora Wildlife Sanctuary is also home to various other fauna and avifauna species as well. Some of the other species found in Pobitora includes Asiatic Water buffaloes, Leopard, Leopard cat, Jungle cat, Fishing cat, Deer, Wild Boras, Chinese Pangolins etc. As per records, there are 27 species of reptiles, 39 species of fishes, 9 species of amphibians and 375 species of birds both resident and migratory are found in the WLS.

Map 39: Showing water bodies in Pobitora WLS[58]



3.1. Flooding events in Pabitora (Pre-Dam scenario)

215. Every year after flood, water bodies of the sanctuary are silted up with seasonal deposition and this causes shrinking of size and depth of the wetlands resulting in decrease of water retaining capacity. Almost 20% of the entire study area has been observed to be under water and this may be due to late rains and extended floods up to November during 2020.[13] During high flood Pabitora gets water from Brahmaputra River (Map 40, Map 41).

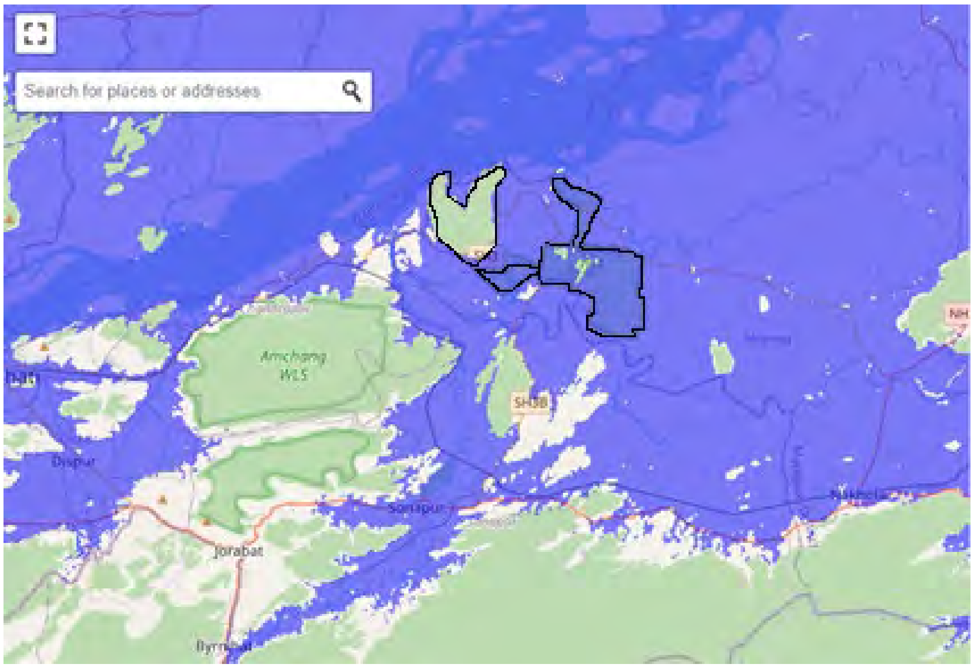
Table - 29: Pabitora as a critical habitat

Name	National Status	IUCN Protected Area Level/Ramsar Criteria	IBA Criteria	KBA	Critical Habitat as a PA
Pobitora WLS	WLS	Category IV as per IUCN	A1, A2, A4iii	Yes	Supports CR/EN & migratory species

[58] LULC changes in Pobitora 2020-21 Nov2021; Technical Report · October 2021; DOI: 10.13140/RG.2.2.10325.70882

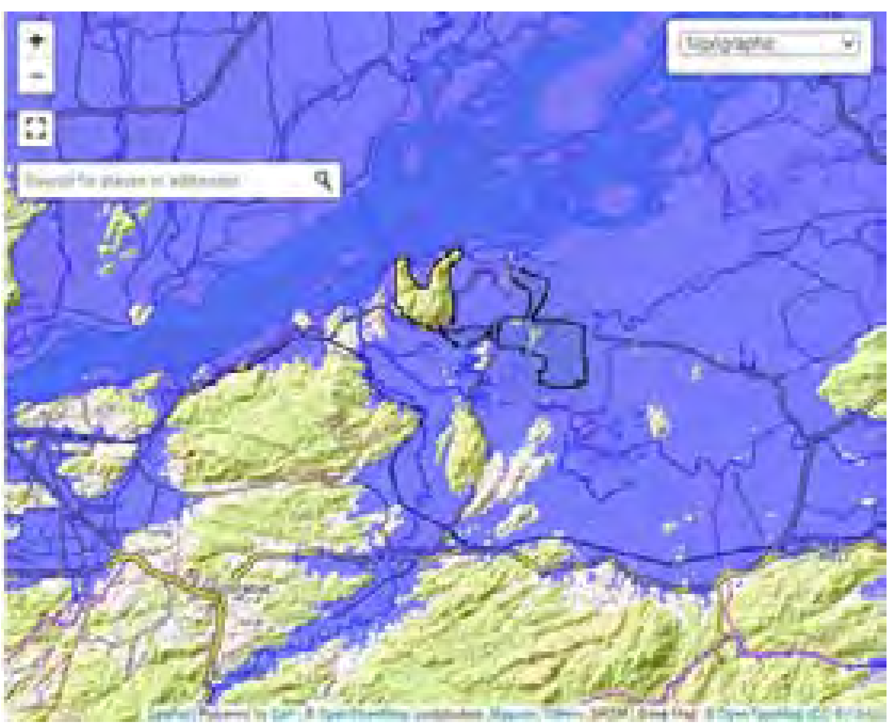
CR = Critically Endangered, EN = Endangered, IBA = important bird area, KBA = Key Biodiversity Areas, IUCN = International Union for Conservation of Nature

Map 40: Inundation of Pabitora WLS during Flood



(Note : Pabitora WLS with addition area)

Map 41: Inundation of Pabitora WLS during Flood in 3D



3.2. Impact of flood on the Rhinos (Pre Dam scenario)

216. In 2020, Pabitora got nine flood waves and due to shortage of grass and fodder, 9 rhinos died. In the last five years, 20 rhinos died naturally and two rhinos were translocated to Manas National Park.

3.3. Flood Management initiatives taken by the Forest Department for the Sanctuary after 2020

217. Presently there are six highlands including two big highlands in the wildlife sanctuary. The wild animals can reside in the highlands when the wildlife sanctuary is flooded. Moreover, the patrolling paths inside the park are also used as shelter by the wild animals during flood. The forest official further clarified that following highlands were constructed in 2021 and they were very useful during the flood for the wild animals (Annexure 5).

1. dimension of 1500 mtrs. (approx.) in length & 4 mtrs. (approx.) in breadth with height of 2.5 mtrs. (approx.),
2. dimension of length 800 mtrs. (approx.) and breadth 4 mtrs. (approx.) with height of 2.5 mtrs. (approx.)
3. rest four (4) highland have dimension of length 50 mtrs. (approx.) & breadth 4 mtrs. (approx.) with height of 1.5 mtrs. (approx.).

Rhinos taking shelter on the Highland during flood[59]

[59] Photo credit should read BIJU BORO/AFP via Getty Images

3.4. Impact of the LKHEP on Pabitora WLS:

218. There is no impact of LKHEP on Pabitora WLS during operation in Lean, Monsoon, non lean non monsoon period. One part of Pabitora (Excluding Bura Mayang Hills) will be inundated during Standard Project Flood (SPF), Probable Maximum Flood (PMF) and 100 years scenario (Map 42. Average depth will be 1.14 m to 1.37 m (Table 30).

Table 30: Impact of LKHEP in different dam operation and PMF, SPF, 100 years

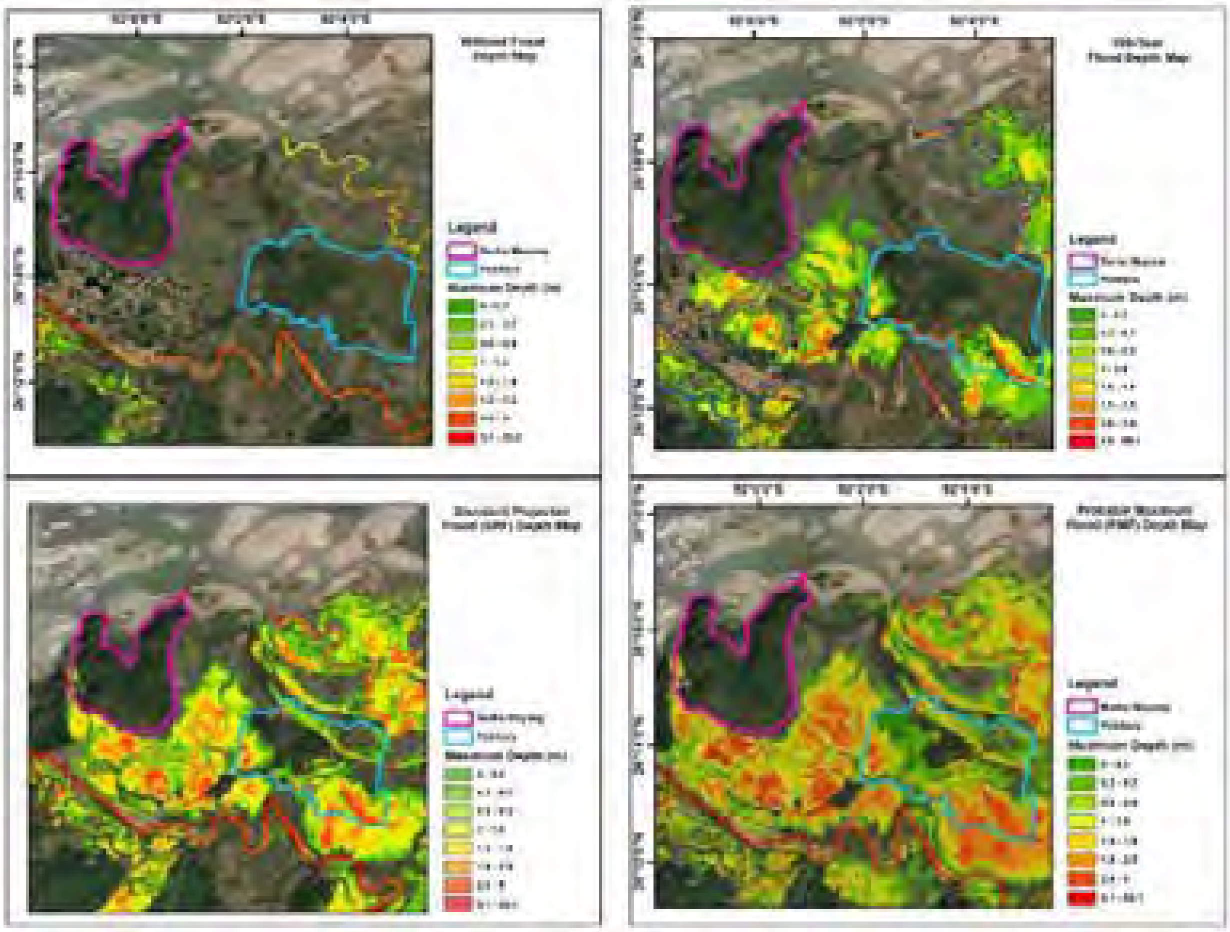
WITHOUT FLOOD CONDITION
*SAFE
There is no impact of LKHEP on Pabitora WLS during low flow and high flow conditions

100-YEAR							
			DEPTH (m)			AT (hrs)	Arrival Time (HH:MM:SS)
Rowid	NAME	ZONE-CODE	MIN	MAX	AVERAGE		
1	Pobitora	1	0.00	3.18	1.14	123.167	123:10:00

SPF CONDITION							
			DEPTH (m)			AT (hrs)	Arrival Time (HH:MM:SS)
Rowid	NAME	ZONE-CODE	MIN	MAX	AVERAGE		
1	Pobitora	1	0.00	4.23	1.25	105.417	105:25:00

PMF CONDITION							
			DEPTH (m)			AT (hrs)	Arrival Time (HH:MM:SS)
Rowid	NAME	ZONE-CODE	MIN	MAX	AVERAGE		
1	Pobitora	1	0.00	4.89	1.37	94.5	94:30:00

Map 42: Inundation area map during different Post Dam scenario



Water level and inundation during different scenario

29. Flood in Pabitora WLS is due to Brahmaputra River, so Kopili River has very little contribution on the flood scenario in the Sanctuary. The existing 6 artificial highlands and the selected patrolling paths are adequate for the conservation of wildlife during flood in Pabitora. The highlands ranges between 50 m to 1500 m in length and with 4 m width. Further, the height of the highlands ranges from 1.5 m to 2.5 m depending on the HFL of the site / location (Annexure 5). There will be a rise of additional 19 cm in certain sections of the sanctuary due to the extreme PMF condition. Arrival time of the PMF to the WLS will be 94 hours 30 minutes (Table 29). DFO appraised about the existing 6 artificial highlands in the park which are constructed after 2020.

220. In the above scenario, additional mitigation measures are not proposed for the Pabitora WLS.

4. Impact on Panimur / Koka water falls

221. Panimur in Dima Hasao district is a renowned location owing its reputation to the multitude of waterfalls and rapids along the Kopili river. Koka, located in West Karbi Anglong is a picnic spot on the river Kopili. Tourists come here to see the water falls from both the banks of the river where boating and rafting are done. Due to Lower Kopili Hydro Power Plant operation there will be change in the water flow regime. To assess the impact, estimation of the water level was calculated in HEC-RAS.

Panimur / Koka Water Falls in Dima Hasao and West Karbi Anglong

222. Water Surface Elevation and water depth at Panimur during high and low flow events are plotted in Figure 49 and Figure 50. Very little variation is observed which ranged between 0.21 m (decrease in low flow) to 0.36 m (Increase in high flow). For peeking power advance information will be sent to the authorities and the boat and raft operators. Consultation with the Revenue Department, Tourism Department, Forest Department of Dima Hasao Autonomous Council were carried out by APGCL on 13th June 2024 to appraise them about the fluctuation of water level during Hydro Power operation and regarding the early warning system. (Annexure 6 : MOM). Peaking power operation and

diurnal increase and decrease in water level and discharge might impact the safety of tourist on boat, raft, bank. To continue with the tourist activities, they will need to follow a strict protocol of timings, do's and don'ts in conformance with the dam operations plan. Also the tourist need to be made aware of the conditions prior to entering the sites or venturing for boating and rafting. Best option however would be to avoid tourist activities in the reservoir or downstream to ensure safety.

Figure 49: Water Surface Elevation at Panimur in low and high flow situation

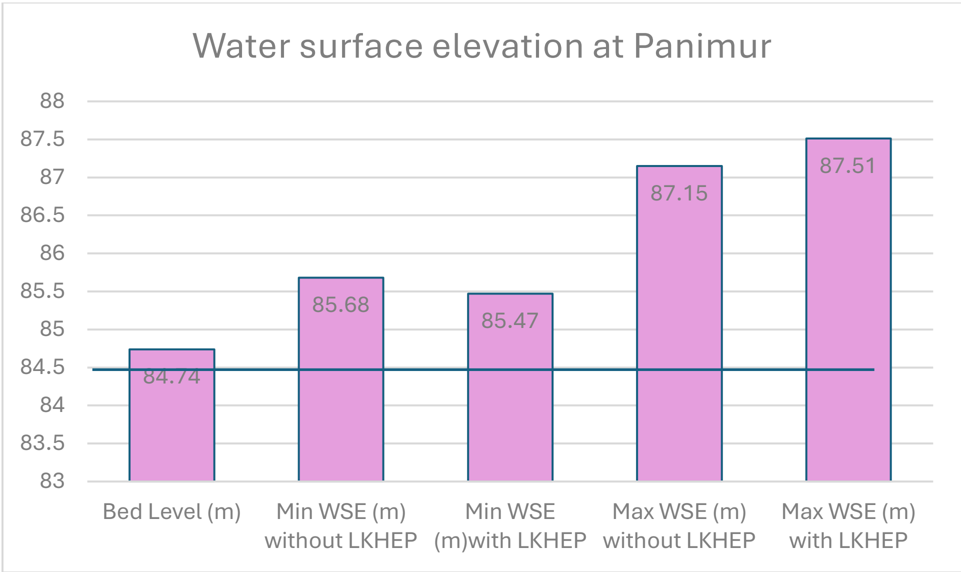
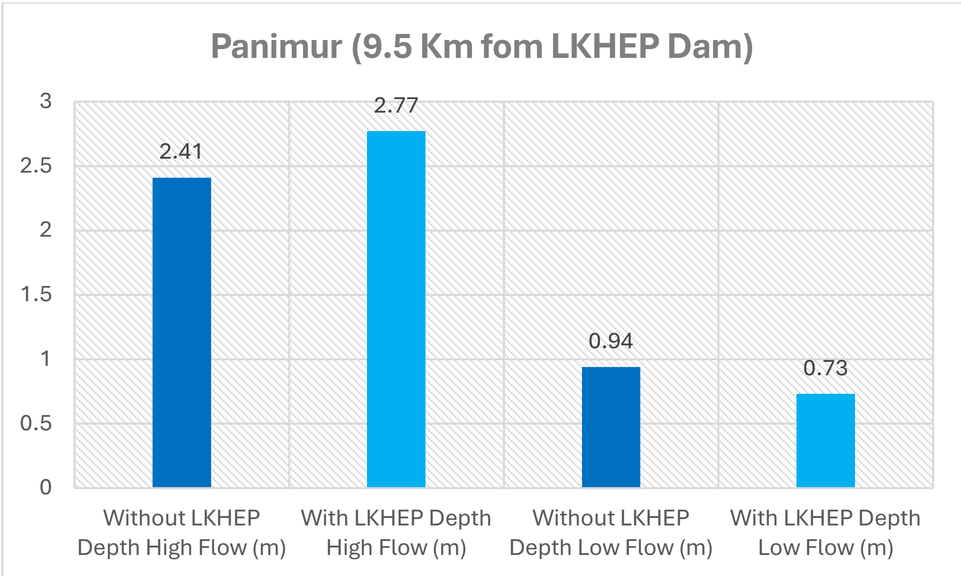


Figure 50: Water depth during High flow and low flow events with and without LKHEP



5. Dam Break Analysis

223. Dam break assessment was carried out by WAPCOS during EIA engaging IIT, Roorkee in 2016. As per the recommendation of International Dan Safety Expert of EMC Dam Break Assessment was again carried out by IIT Roorkee during Feb to May, 2024 with the CEA approved Dam design and conditions as per MOC, dated 19th November 2019.

5.1. Selection of Critical Dam Break Scenario

224. The Lower Kopili Dam is a concrete dam with a spillway having six gates and seven bays. The dam also has a gate for debris flow. In concrete dams, the primary causes of failure are mainly through overtopping. Therefore, this study considers the overtopping failure mode. The flood modelling was conducted for PMF, SPF, and 100-year flow conditions, assuming that the reservoir is at FRL before the inflow of floodwaters into the reservoir. Additionally, the analysis included a scenario without any flood conditions (fair weather failure) when the water level is at FRL, with a constant river flow of 113.2 cumecs. To assess the dam's safety against the PMF, the PMF was allowed to pass through the gate keeping all gates open. The following table details the scenarios that were considered for further analysis:

Map 43: Digitised Dam Structure Model

Table 31: Modelled scenario and inflows details

Scenario No.	Attribute	Failure Mode	Inflow
1	PMF Routing	All gates open	PMF Hydrograph
2	PMF	Overtopping	PMF Hydrograph
3	SPF		SPF Hydrograph
4	100- years		110 Year Flood Hydrograph
5	No Flood / Fair Weather		Constant river flow

225. The FRL of the dam is 226 m and the Top Bank Level (TBL) is 228 m. There is a 1 m parapet wall above the TBL. As found in the literature, concrete dam failure should be conducted when the water level is about 0.6 m above the TBL. Hence the dam failure condition considered in this study is 228.6 m. The weakest section where the possibility of dam failure is high is the section having the gates which are centrally located. Hence, the centre location of the failure is assumed at the centreline of the dam.

5.2. Breach Parameter

226. As per section 3.9.1.2 of chapter 3, the average breach width (Bavg) is calculated using the Froehlich 2017(b) equation and found to be 133.96 m. Also, for a concrete dam, the breach side slope is assumed to be equal to Vertical (0:1); considering the structural characteristics of this type of dam, the side slope (m) is taken as 0. The breach formation time, according to the USACE (2014), ranges between 0.1 and 0.5 hours (Ref. Doc. No. CDSO_GUD_DS_05_v1.0, pg. 24), and after sensitivity analysis, it is adopted as 0.3 hours. The final breach parameters adopted for all the cases after sensitivity analysis are shown in Table 32 below.

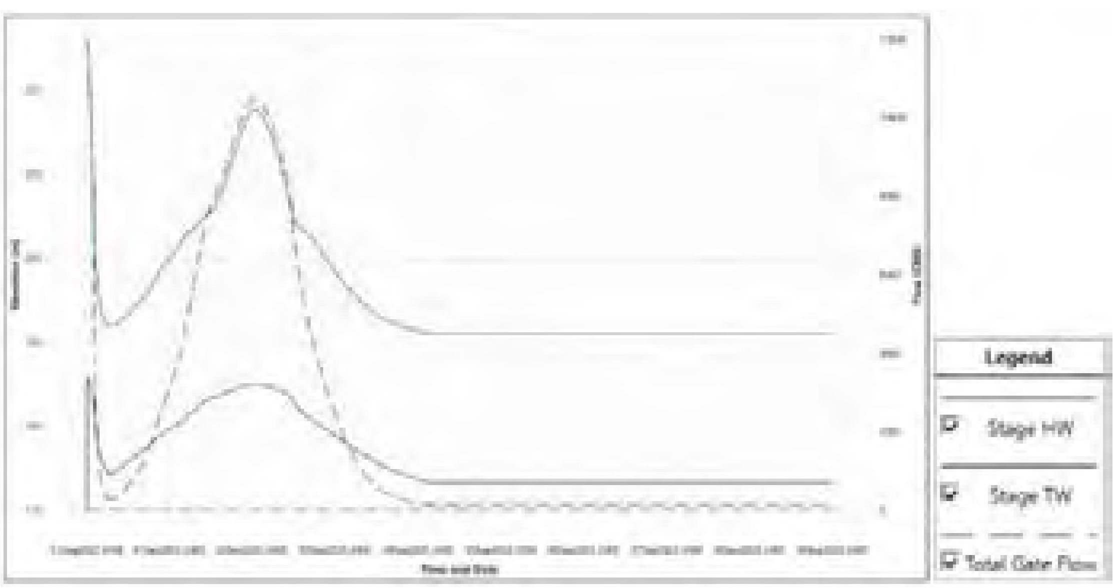
Table 32: Breach Parameters Selection

Breach Parameters	Value	
Calculated Average Breach Width (m), B_{avg}	138.83	
Min. Breach Width (m)	105.732	
Max. Breach Width (m)	182.309	**Scenario**
Adopted Avg. Breach width (m)	122	PMF, SPF, 100 years
	113	Without Inflow
Breach formation time (t_f), hrs	0.3	All
Breach side slope	0	All
Breach bottom elevation	174	All
Breach height (m)	52	All
Triggered failure at	Water Surface Elevation 228.6	PMF, SPF, 100 years
	start time-00:00 hrs	Without Inflow

5.3. Analysis of Scenario #1: Routing of PMF (Gates open)

227. The water surface elevation is assumed at FRL and the PMF occurs with river having a flow equal to the average monsoonal flow. In this scenario, all gates were kept fully opened to pass the PMF. Figure 51. below illustrates the routed flow and stages.

Figure 51: Routed PMF Flow from the dam with all gates fully open



228. The results indicated that, with all the gates open, the dam will safely pass the PMF peak flow. The maximum stage on the headwater side reaches to 217.66 m when the PMF peak passes through the dam. Therefore, it is concluded that the dam is safe against the design PMF if all the gates function properly. It was also concluded that the dam break will occur only (i) when the gates are not operated to their full capacity, or (ii) when a flood much higher than the PMF occurs. Hence, it was also concluded that the worst scenario would be when all the gates are closed.

229. To evaluate the worst-case scenario of a dam break due to some unavoidable conditions like gates malfunctioning, structural defects, sabotage, etc., a dam break analysis was performed. This analysis assumed all gates closed during the event, the water surface elevation was assumed at FRL in the reservoir, and PMF, SPF, and 100-year flow impinge. Additionally, the analysis was also conducted without any flood conditions (fair weather failure) to account for structural failure.

5.4. Analysis of Scenario #2: Routing of PMF (Gates closed)

230. In this scenario, a forced failure of the dam is analysed when PMF impinges. It is assumed that all gates are kept fully closed during the event, and the critical depth of 0.6 meters above the dam crest triggers overtopping failure. A hydrograph near the confluence points of Kopili with different rivers downstream of the dam is obtained.

Table 33: Peak Flow value near different confluence point (PMF)

Location (nearby)	Chainage (km)	Peak Flow-Dam break (cumec)
Dam	0.00	60810.610
Kopili-Amreg	14.43	35177.50
Kopili-Diyung	27.08	10396.30
Kopili-jamuna	94.70	9048.10
Kopili-Kolong	139.18	5798.20
Kopili-Borpani	142.29	5428.70
Kopili-Umium	168.57	4748.40
Kopili-Digaru	222.26	1436.20
Kopili-Brahmaputra	226.00	1498.30

Map 44: Maximum depth (flood inundation) map (PMF)

Map 45: Maximum velocity (flood inundation) map (PMF)

Map 46: Minimum flood wave arrival time in the inundated area (PMF)

5.5. Analysis of Scenario #3: Routing of SPF (Gates closed)

231. In this scenario, a forced failure of the dam is analysed when the Standard Project Flood (SPF) impinges. The hydrograph's peak values resulting from the dam break event are also given in the Report   Flood is routed downstream up to the Kopili-Brahmaputra Confluence (KB confluence), and the peak flow obtained at that location is approximately 923.24 cumec, corresponding to the stage of 41.64 m (Figure 4.14 in Dam Break Analysis). The total time taken by flood wave to reach KB confluence after the dam break is about 201 hours 22 minutes.

5.6. Analysis of Scenario #4: Routing of 100-year flood (Gates closed)

232. This scenario also analysed a forced failure of the dam when 100-year return period Flood impinges. All other conditions are kept same as in PMF and SPF cases. 100-year return period Peak of 4962 cumecs reached 46th hours at the dam site. Flood is routed downstream up to the Kopili-Brahmaputra Confluence (KB confluence), and the peak flow obtained at that location is approximately 688.81 cumecs, corresponding to the stage of 40.82 m. The total time taken by flood wave to reach KB confluence after the Dam break is about 256 hours 42 minutes.

5.7. Analysis of Scenario #5: Fair weather case / No flood Scenario (Gates closed)

233. In this scenario, the analysis was conducted without any flood conditions (fair weather failure) to assess the downstream impact of the dam break. This is only possible if there is any structural failure takes place. It is again assumed that all gates are kept fully closed during the event. The initial level in the reservoir is assumed to be at FRL, i.e., 226 meters. And the failure is assumed to be triggered at set time of 0 hours. Also, a constant average monsoonal flow of 113.2 cumecs is impinged into the reservoir.

234. The dam break, in this case, is set to be at 0 hours, and the event took 0.3 hours (18 minutes) for the breach width to form, resulting in a peak flow of 53735.15 cumecs. The total expected volume of water released during the breach is approximately 251.502 million cubic meters (Mm3). Flood is routed downstream up to the Kopili-Brahmaputra Confluence (KB confluence), and the peak flow obtained at that location is approximately 464.18 cumecs, corresponding to the stage of 40 m. The total time taken by flood wave to reach KB confluence after the Dam break is about 74 hours 16 minutes.

Map 47: Maximum depth (flood inundation) map (Fair Weather Case)

6. Emergency Action Plan

235. Emergency action plan is required by the dam owners for the emergency preparedness and response capabilities to face any situation caused either by dam failures or by extremely large releases of dam water during severe weather conditions. Enormous amounts of water flow out of a dam when it fails catastrophically, or when excess water is released through the spillways to protect the dam from failure during extreme weather conditions. This phenomenon adversely affects people, infrastructure, and the environment downstream of the dam. Concerted efforts are required from various organizations to protect lives and property, and to reduce damage to the environment. Emergency Action Plans help in streamlining the efforts and bring about better coordination among different agencies to execute rescue and relief activities[60].

236. Kopili is often noted as 'mighty' for its volume of water flow and intensity during peak monsoons causing flash floods, landslides, widespread displacement of people, and laying waste to property. These scenes exemplify the situation of disaster risk in the Hojai, Dima Hasao, Karbi Anglong, Morigaon and Nagaon districts through which the river traverses, where road network connectivity, critical services sustenance (food, shelter) and resources are beyond compromised. Additionally, the planning and construction of the Lower Kopili Hydro-electric Project (LKHEP) is also under headway. These events and processes necessitate careful management of the basin and risks to the community living in the area. These conditions require targeted interventions from multiple stakeholders using a multi-pronged approach comprising flood risk identification, forecasting and disaster risk reduction in the project area. Thus, prior planning is a pre-requisite for foreseeing any development in the Kopili river basin.

237. There is a requirement to develop resource management system and community-based disaster risk reduction in the project area with a focus on the Kopili river and its flooding scenarios in Assam. This can be achieved through flood modelling and mapping of the project area with its resources, infrastructure, and land-use and cover, supported by the establishment of Early Warning System (EWS) catering to improve preparedness and flood response in the region. Flood forecasting system will also be operative for the Kopili River basin from June 2024. The real-time data on dashboards will be shared to relevant state agencies (ASDMA, WRD, FREMAA, APGCL) and the five district authorities so that can make informed decisions on the likely impacts on communities and physical infrastructure and take necessary measures to mitigate the impacts. This is being done under Resource Management Systems in the Kopili River Catchment Area with the support from JFPR grant.

238. Under the same grant Community Resilience and Disaster Preparedness, five vulnerable villages were identified, one in each district and undertake a needs assessment. Following the assessment design and implement a participatory village resilience disaster risk reduction plan to increase resilience and disaster preparedness. Implement the village disaster risk reduction plan in consultation with village communities.

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[60] Guidelines for Developing Emergency Action Plans for Dams; Doc. No. CDSO_GUD_DS_01_v2.0 February 2016; Central Water Commission.

6.1. EAP for the project

239. Emergency Action Plan for the LKHEP was prepared by International Centre of Excellence for Dam, IIT, Roorkee[61]. Effort has been taken to estimate the severity of flooding and inundation areas likely to be affected by Lower Kopili Dam in an emergency condition. Every effort has been made to foresee varied emergency possibilities and develop appropriate notification procedures for timely rescue and relief operations. However, implementation of the emergency Action Plan (EAP) involves many agencies, who are required to work in a coordinated manner to reduce the consequences triggered by the dam site condition. Effectiveness of the rescue and relief operations depend on many factors including the adequacy and accuracy of the estimation of the severity of flooding, coordinated efforts of all the agencies involved in rescue and relief efforts and available of facilities like power, telephones, road communications, etc.

240. The EAPs are required to outline “who does what, where, when and how” in an emergency situation or unusual occurrence affecting the dam. Emergency action plans proposed by the Dam Safety Act, 2021 will be put into effect as and when conditions arise that are likely to be hazardous to a dam or potentially hazardous to public safety, infrastructure, other property, or the environment.

6.1.1. Outline of the EAP Five-Step Response Process

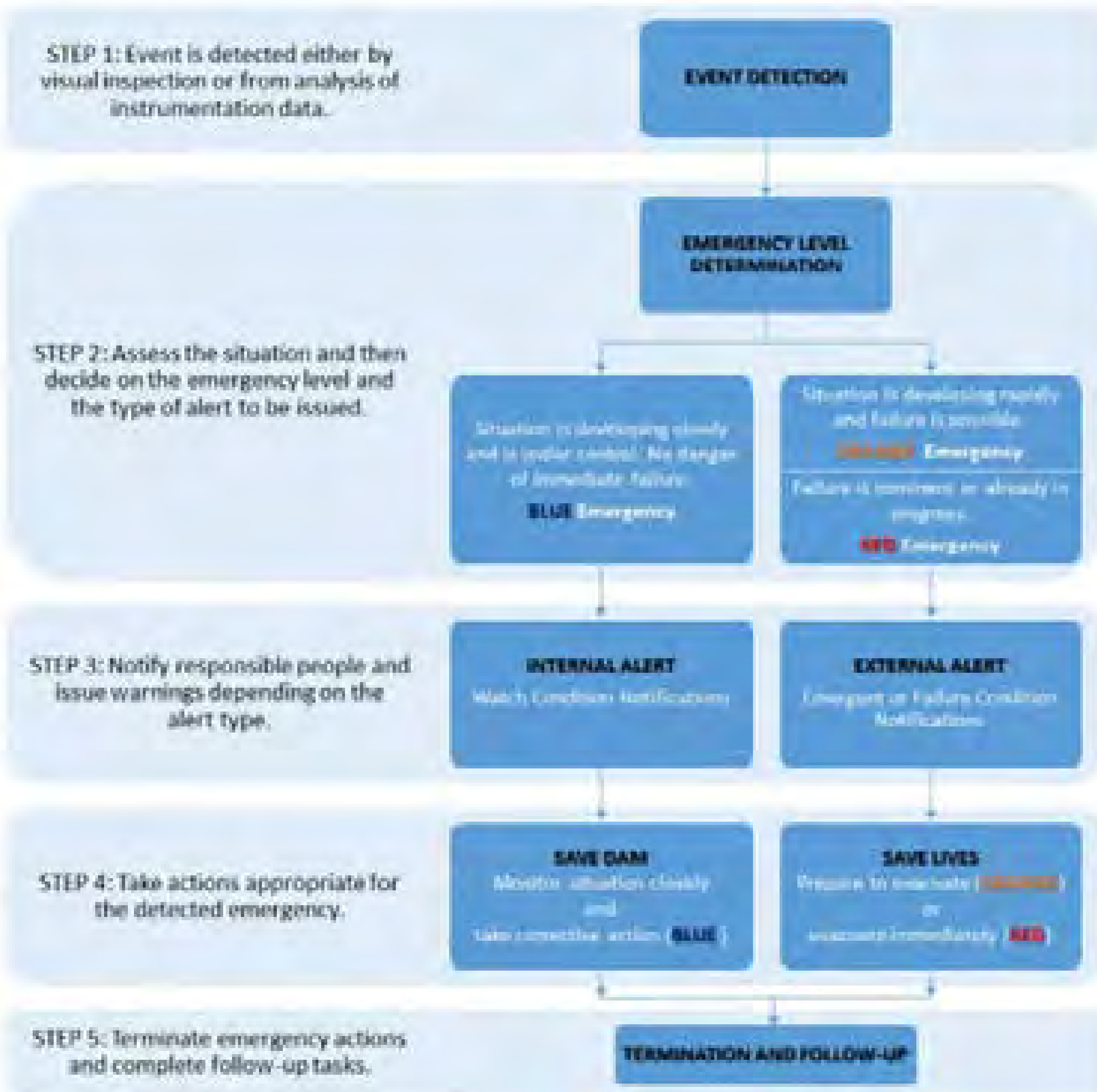
241. Five steps should generally be followed when an unusual or emergency incident is detected at a dam. These steps (Figure 54) constitute the EAP response process as outlined below[62]:

Step 1. Event Detection
Step 2. Emergency Level Determination
Step 3. Notification and Communication
Step 4. Actions to be Taken
Step 5. Termination and Follow-up

242. The five steps to take during an unusual event or emergency are illustrated in the flowchart shown in Figure 53. Responses for each alert type (Internal Alert for BLUE level emergency, or External Alert for ORANGE or RED level emergencies) contain all five steps. Depending on the type of alert to be issued, these steps will contain different notification lists and procedures. Careful preparation and review of all five steps will provide guidance during an unusual event or emergency. The five-step EAP response process and the three emergency alert levels are described below.

[61] EAP will be disclosed at the APGCL’s website.
[62] Guidelines for Developing Emergency Action Plans for Dams; Doc. No. CDSO_GUD_DS_01_v2.0 February 2016; Central Water Commission.

Figure 52: Flowchart showing the five-step response process of an EAP for a dam[63].



243. EAP covered the following elements general description of dam, responsibilities, notification flowcharts, inundation maps, possible emergency conditions, preventive actions to be taken. supplies and resources and implementation procedures.

[63] Guidelines for Developing Emergency Action Plans for Dams; Doc. No. CDSO_GUD_DS_01_v2.0 February 2016; Central Water Commission.

6.1.2. Objective of Emergency Action Plan

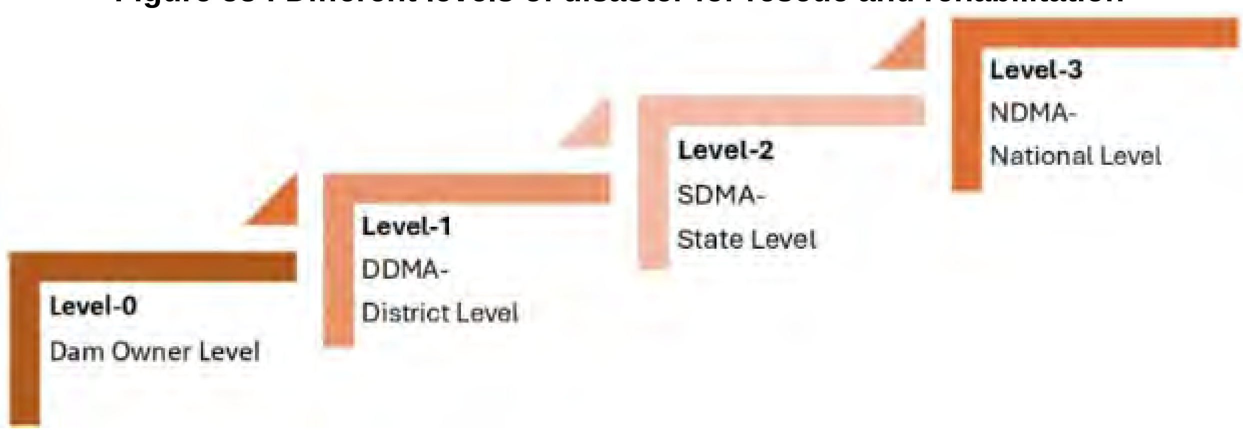
244. The main objective of EAP is to ensure Dam Safety at all times and in all weather conditions, with 360^0 triangulation using a series of mixed method investigation, involving 24x7 for all 365 days. The main objective may be detailed as key objectives as under.

245. The key objectives of Emergency Action Plan are:

- To assess the preparedness of dam safety personnel to face the dam break scenario;
- To adhere to the Dam Safety practices, Dam related Technical Guidelines, Standard Operation Procedures (SOPs) for all processes and sub-processes
- To check, verify, the functional health of all the monitoring and communication equipment at all time.
    - o Further, it is pertinent to check that all equipment for their repair/ replacement status;
    - o they are covered under Warranty and/or AMC status.
    - o Back-up equipment maybe planned/procure so that all dam safety is not hindered
- To delineate the authority to different officers and staff for pro-active action;
- To ensure that the dam safety personnel are trained repeatedly and meticulously record (evidence) such trainings
- To carry-out routine inspections and remedial actions

246. EAP emphasises on institutional and coordination mechanism among different agencies for effective disaster management in the event of dam failure. EAP is a dynamic document, which need to regularly updated, to serve as a tool for activating and/or escalating the DISASTER case to District (L1), State (L2) and National (L3) requesting for help for rescue and rehabilitation.

Figure 53 : Different levels of disaster for rescue and rehabilitation



247. The main purpose of this Emergency Action Plan (EAP) is to identify the emergency situations that could threaten LKHEP Dam and to plan for an expedite, effective response to prevent failure of the dam and warn downstream residents of impending danger. This

plan defines the notification procedures to be followed in the event of a potentially hazardous situation. The procedures are intended to protect lives and prevent property damage from an excessive release of water from the dam spillways or an uncontrolled outflow of water from the breached portion of the dam.

248. The three dam safety emergency levels (BLUE, ORANGE, or RED) described below are recommended. However, dam owners, in coordination with disaster management authorities, should determine the number of emergency levels required for each dam on a case-by-case basis.

249. BLUE Emergency Level A BLUE emergency level is created by an unusual, slowly developing event that poses no threat to the structural stability of the dam or to its operational elements, and which does not make unviable the dam observation system. The condition will not have an off-site impact. However, the situation is one that needs to be monitored closely to make sure the condition does not worsen. If the condition does become more severe or unfavorable, the emergency status will be elevated to the next level [18] (Figure 54).

250. A RED emergency level is triggered when dam failure is about to occur or is lready in progress. Once a decision is made that there is no possibility of preventing failure, an order for evacuation of residents in potential inundation areas will be issued immediately by the incident commander or emergency responder[18] (Figure 55).

251. An ORANGE emergency level occurs when a rapidly developing situation is taking place that will probably cause the dam to fail and produce a devastating flood. However, enough time is available for analysis before deciding whether or not to evacuate residents. Emergency responders in affected areas will be alerted that an unsafe situation is developing and dam failure is possible. Authorities responsible for rescue and relief shall gear up for evacuation of residents in potential inundation areas. When it is determined that there is no longer time available to implement corrective measures to prevent dam failure, the emergency status will be elevated to the highest (Red) level[18] (Figure 56).

Figure 54 : Flow Chart for the Blue alert

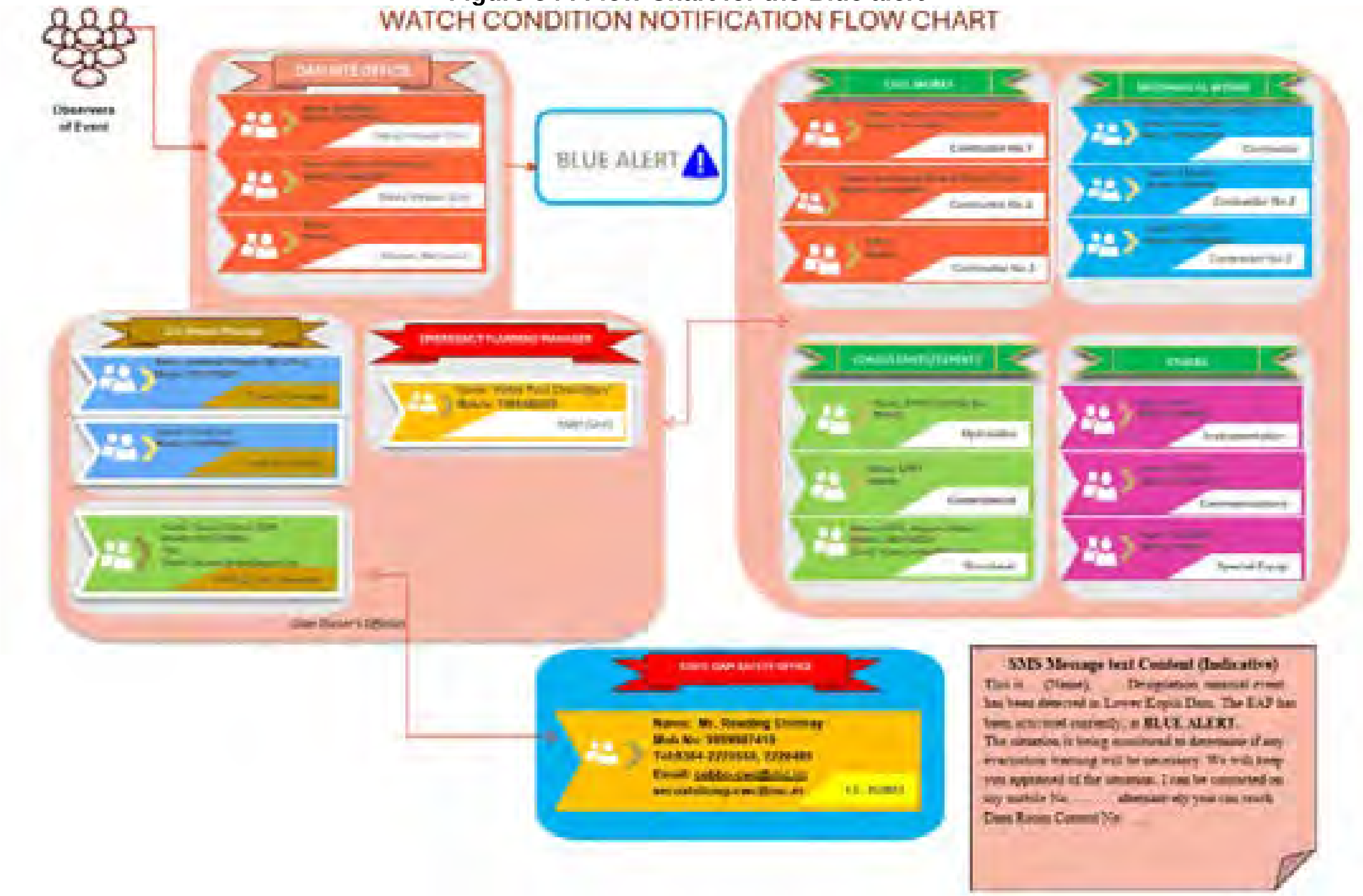


Figure 55 : Flow Chart for the Red alert

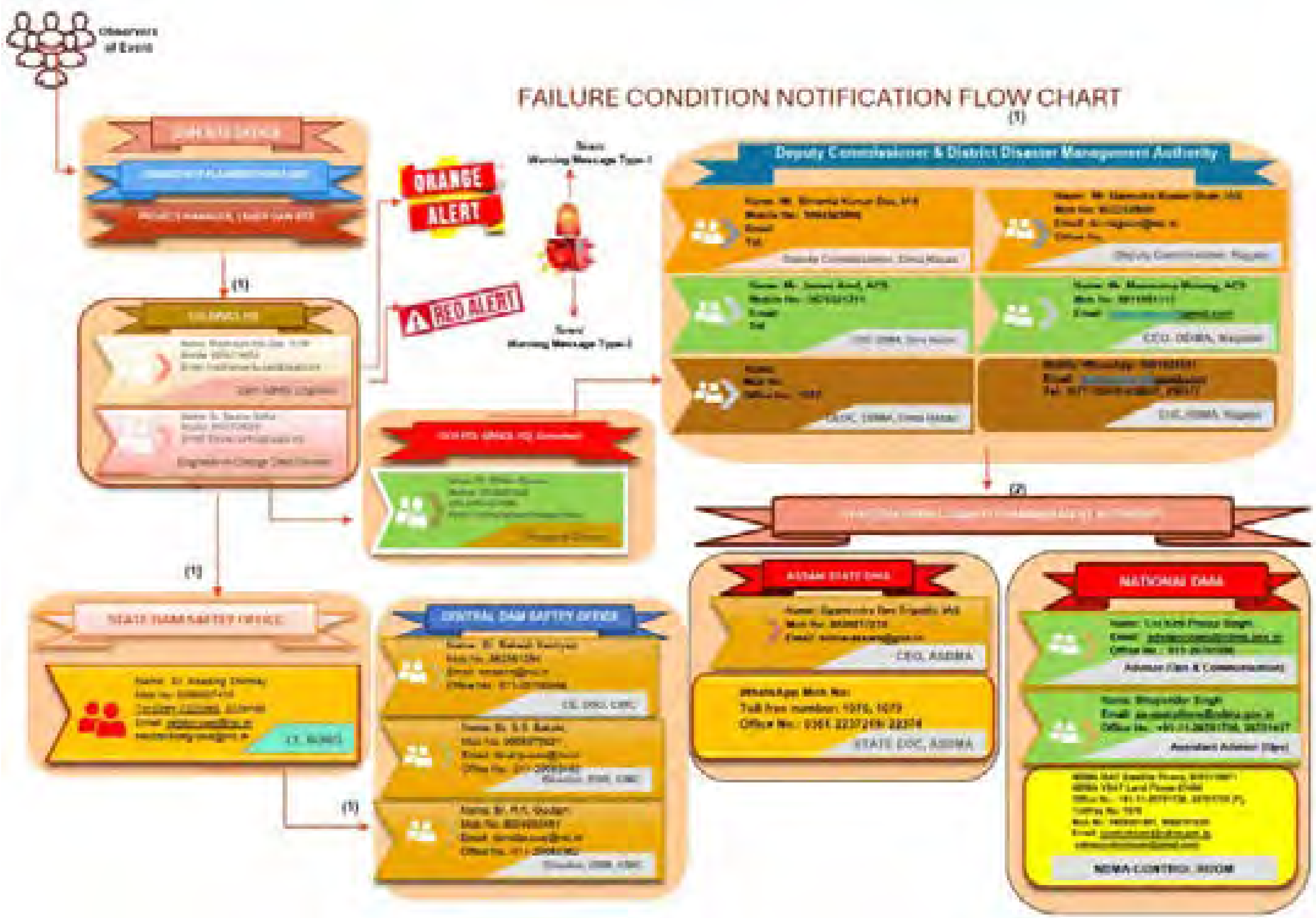
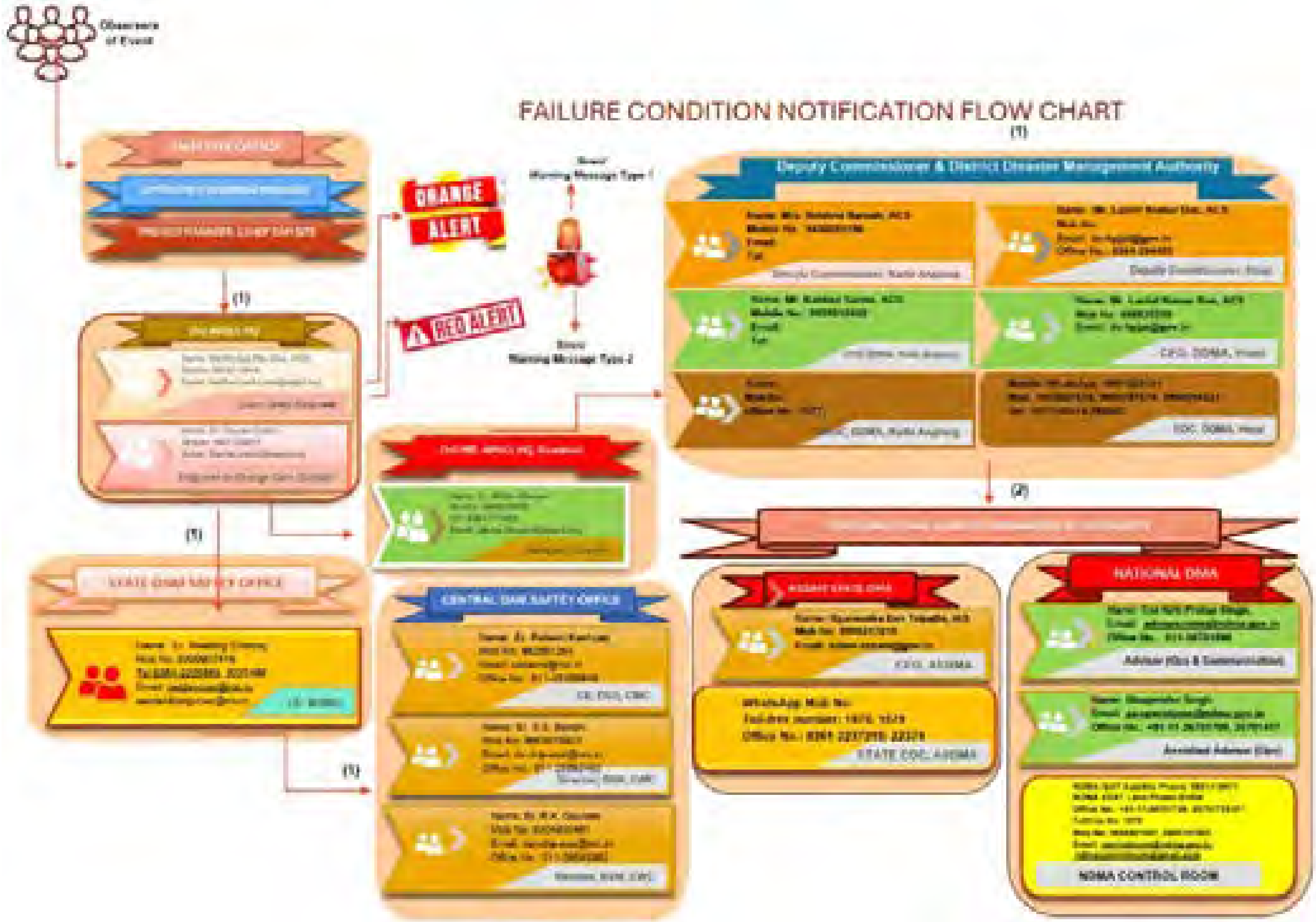


Figure 56 : Flow Chart for the Orange alert



6.1.3. Dam Owner's Responsibilities

252. The dam owner, APGCL is responsible for all dam operation and maintenance. The EAP is not intended to designate a specific person for a specific responsibility but instead designate the person's duties or job description for both, before and during Emergency event. The entire EAP mechanism is to ensure preparedness and avert possible eventualities. As wetlands act as a natural sponge, absorbing and storing excess rainfall and reducing flooding. Wetland Management Plan for creating a cushion for flood water is also being prepared by APGCL through RMSI. The GM (Dam Site) as Project Manager represents Dam Owner. S/he is the authorized representative for all practical solutions at the field level.

6.1.3.1. Responsibilities of Project Manager, LKHEP Dam Site:

253. The Project Manager, in co-ordination with line Managers is the first-line of dam observers, and are the persons responsible for initiating and implementation of EAP. The brief responsibilities are as listed below:

1) Implementation of EAP.
2) To conduct routine inspection of dams.
3) To classifies the events into the emergency alerts.
4) To ensure that the current approved version of the EAP is functional and available to all stakeholders.
5) To ensure effective transmission of hydro-mechanical and flow data.
6) To periodically carryout pre-monsoon and post-monsoon inspection as per the standard maintenance manual of dams.
7) To periodically check the electromechanical operations of gate's hoists, clean the downstream water way, so as to dissipate the water smoothly in case of large flood water discharge from reservoir during heavy floods.

6.1.3.2. Responsibilities of Assistant General Manager (Civil), LKHEP Dam

254. AGM (Civil) is the executive head at the LKHEP Dam site. In co-ordination with Managers (Civil) are in the second line of dam observers responsible for Emergency planning. The responsibilities of the above said officers is as described below.

1) AGM (Civil) is responsible for collecting weather forecasts and the inflow forecasts and alerting of any potential emergency situation.
2) S/He is responsible for conducting routine dam maintenance, such as annual weed control, conducting dam integrity inspections, and notifying Assam Water Resources Department (MWRD) through his Authorities of any potential emergency situations.
3) S/He is responsible for contacting emergency personnel should a dam failure be imminent.
4) S/He is responsible for informing State Disaster Management Authorities (SDMA) and District Disaster Management Authorities (DDMA) and notify in case of failure or should a dam failure be imminent.

6.1.3.3. **Responsibilities of Deputy Manager (Civil), LKHEP at Dam Site**

255. Following are the responsibilities of Dy. Manager

1) To ensure that the EAP is updated by Dy. Manager (Civil) LKHEP Dam periodically.
2) To review annually to ensure that the contact details are current details as described in the notification flow chart.
3) Directing and initiating appropriate action during emergency, such as opening or closing water outlets and remedial construction activities such as earth moving etc.
4) To keep in contact with all the members of the notification flow chart and update them regarding the situation of the dam.
5) To invite experts (Structural, chemical, Electromechanical, Geological etc) to the dam who can anticipate the flow data, seepage data etc into useful suggestions which are necessary for maintaining the health status of dam.
6) Contact the Deputy Commissioners and Superintendent of Police downstream districts to inform regarding the Emergency condition.

6.1.3.4. Responsibilities for Notification

256. Notification responsibilities:

1) The Project Manager (Damsite) is responsible for inspecting the dam in a potential emergency such as the potential threat of high waters or a tropical cyclone.
2) S/He shall contact Deputy Commissioner’s and Superintendent of Police of downstream districts to inform regarding the Emergency condition.
3) If warranted, if the emergency level escalates Project Manager (Damsite) shall notify the Circle, District and State Disaster Management Authorities for the Authorities to activate incident command centres as per Disaster Management protocol.

6.1.4. Emergency Operations Centre

257. In the event of a failure condition, the AGM (Civil) shall activate the Dam site Emergency Operations Center (EOC) to serve as the main coordination center for warning and evacuation activities. Designated Dam Safety Officer shall be responsible to establish and manage the coordination activities involving rescue, evacuation and relief until the Circle or Block EOC or district EOC is activated.

6.1.5. Responsibilities for Evacuation

258. Evacuation and relief actions are exclusive responsibilities of District Authorities and District Disaster Management Authority (DDMA). If the emergency escalates beyond control and/or involves 2-3 districts, State Disaster Rescue Forces (SDRF) or National Disaster Rescue Forces (NDRF) are called for evacuation.

259. In the event of Lower Kopili HEP dam failure, there are several villages involving six downstream districts of Assam maybe affected. A detailed list of gradations of Risks – BLUE, ORANGE, RED are prepared (Table 34, Annexure 1). Therefore, in event of dam failure / Emergency situation due to heavy rainfall in the catchment /any other reason which may cause increase in the water level, the DDMAs of these districts are notified for evacuation and relief actions under their jurisdiction, along with possible inter-district coordination to ensure that no life lost and/or property damaged.

Table 34: Emergency Level Determination
(Action Data Sheet Index)

Event/ General Observation	Specific Observation/Condition	Emergency Level	Action Data Sheet
Unexpected Failure	Dam unexpectedly and without warning begins to fail	RED	SHEET A
Spillway Release; Increasing Reservoir Water Surface Elevation	High intensity rainfall in the catchment area of reservoir. Reservoir level rising and rain continuing (inflow range more than 1500 Cumec and Dam Level from 90.5 to 95.2 m)	BLUE	SHEET B1
	Either Large inflow to reservoir more than 1300 Cumec or Outflow from Dam above 2900 Cumec and Dam level is continuing to rise	ORANGE	SHEET B2
	Large inflow to reservoir approach toward design flood discharge i.e (9000 Cumec); Water level has crossed FRL or Inflow or/and Spilling ≥ 4450 cumec	RED	SHEET B3
Concrete/ Masonry structure	Minor cracks (bigger than ¼ cm.) in the masonry/concrete structure, without leakage.	BLUE	SHEET C1
	Enlarging cracks (bigger than ¾ cm.) and active movement in the masonry/concrete structure, with leakage passing through.	ORANGE	SHEET C2
	Enlarging cracks with sudden or rapidly proceeding movements/displacements in the masonry/concrete structure with severe leakage passing through.	RED	SHEET C3
Instrumentation	Instrumentation readings are beyond threshold values.	BLUE	SHEET D1
Malfunction of Radial/Sluice Gate(s)	Structural member of a gate, either broken or severely damaged, which prevent operation of the gate(s). No leakage or uncontrolled discharge is detected. Flood can be routed without damaged/non-operational gate(s).	BLUE	SHEET E1
	Structural member of a gate, either broken or severely damaged, which prevents operation or malfunction of the gate(s). Considerable leakage or uncontrolled discharge is detected. Flood cannot be routed without damaged/non- operational gate(s).	ORANGE	SHEET E2
	Structural member of a gate, either broken or severely damaged, which prevents operation or malfunction of the gate(s). Unexpected high discharge is occurring. Flood cannot be routed without damaged/non-operational gate(s).	RED	SHEET E3
Earthquake	Measurable earthquake felt or reported and dam appears to be stable.	BLUE	SHEET F1

<table>
<tr><th>Event/ General Observation</th><th>Specific Observation/Condition</th><th>Emergency Level</th><th>Action Data Sheet</th></tr>
<tr><td rowspan="2"></td><td>Earthquake resulting in visible damage to the dam or appurtenances which can cause a potentially dangerous situation</td><td>ORANGE</td><td>SHEET F2</td></tr>
<tr><td>Earthquake resulting in uncontrolled release of water over dam or rapidly developing flow through cracks or rapidly developing erosion through increased seepage</td><td>RED</td><td>SHEET F3</td></tr>
<tr><td rowspan="3">Security Threat/ Sabotage/ Vandalism</td><td>Unverified bomb threat or verified damage to the dam/appurtenances with no impacts in the functioning of the dam</td><td>BLUE</td><td>SHEET G1</td></tr>
<tr><td>Verified bomb threat that if carried out, could result in damage of the dam/appurtenances that impacts the functioning of the dam OR verified damages due to vandalism that impacts the normal operation of the dam.</td><td>ORANGE</td><td>SHEET G2</td></tr>
<tr><td>Detonated bomb resulting in visible damage to the dam or appurtenances OR verified damages due to vandalism causing an uncontrolled water release</td><td>RED</td><td>SHEET G3</td></tr>
<tr><td rowspan="2">Overtopping</td><td>Water flowing over the dam and reservoir continuing to rise. No significant erosion of downstream embankment.</td><td>ORANGE</td><td>SHEET H1</td></tr>
<tr><td>Water flowing over the dam, the reservoir continuing to rise and significant erosion of downstream embankment with development of head cuts encroaching on the dam crest or significant movement of concrete portion of Dam</td><td>RED</td><td>SHEET H2</td></tr>
<tr><td rowspan="3">Piping Failure</td><td>Seepage through the dam body. New or minor seepage at toe on slope of embankment abutments or galleries, water flowing clean.</td><td>BLUE</td><td>SHEET I1</td></tr>
<tr><td>New serious of rapidly increasing seepage flow rate at toe, on slope of embankment abutments or galleries, water flowing cloudy.</td><td>ORANGE</td><td>SHEET I2</td></tr>
<tr><td>Seepage through the dam body. New or minor seepage at toe on slope of embankment abutments or galleries, water flowing failure of the dam in imminent.</td><td>RED</td><td>SHEET I3</td></tr>
</table>

260. Evacuation is an activity of preparedness stage of any Disaster Management. Evacuation exercise involves relocation of people, domestic animals, moveable properties to identified safer places in quickest possible time. It is a systematically exercise with meticulous planned stages. Entire District Administration is involved in this, with District Collector/Magistrate heading the team. In any disaster-prone district, depending on the type of disaster safer places are identified or constructed at higher elevation ground which will be used at the time of emergencies. Economically, available schools are used for evacuation purposes, however, not all schools are suitable to be used for rehabilitation during evacuation. Therefore, it is pertinent to identify suitable schools and more importantly the infrastructure facilities need to be pre-listed with its accommodating capacity.

261. As dam break is a sectoral disaster of Water Resources Secor, DDMAs of the affected districts are responsible for installations and rehabilitation of the affected public and livestock. The brief duties are as described below.

a) The district administrations of these districts mobilise line departments for arranging rehabilitation centers with basic facilities such as clean drinking water, food, medicines, blankets etc. for the distressed and evacuated people along with a safe shelter.
b) The DDMAs are responsible for keeping into account the number of people evacuated (head count of women, children, aged men and women and men).
c) The district administration is responsible for establishing cow shelters for cattle and livestock with sufficient fodder and water.
d) The district administration shall inform the respective district health officers, Animal husbandry officers to further deploy necessary staff to take care of people and livestock at the rehabilitation centre.

6.1.6. Responsibilities for Duration, Security, Termination, and Follow-up

262. The Project Manager or AGM (Civil) is responsible for monitoring of emergency situations at the dam and keeping authorities informed, based on the Notification Flowcharts.

263. The Project Manager or AGM (Civil) communicate the watch condition and emergency District Commissioners or Deputy Commissions or CEOs of downstream districts. The Chairman, DDMA or CEO, DDMA are responsible for declaring that an emergency at the dam is terminated. Applicable authorities will be notified based on the Notification Flowcharts.

264. AGM (Civil) will ensure that a follow-up evaluation of Dam site is completed by all participants after the emergency. All further actions of the responsible departments shall be coordinated by the DDMA. The results of the evaluation should be documented in a written format/report and filed with the EAP.

265. The EOCs of DDMA of downstream Districts shall further coordinate and responsible for initiating evacuations in turn they will contact Circle Officers of respective districts for addressing the emergency situation in their jurisdiction as per the Disaster Management protocol.

6.1.7. Communications

266. Local officials and downstream residents will be notified by landline telephone, if available; otherwise, they will be notified via cell phones or emergency personnel (in person or using their radios). The various networks for emergency use include the networks of the downstream districts. Sample public announcements shown below (Figure 57).

Figure 57: Sample Public Announcements

Note: These messages are communicated to downstream residents to alert the public of impending danger. APGCL should coordinate with the Indian Meteorological Department and District Disaster Management Authorities of Downstream districts of Assam, prior to release. Messages can be communicated via radio, television, bulk SMSs of local mobile networks and other media outlets.

Announcement for slowly Developing "WATCH" Condition (BLUE Emergency Level)

*APGLCL has declared a **BLUE** Level **"WATCH"** Condition for **Lower Kopili Dam, Project Identification Code: ASXXCC0001** as of .... (time) on ....(date). [Briefly describe the problem or condition]. Although there is no immediate danger of the dam failing.*

Announcement for Worsening "WATCH" Condition (BLUE Emergency Level)

*APGCL has declared a **BLUE** Level **Worsening "WATCH"** Condition for **Lower Kopili Dam, Project Identification Code: ASXXCC0001** as of .... (time) on ....(date). [Briefly describe the problem or condition]. Although there is no immediate danger of the dam failing a possibility now exists that the dam will fail if correction efforts are unsuccessful. Describe what actions are being taken to monitor and correct the situation.] [State the quantity of any releases from the reservoir]. Additional news will be made available as soon as it is received.*

Announcement for a Probable "FAILURE" Condition (ORANGE Emergency Level)

Urgent! This is an emergency message.

*APGCL has declared a ORANGE Level Probable **"FAILURE"** Condition for **Lower Kopili Dam, Project Identification Code: ASXXCC0001** as of .... (time) on ....(date). [Describe what actions are being taken to monitor and control the situation.] It is possible that the dam will fail in [##] hours. Residents in low lying areas along the Kopili River should prepare for immediate evacuation. Additional news will be made available as soon as it is received.*

Announcement of an Impeding "FAILURE" Condition (RED Emergency Level)

Emergency! This is an emergency message.

Lower Kopili Dam, Project Identification Code: *ASXXCC0001* is going to fail at any moment. Residents in the downstream should immediately evacuate the along the low-lying areas of Kopili River. The flood waters have already reached ...., ... Additional news will be made available as soon as it is received.

Announcement of an Ongoing "FAILURE" Condition (RED Emergency Level)

Emergency! This is an emergency message.

Lower Kopili Dam, Project Identification Code: *ASXXCC0001*. failed at ....(time) on ....(date). Residents who have not yet vacated should immediately evacuate the Village/ city .... along the Kopili River. The flood waters have already reached ...... Additional news will be made available as soon as it is received.

293. Verification or authentication of the situation can be made by contacting the Head of Power Station, DGM (Technical) and DDMA of downstream districts.

- Television, Radio, and bulk SMS facilities of the local Mobile Network Operators can be used as much as possible to notify area residents of the potential dangers.
- Public announcements are to be issued by the concerned DDMA Officials

6.1.8. Bottle necks & Suggested Solutions

267. Suggested solutions:

- Regular mobile and landline communications maybe disrupted during emergencies
- A satellite phone maybe required for emergency communication
- To establish last-line communication and also to create an alternative communication channel. Some suggestions are:
  - o Community radio involving youths maybe promoted in the downstream villages in these six districts, which will be handy to address the disasters
  - o A new technology involving a closed communication network (similar to LAN) is in the developing stage, which connects emergency offices in the range of 10 Km radius may be explored.
  - o Siren will be installed in the dam vicinity, power house vicinity and in Panimur.
  - o These youths shall effectively volunteer as Quick Response Team (QRT) during emergencies

6.1.9. Emergency Detection, Evacuation, and Classification

6.1.9.1. Emergency Detection

6.1.9.1.A.. Situations

268. The situations vary and dam conditions can lead to emergency situations, not all of which will necessitate the implementation of the EAP. However, if any of them occur, the appropriate actions must be taken. Sometimes, a group and/or sequence of the following situations occur, which need to be examined and considered seriously for resulting in any abnormal conditions.

- Severe Storms/ Inclement weather: These are unpredictable climatic events that vary depending on the atmospheric conditions. Although generally not a threat to the dam, severe storms and other inclement weather conditions can contribute to an existing problem and hinder any remediation efforts. Severe storms also cause the uncontrolled release of floodwater, and increase flow in already rain-swollen areas. A team of experts need to be formed to analyse the situation to plan and initiate actions.

- Tropical Cyclone: Tropical cyclones do occur in the area, with the potential for structural damage to the dam, possibly resulting in its failure. If a tropical cyclone has struck the area, an inspection of the dam for any signs of damage will be appropriate.

- Earthquake: Lower Kopili HEP Dam is located in the seismic Zone-V, which is highly prone to earthquakes. The structure and model of the Dam are suggested after thorough examination by (Dept. of Earthquake Engineering, University of Roorkee, 1997). Therefore, frequent dam inspections may be required to assess any damage to dam structures. Further, earthquakes with epicenter in neighboring countries like Nepal, Bangladesh, Bhutan should be taken seriously, and appropriate post-earthquake inspections should be performed.

- Sabotage: LKHEP Dam is located near international borders, accessible to destructive elements. A watchful eye is required for dam protection. The appropriate protocol needs to be systematically followed to allow anyone into the dam site. Systematic precautions must be taken to protect the dam from any possible sabotage resulting in dam break.

6.1.9.1.B. Signs of Failure

269. Construction-wise and design-wise, LKHEP Dam is a robust structure with no or least signs of failure. SOPs are in place and must be continuously followed to avert any unpredicted situations.

270. The DGM (Technical), as Engineer-In-Charge is responsible for conducting routine inspections and identifying conditions that could indicate the onset of problems leading to a dam failure. The early identification of potentially dangerous conditions can allow time for the implementation of EAPs. It is essential to understand how distress can develop into failure. With appropriate action, distress need not lead to a catastrophic failure of the dam. The following sections describe some of the different types of failure that could lead to dam failure.

- Seepage Failure: Although all earthen embankments allow some minor seepage through the dam or the foundation, excessive, uncontrolled seepage can result in piping (the movement of embankment material in the seepage flow) and lead to failure. Piping can occur for years at a slow rate. If the piping has progressed to a dangerous level, it will be evident by increased flow or the discharge of muddy water (or both). At that stage, immediate action is needed to stop the piping. Fully developed piping is difficult to control and will likely result in failure. A whirlpool in the reservoir is a sign of uncontrollable piping and necessitates immediate emergency action.

- Embankment or Foundation Sliding: Sliding is usually first apparent when cracks or bulges in the embankment appear. Slides with progressive movement can cause embankment failure.

- Structural Failure: The structural failure or collapse of any non-overflow portion of the dam, spillway or spillway gates could result in loss of the reservoir. A structural failure of a portion of the spillway could cause piping and possibly embankment failure.

- Overtopping Failure: Overtopping of the embankment results in erosion of the dam crest. Once erosion begins, it isn't easy to stop. A 24x7 watch and alert system should be followed by the Dam control room to monitor the water level. All records should be meticulously maintained and updated on a day-to-day basis.

6.1.9.2. Emergency Evaluation and Classification

271. This section lists the conditions and actions that may be used to classify the level of emergency response and as a guide for the DGM/ Engineer-In-Charge. Specific dam observations and corresponding emergency classification levels prepared as Evidence of Distress (Table 35).

Table 35: Evidence of Distress

General Observation	Specific Observation	Emergency Condition Level	Emergency Action	Equipment, Material & Supplies	Data to Record
Boils	Small boils, no increase of water flow, flowing clear water.	BLUE	• Closely check all of downstream toe, especially in the vicinity of boil for additional boils, wet spots, sinkholes, or seepage. • Closely monitor entire area for changes or flow rate increases.	None	Site and location, approximate flow
	Large or additional boils, near previously identified ones, without increasing flow rate, but carrying small amount of soil particles.	BLUE	• Initiate 24-hour surveillance. • Monitor as described above. • Construct sandbag ring dykes around boils, to cover them with water to retard the movement of soil particles. • Filter cloth maybe used to retard soil movement, but do not retard the flow of water.	Sandbags, filter cloth	Site and location, approximate flow
	Large or additional boils, near previously identified ones, increasing flow rate, carrying soil particles,	ORANGE	• Continue 24-hour surveillance. • Continue monitoring and remedial action as described above. • Initiate emergency lowering of reservoir. Issue a warning to downstream residents.	Sandbags, pump	Site and location, approximate flow
	Rapidly increasing size of boils and flow increasing and muddy water,	RED	• Downstream evacuation. • Employ all available equipment to attempt to construct a large ring dyke around the boil area.	Dozer, shovels, source of earth fill	Site and location, approximate flow

General Observation	Specific Observation	Emergency Condition Level	Emergency Action	Equipment, Material & Supplies	Data to Record
Seepage	Minor seepage of clear water clear water at toe, on slope of embankment, or at the abutments.	BLUE	• Closely check entire embankment for other seepage areas. • Use wooden stakes or flagging to delineate seepage area. • Try to channel and measure flow. • Look for upstream whirlpools.	Wooden stakes, flagging	Site and location, approximate flow
	Additional seepage observed flowing clear water and/or increasing flow rate.	BLUE	• Initiate 24-hour surveillance. • Monitor as described above. • Construct measuring weir and channel all seepage through weir. • Attempt to determine source of seepage	Dozer, shovels	Site and location, approximate flow
	Seriously or rapidly increasing seepage, under-seepage, drain flow.	ORANGE	• Continue 24-hour monitoring and remedial action as described above. • Initiate emergency lowering of the reservoir. • Construct a large ring like dyke around the seepage area.	Dozer, shovels, source of fill material	Site and location, approximate flow
	Additional seepage areas with rapid increase in flow and muddy water	RED	• Downstream evacuation. • Employ all available equipment to attempt to construct a large ring like dyke around the seepage area.	• Dozer, • Shovels, • Source of fill material	Site and location, approximate flow

General Observation	Specific Observation	Emergency Condition Level	Emergency Action	Equipment, Material & Supplies	Data to Record
Slides or Severe Erosion	• Skin slide or slough on slope of embankment. • No further movement of side and embankment crest not degraded	BLUE	• Examine rest of embankment for other slides. • Place stakes in slide material and adjacent to it for determining it further movement is taking place	• Stakes, • Tape measure	Distance between stakes
	Slide or erosion involving large mass of material, crest of embankment is degraded, no movement or very slow continuing movement	BLUE	• Initiate 24-hour surveillance. • Mobilize all available resources and equipment for repair operations to increase freeboard and to protect the exposed embankment material. • Start filling sandbags and stockpile near slide area.	• Dozer, • Shovels, • Sources of fill material, • Sandbags	Distance between stakes
	Slide or erosion involving large mass of material, crest of embankment is degraded, progressively increasing in size	ORANGE	• Continue monitoring and remedial actions as described above. • Place additional material at the toe of the slope to stop the slide.	• Dozer, • Shovels, • Sources of fill material • Pump	Distance between stakes
	Slide or erosion involving large mass of material, crest of embankment is severely degraded, movement of slide is continuing and may reach pool level	RED	• Downstream evacuation. • Utilize all available equipment and the personnel to sandbag the degraded slide area to prevent it from overtopping	• Dozer, • Shovels, • Sandbags • Pump	Distance between stakes

General Observation	Specific Observation	Emergency Condition Level	Emergency Action	Equipment, Material & Supplies	Data to Record
Sinkholes	Sinkholes anywhere on the embankment or within 150 meters downstream from the toe.	BLUE	• Carefully walk the entire embankment and downstream area looking for additional sinkholes, movement, or seepage.	• Stakes • Flagging	• Size, • Location
	Sinkholes with corresponding seepage anywhere on the embankment or downstream from the toe.	BLUE	• Initiate 24-hour surveillance. • Monitor as above • Construct sandbag dike around the seepage exit point to reduce the flow rate. • Start filling sandbags and stockpile near slide area.	• Dozer, • Shovels, • Pump	• Size, • Location
	Large sinkholes with corresponding seepage anywhere on the embankment or downstream from the toe.	ORANGE	• Continue monitoring and remedial action as described above. • Utilize sandbags to increase the freeboard on the dam if necessary.	• Sandbags • Dozer, • Pump	• Size, • Location
	Sinkholes rapidly getting worse, seepage flowing muddy water and increasing flow.	RED	• Downstream evacuation. • Utilize all available equipment and personnel to attempt to construct a large ring dike around the area	• Dozer, • Shovels, • Pump	• Size, • Location

General Observation	Specific Observation	Emergency Condition Level	Emergency Action	Equipment, Material & Supplies	Data to Record
Settlement	Obvious settlement of the crest of the embankment that is progressing, especially adjacent to concrete structures	BLUE	Look for bulges on slope or changes in crest alignment	None	• Size, • Location
	Settlement of crest of embankment that is progressing, especially adjacent to concrete structures or if any corresponding seepage is present.	BLUE	• Initiate 24-hour surveillance. • Mobilize all available resources for repair operations to increase freeboard. • Fill and stockpile sandbags. • Identify any boils near settlement points for flowing material and pursue action for boils.	• Sandbags • Shovels, • Dozer, • Sources of fill material	• Size, • Location
	Settlement of crest of embankment that is rapidly progressing, especially adjacent to concrete structures or if any corresponding seepage is flowing muddy water or increasing flow.	ORANGE	• Continue monitoring and remedial actions as described above. • Use sandbags to increase the freeboard on dam if necessary.	• Sandbags • Shovels, • Dozer, • Sources of fill material	• Size, • Location
	Progressing settlement that is expected to degrade embankment to reservoir level.	RED	• Downstream evacuation. • Utilize all available equipment and personnel to build up the crest in the area that is setting. • Identify any boils near settlement points for flowing material and pursue action for boils.	• Dozer, • Shovels, • Sources of fill material • Sandbags	• Size, • Location

Cracking	Cracks in the embankment crest or on slopes.	BLUE	Walk on entire crest and slope and check for additional cracking	• Stakes, • Tape measure	• Size, • Location
	Numerous cracks in crest that are enlarging, especially those perpendicular to the centerline of the dam.	BLUE	• Initiate 24-hour surveillance. • Carefully monitor and measure cracking to determine the speed and extent of the problem • Mobilize to fill cracks. • Cracks parallel to the centerline indicate a slide. • Follow remedial action	• Stakes, • Tape measure • Dozer, • Shovels, • Sources of fill material	• Size, • Location
	Large cracks in the crest that are rapidly enlarging, especially those perpendicular to the centerline of the dam.	ORANGE	• Continue monitoring and remedial action as above	• Dozer, • Shovels, • Sources of fill material	• Size, • Location
	Cracking that extends to pool elevation	RED	• Downstream evacuation • Continue remedial action as above	• Dozer, • Shovels, • Sources of fill material	• Size, • Location

Cracking or Movement of Concrete Structure	• Minor cracking and/or movement	BLUE	• Immediately install measuring device to monitor movement	• Burlap • Rocks • Dozer • Shovels	• Size, • Location
	• Significant cracking and/or movement	BLUE	• Initiate 24-hour surveillance. • Lower burlap on upstream face of crack to reduce flow of soil particles • Dump large rock on downstream of moving concrete structure monolith to resist the movement	• Dozer • Rocks • Burlap • Shovels	• Size, • Location • Flow rate
	Serious cracking and/or movement	ORANGE	• Prepare for evacuation. • Continue monitoring and remedial action as described above.	• Dozer, • Rocks • Burlap • Crack monitors	• Size, • Location • Flow rate
	Major cracking and/or movement	RED	• Downstream evacuation. • Dam failure is imminent. • Continue monitoring and remedial action as described above.	• Dozer, • Shovels • Rocks	• Size, • Location • Flow rate

Upstream Whirlpool	Whirlpool in the lake in the vicinity of the embankment	RED	• Downstream evacuation. • Attempt to plug the entrance of the whirlpool with riprap from the slope of the embankment. • Search downstream for an exit point and construct a ring dyke to retard the flow of soil particles.	• Dozer, • Fill material • Sandbags, • Filter cloth, • Straw • Rocks	• Lake level, • Rainfall
Malfunctioning of	• Structural member of a gate or gate operator broken or severely damaged so as to prevent operation of the gate	ORANGE	• Initiate 24-hour surveillance • Immediately place stop logs in front of gate and initiate necessary actions to get gate repaired	• Crane and • Welder	• Type of problem, • location
Rapidly Raising	• Lake level rising and rain continuing	BLUE	• Initiate 24-hour surveillance of lake level and rainfalls. • Generate inflow forecasts every 12 hours	-	• Lake level, • Rainfall
Overtopping	• Water flowing over the dam and lake continuing to rise. • No significant erosion of downstream embankment.	ORANGE	• Prepare for evacuation. • Continue monitoring generate inflow forecasts every hours	• Dozer, • Fill material • Sandbags, • Filter cloth, • Rocks	• Lake level, • Rainfall
	Water flowing over the dam, the lake continuing to rise, and significant erosion of downstream embankment with development of head-cuts encroaching on the dam crest, or significant movement of sections of concrete or masonry portions of the dam.	RED	• Immediate evacuation. • Dam failure is imminent or ongoing	Cameras	• Status of breach formation. • Width of breach as it enlarges

6.1.9.2.1. Internal Alert Condition BLUE - A “watch” condition

272. A problem has been detected at the dam that requires constant monitoring. At this time, the distress condition is manageable by dam personnel. The DGM (Tech) as Engineer-in-Charge shall be responsible for monitoring, repairing as soon as possible, and implementing the appropriate Notification Flowchart. The following is a list of conditions that would initiate this condition:

- Cloudy or dirty seepage or seepage with an increase in flow, boils, piping, or bogs
- Seepage around conduits
- Large sinkholes with corresponding seepage anywhere on the embankment or downstream from the toe
- Any slide that degrades the crest of the embankment or that is progressively increasing in size
- Cracking or movement of any concrete structure
- An increase in the reservoir level leading to engagement of the emergency spillway
- Exceptionally heavy rainfall in the catchment of the dam reservoir

6.1.9.2.2. External Alert Condition ORANGE

273. This indicates a dam condition that is progressively worsening; there is a high probability of dam failure. Although there is no immediate danger, the dam could fail if conditions continue to deteriorate. The Executive Engineer will be responsible for initiating immediate repairs, including lowering the reservoir if appropriate and implementing the appropriate Notification Flowchart. The following is a list of conditions that would initiate this condition:

- Large boils, increasing in size and flow rate, especially if there is flowing muddy water
- Significantly increasing seepage, especially flowing muddy water
- Slides involving a large mass of material that impairs the crest of the dam and is continuing to move
- Sinkholes with seepage flowing muddy water
- Large cracks, movement or failure of a portion of any major concrete structure that forms an integral part of the dam
- An increase in the reservoir level to near the top of the dam
- Overtopping of a dam that is not designed for overtopping
- Near to ‘Design Flood’ inflow forecast

6.1.9.2.3. External Alert Condition RED

274. These are “failure” conditions. Either the dam is in immediate danger of failing or has already failed. No time remains to implement measures to prevent failure. Evacuate immediately. Evacuation efforts will continue until the situation is stabilized. The Executive

Engineer is responsible for implementing the appropriate Notification Flowchart. The following is a list of conditions that would initiate “imminent dam failure” or “dam failure” conditions:

- Rapidly increasing boils or the presence of new, significantly flowing boils, particularly muddy ones near previously identified ones
- Rapidly increasing seepage, especially flowing muddy water
- Slides involving a large mass of material or which have degraded the crest of the embankment to a level that approaches the water surface level, or if significant seepage is observed through the slide area
- Settlement that is predicted to degrade to the reservoir level
- Cracks that extend to the reservoir level
- Significant movement or failure of any structure that forms an integral part of the dam
- Overtopping of an earthen dam
- Uncontrollable release of the reservoir

6.1.9.3. Previously Known Problems

275. Lower Kopili HEP dam is 66.5 high concrete gravity dam built adhering to all kinds of simulations and engineering calculations considering all relevant eventualities. Its designing and construction lasted bit more than five years which is ample time for ground setting and all kinds of technical tests and evaluations. Being the youngest dam in Assam, LKHEP dam has no known previous problems.

6.1.10. Preparedness

276. The Surveillance, Operation and Maintenance of Lower Kopili HEP dam is planned to be handled by qualified and trained staff are providing 24x7 support at the Dam site.

277. Preparedness actions are to be taken both before and following the development of emergency conditions. They should identify ways of preparing for an emergency, increasing response readiness in a uniform and coordinated manner, and helping to reduce the effects of a dam failure. The following steps could prevent or delay failure after an emergency is first discovered.

- Surveillance: CCTV cameras and a watch tower are planned, which are directly monitored from the Dam Control Room located in the Powerhouse. The Dam Site Engineer and his Team will monitor the dam during emergency situations such as a severe storm event.
- Response on forecast of excessive inflow: APGCL, Dam Site Team headed by CGM (Hydro) monitors and responds to situation of excessive inflow forecast by way of controlled spillway releases after ascertaining the reliability of the forecast.
- Response during weekends and holidays: Engineer-in-Charge and his Team are available 24x7 for emergency response during weekends and holidays and can be present at the dam site within 30 minutes of detection of an emergency condition.

- Response during periods of darkness and adverse weather: Engineer-in-Charge shall arrange for access to generators and lights to adequately monitor the situation Dam Site Engineer and his team are stationed in Powerhouse and will be able to access the site during adverse weather conditions by multiple methods - by foot, utility vehicle, paddle boat. Power backup generators, torches and searchlights are available at identified points at Dam Site for emergency use.
- Access to the Site: In the event of an emergency at the dam, alternate access routes are identified through Power House road and National Highway 627 heading towards Pump House.

278. Preventive measures maybe taken in an emergency to prevent or postpone or mitigate the catastrophic failure of the dam, but such repairs should be undertaken with extreme caution. The repairs are only temporary, and a permanent repair should be designed by an Engineer-n-Charge as early as possible.

279. The following actions should only be undertaken under the direction of a professional engineer or contractor. In all cases, the appropriate Notification Flowchart must be implemented and the Dam site in-charge must be notified.

280. Consider the following preparedness actions if the dam's integrity is threatened by:

Seepage Failure

- Plug the flow with whatever material is available (hay, bentonite, or plastic) if the entrance is in the reservoir.
- Lower the water level in the reservoir by using the low flow outlet and pumping, if necessary, until the flow decreases to a non-erosive velocity or until it stops. Place an inverted filter (a protective layer of sand and gravel) on the exit area to hold the material in place.
- Continue operating at a lower level until a repair is made.

Embankment or Foundation Sliding

- Lower the water level in the reservoir by using the low flow outlet and pumping if necessary at a rate and to an elevation considered safe, given the slide condition.
- Stabilize the slide, if on the downstream slope, by weighting the toe area below the slide with soil, rock, or gravel.
- Continue operating at a lower level until a repair is made.

Structural Failure

- Implement temporary measures to protect the damaged structure, such as placing rock riprap in the damaged area.
- Lower the water level to a safe elevation through the low flow outlet and by pumping if necessary.

6.1.11. Supplies and Resources

281. At this stage, as this is a draft EAP for an under-construction Dam, supplies and resources provided in this section are indicative, precisely exhibiting Dam Owner's awareness and preparedness to face any eventualities. This section should necessarily be completed with factual data after commissioning of the Dam.

6.1.11.1. Contracts

282. Should Head of Power Station or DGM (Technical) personnel and resources prove to be inadequate during an emergency, requests will be made for assistance from other local jurisdictions, other agencies, and industry, as needed. Such assistance may include equipment, supplies, or personnel. Authorised officials will make all agreements and should be in writing whenever possible. The DGM (Technical), Emergency Planning Manager shall have the authority to enter into agreements as deemed necessary to prevent dam failure.

6.1.11.2. Equipment and Supplies

283. Details of Emergency Supplies and Equipment Suppliers are also prepared. Local suppliers/contractors maybe contacted to provide equipment during an emergency event.

6.1.11.3. Reports

6.1.11.3.1. Technical Data

284. Pre-monsoon and post-monsoon dam inspections will be made to evaluate its structural safety, stability, and operational adequacy. In the event of an abnormal occurrence, reference to these reports, mainly the photographs, can be beneficial in evaluating a potential problem.

285. Technical records such as drawings and inspection reports should be stored and carefully maintained at the Head of Power Station or DGM (Technical) Site offices. Alternate personnel will be familiar with the location of the documents in the event of an emergency situation.

6.1.11.3.2. Emergency Operations Center Activity Log

286. Any unusual or emergency condition should be documented, including the following:

- Activation or deactivation of emergency facilities
- Emergency notifications to other local governments and to state and central government agencies
- Significant changes in the emergency
- Major commitments of resources or requests for additional resources from external sources
- Telephone calls should be recorded in chronological order

- Issuance of protective action recommendations to the public
- Evacuations
- Casualties
- Termination of the incident

6.1.11.3.3. Costs of the Emergency Operations Centre

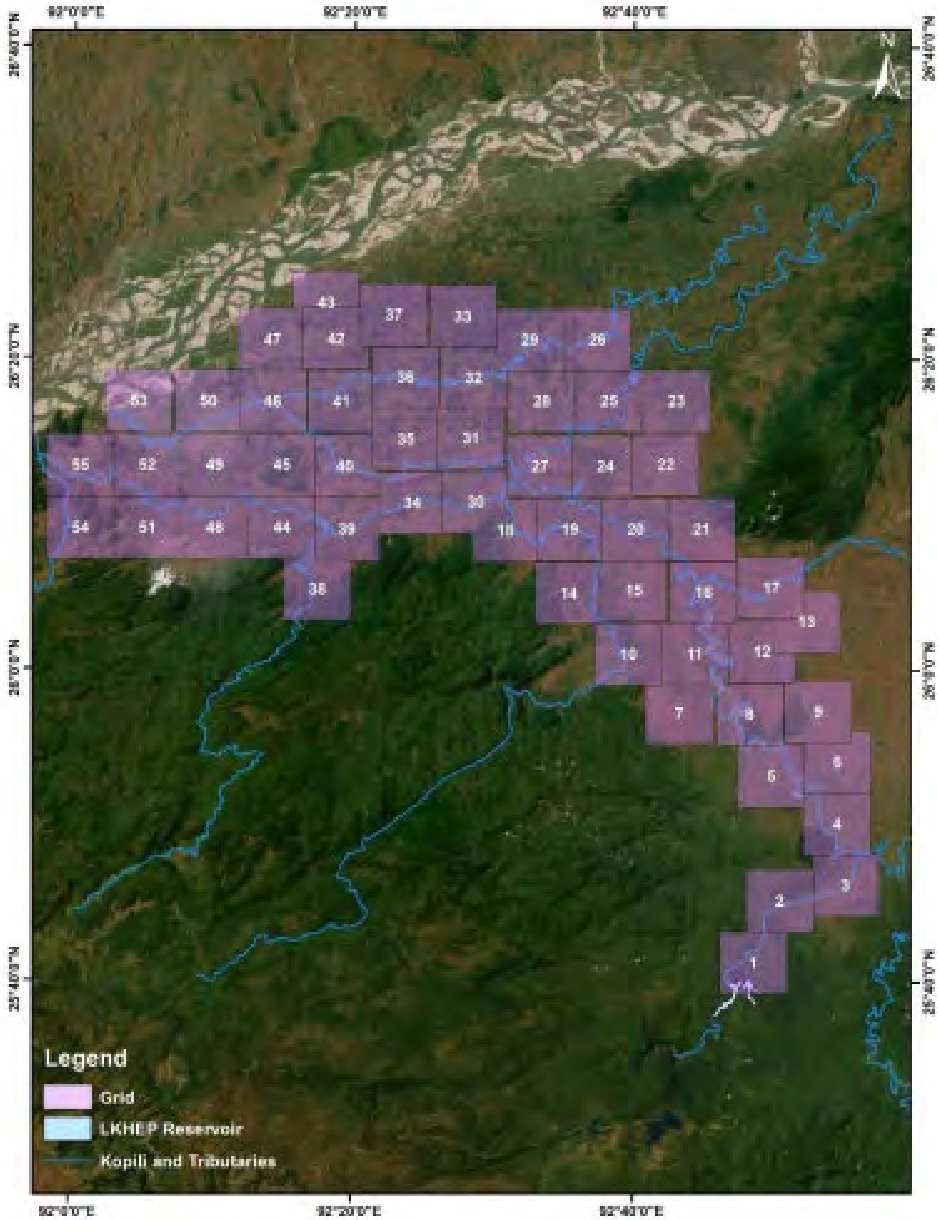
287. The emergency operations center will maintain detailed records of costs expended for major emergencies. These records may be used to recover costs from the responsible party or insurers, or as a basis for requesting financial assistance for certain allowable response and recovery costs from the state or central government. Documented costs should include:

- Personnel costs, especially overtime
- Equipment operation
- Equipment leasing and rental
- Contract services to support emergency operations
- Specialized supplies expended in emergency operations
- Specialized supplies expended in emergency operations

6.1.12. Inundation Area

288. Inundation Maps are prepared following the Dam Break Analysis. The inundation map illustrates that the inundated villages subject as per the Arrival Time and Depth due to flooding from dam failure (Map 46 and details in EAP report submitted to APGCL). Based the output from DBA results inundation map was prepared and the inundated villages are displayed as per their Arrival Time. The Dam Break Analysis including Inundation Maps prepared by IIT Roorkee. After examining the results of the breach analysis of Lower Kopili HEP Dam, it has been determined that Dima Hasao and West Karbi Anglong Districts of Assam where the LKHEP Dam is located, shall be the minimally affected. The downstream inundated area falls in Morigaon, Nagaon, Kamrup Metropolitan and Hojai Districts, which could be affected by a design flood or sunny-day dam breach. Downstream, as many as five more rivers/streams join the Kopili River swelling it further, before it reaches the Brahmaputra confluence. Thus, it required a systematic triangulation of methods to calculate the volume of inundated flood water contributed into Kopili river.

Map 48: Inundation Map



289. A Vulnerability Atlas has been attempted to add value addition to this EAP Report. No Census results are published after 2011. Therefore, based on 2011 Census Population data current population in inundated villages are estimated by factoring 1.6% annual growth.

290. The dam break analysis result shows that 1162 villages in Dima Hasao, West Karbi Anglong, Morigaon, Nagaon, Kamrup Metropolitan and Hojai Districts were affected by dam breach. A detailed list of affected villages as per the Wave Arrival Time is also prepared.

291. The breach analysis contains profiles of the expected peak flood levels, as well as an estimation of the time from the beginning of the breach to the peak flood elevations. A comparison of the areas that are likely to be flooded with the plots showing the times from the start of the breach to the flooding shows the areas of evacuation and the time constraints involved (Ref : Section 7 of the Dam Break Analysis). Figures in the breach analysis include information on the estimated impact of flooding on the bridges along the Sonai River. These structures may suffer such impacts before the peak elevation of the flood wave.

6.1.13. Local Evacuation Plan

292. If imminent failure of the dam with uncontrolled downstream flooding is anticipated, DDMA Dima Hasao, Circle Disaster Management Authorities, and local law enforcement personnel should notify those downstream, for evacuation in the most expedient manner possible. (Figure 61 for Sample Notification and refer to WATCH CONDITION & FAILURE CONDITION FLOWCHARTS). The organizations and personnel on the Notification Flowchart should be contacted immediately. Local law enforcement officials, along with local mobile network operators, radio and television stations can best spread the notice for evacuation.

293. The dam structure is being strong and robust all other dam breaks are ruled out except sunny-day and design flood breaches, the following actions should be taken:

- Barricading all bridges that could be flooded to prevent access to the affected area.
- The District Disaster Management Authority of respective districts may coordinate with the notification of all persons and agencies involved, with the possibility of additional support—including contacting others not accessible by radio or telephone.
- District officials are generally familiar with developed areas in their jurisdiction. Such knowledge, coupled with the requirements of state law that they respond to disasters, make them the logical officials to be notified and to spread the warning message to all areas subject to flooding.
- District-wise relevant Emergency Contact along with details like Department, Name, Mobile Number are placed in EAP Report submitted to APGCL, which may be used as quick reference.
- Revenue Circle-wise Vulnerability Atlas are placed at Annexures of the EAP report submitted to APGCL. Accordingly details of Local Relief Camps of the affected Dima Hasao, West Karbi Anglong, Morigaon, Nagaon, Kamrup Metropolitan and Hojai district along with their geological coordinates (as provided) are placed separately. Both Relief camps and inundates villages list are intentionally placed as per their Districts/Revenue Circle to help during mock drills and/or to print and use them as HANDOUTS by the Aapda Mitra during the emergency events.

6.1.14. EAP Implementation

6.1.14.1. Development

294. Lower Kopili HEP Dam is still under construction and ICED IIT Roorkee has been assigned to prepare the EAP. As the project is still under construction, based on the DRIP guidelines (2016) to prepare an emergency action plan, ICED IIT Roorkee developed this Emergency Action Plan using the field data and the input provided by the APGCL Team.

295. Upon completion and commissioning of the LKHEP DAM, a revised EAP need to be developed using factual data.

6.1.14.2. Updating

296. For updating the EAP:

- Copies of the EAP have been provided to the appropriate persons. The EAP has been approved and signed by the owner and the person(s) in charge of emergency response, as shown in the Distribution List and Approval and Implementation sheets at the front of the report.
- Emergency Action Plan shall be reviewed and updated annually by the Head of Power Station / CGM (Hydro), APGCL and respective DDMAs of inundated districts in conjunction with the Manager (Civil), APGCL, responsible for annual maintenance inspection of the dam.
- The Manager (Civil), APGCL shall review and complete all items on the Annual EAP Evaluation Checklist in Annexure - 2. This plan will be reviewed and updated annually and tabletop drills will be carried out at least once in every five years. All the reviews of the EAP to be documented. After the annual update is complete, a new Approval and Implementation sheet will be attached,

6.1.14.3. Testing

297. A tabletop drill will be conducted at least once every five years. The tabletop drill involves a meeting of the Head of Power Station / DGM (Technical), APGCL with DDMA and SDMA Officials in a conference room. The drill begins with a description of a simulated event. It proceeds with discussions by the participants to evaluate the EAP and response procedures, and to resolve concerns regarding coordination and responsibilities. Any problems identified during a drill should be included in revisions to the EAP. Records of training and mock drills shall be maintained as per Annexure - 3.

6.1.14.4. Training

298. All people involved in the EAP will be trained to ensure they are thoroughly familiar with its elements, the availability of equipment, and their responsibilities and duties under the plan. Personnel will be trained in problem detection, evaluation, and appropriate corrective measures. This training is essential for proper evaluation of developing situations at all levels of responsibility. Training records will be maintained in Annexure - 3. A discussion-based exercise where personnel with roles and responsibilities in this EAP meet in a classroom setting or in breakout groups to validate the content of the plan by discussing their roles during an emergency and their responses to a particular emergency situation. The main objective of this exercise is to emphasize on the role clarity

and to make feel of the tension, anxiety and train the staff for actual emergency situations. SOP for Table Top exercise in given in Annexure 4.

6.2. VDMP for five pilot vulnerable villages

299. Village (community) resilience plan aims to enhance community's capacity to handle preparedness, and response to emergency situation. Communities being first responders to emergency situation, it is important to have a well-defined framework and standard operation procedures (SOP) for different phases of Disaster Management. The SOP will help to define roles and responsibilities of the identified people in community to coordinate with administration to avoid chaos and panic during emergency situation.

Figure 58: Different phases of DM Cycle

300. **The key pillars considered for disaster resilience includes:**

- Preparedness
- Protection
- Early warning
- Response
- Recovery

301. These pillars are to be reinforced at different administrative levels while community level resilience plan plays vital role in this. For community resilience additional aspects that needs to be considered include ensuring last mile connectivity and improving economic resilience of the community. Ensuring last mile connectivity is critical to make sure the alert or any communication reach the community and in case of emergency situation the support also reach the community on right time. Improving economic resilience helps community to recover faster from the impacts of disaster. For the rural

systems of India, diversifying economic activities can be one option to improve economic resilience.

302. India has laid down a well-defined framework at different administrative levels for (National, State, District and local level) to handle different aspects during different phases of disaster management. This framework was formalized through DM act of 2005, followed by issuing National Policy on DM in 2009, and subsequently aligned with the UN Sendai Framework for DRR (2015-2030). National Disaster Management Authority (NDMA) in collaboration with National Institute of Disaster Management (NIDM) has developed guidelines to develop DM plans for State, District and Local level and sector specific DM plans. The States are directed to develop DM plans as per this guideline and most of the states in India has developed and is systematically updating these plans. Several states, mostly those which are more vulnerable to multiple hazards have developed local DM plans through community participation.

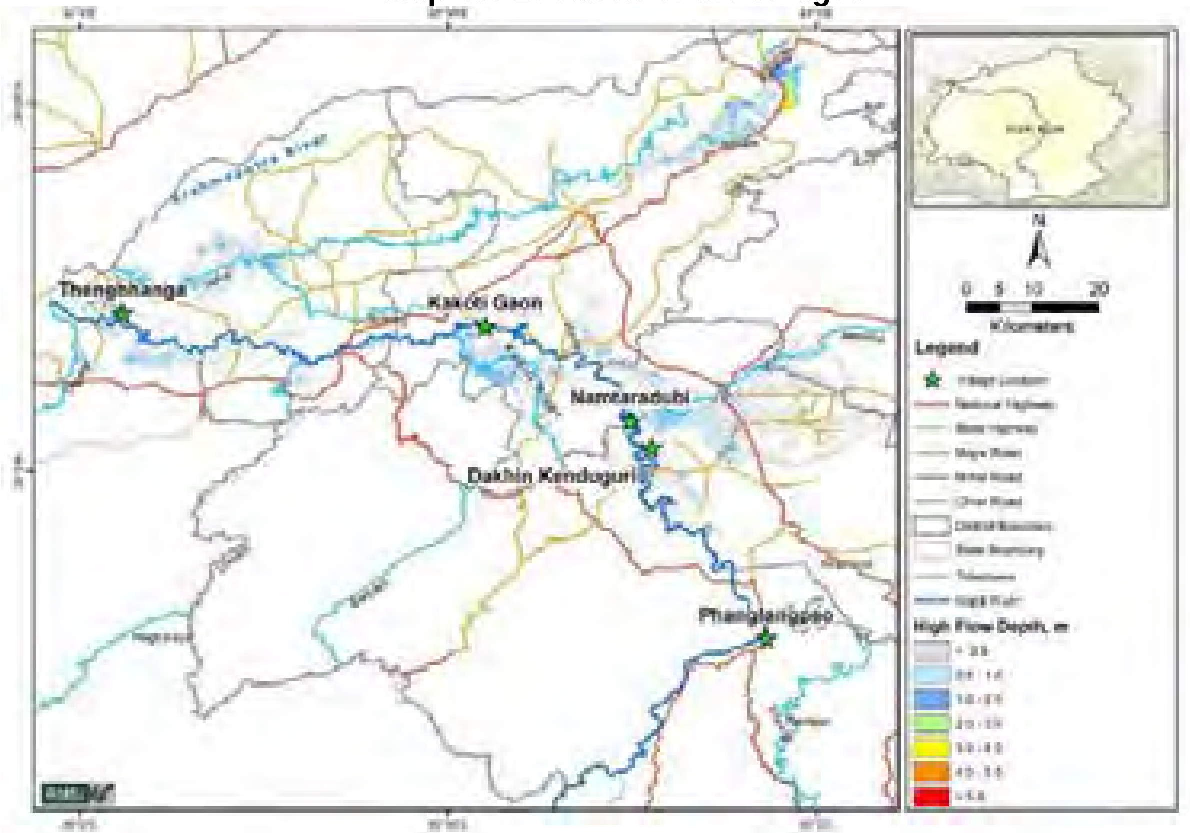
303. Assam State which is vulnerable to multiple hazards including floods also has developed State, and District DM plans. Some of the districts under different funding initiatives have prepared village DM plan as well. As part of the present ADB assignment, 5 village resilience plans are prepared, one in each district in the Kopili River Basin through community participation. These 5 village DM plans are to be considered as pilot plans which the State and Districts can take forward by extending it to rest of the villages.

304. The following five villages were identified through field visit, community consultation and consultation with DDMA and ASDMA (Table 36, Map 49).

Table 36: Selected villages in the downstream District

S. No	District	Village name	Distance from the LKHEP Dam (Km)	Arrival time (PMF) (HH:MM:SS)
1	Dima Hasao	Phanglangso	23	14:10:00
2	Hojai	Dakhin Kenduguri	54	25:34:48
3	Karbi Anglong	Namtaradubi	63	26:20:00
4	Nagaon	Kakotigaon	83	67:25:12
5	Morigaon	Thengbhanga	123	122:04:59

Map 49: Location of the villages



305. Though the nature of flooding and vulnerability is more or less homogenous across the study area in Kopili, one can infer difference in flooding characteristics in the Dima Hasao and Karbi Anglong while comparing the other three districts - Morigaon, Nagaon and Hojai districts. Different rounds of consultations with communities were carried out to understand the flooding issues, community needs and problems faced during the flood situation. Community issues and needs assessment took into consideration gender needs, mitigation measures community feels required to reduce the impact of floods and shelter requirements in case of any flood. This information is documented separately for each of the villages in the subsequent section of this DM plan document.

306. As part of the impact analysis of the dams, the team has modeled the low and high flow on release of water from the dam and dam break scenario (catastrophic scenario which can be caused due to earthquake). Flood maps of all five villages of high flow scenario based on 10-day discharge from dam (based on input from APGCL). For VDMP which is developed based on consultative approach we are considering the past flood events and consider the maximum flood zones based NRSC analysis of historical flood data. The regulated discharge of water from the dam is showing less extend of flood compared to flood zone map and for VDMP it is appropriate to consider worse scenario to ensure safety of the community.

6.2.1. Emergency Response Plan

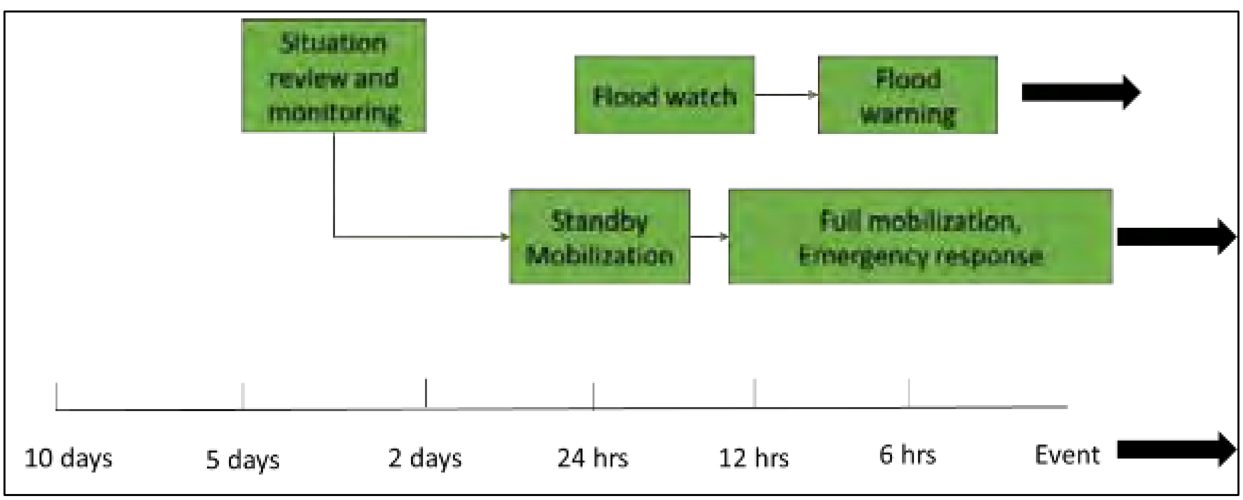
6.2.1.1. Existing flood early warning system

307. Presently, ASDMA provide flood early warning based on the input provided by NESAC. NESAC use WRF forecast rainfall to model flood for entire assam and provide warning to ASDMA. ASDMA disseminate this information further to respective Districts. Districts further disseminate this to circle level and villages. WRD observe water level and gauge stations and provide water level information also to ASDMA. Mainly the forecast is for 24 hours. The communication channel to the village is mainly over phone. The villagers with the support of circle office team are watching the vulnerable points and local water level changes to take action on ground. Some villages conveyed that community volunteers were deploy even at night to watch the rise in water level in the river.

6.2.1.2. Proposed flood early warning system under LKHEP

308. Once the LKHEP is completed the lead-time for warnings is highly influenced by the dam operation and sub catchment characteristics. The least lead time for flood water to reach habituated area in each village were estimated. However, with the reduced discharge based on simulated high flow model, the water will not overtop and inundate the settlement area in the upper reaches of the river (where the lead time is mentioned as one hour). The Figure 59 schematic diagram represents the warning levels recommended by WMO with appropriate actions to corresponding lead-times.

Figure 59: Schematic diagram of warning and respective lead-times (source: WMO 1072[64])

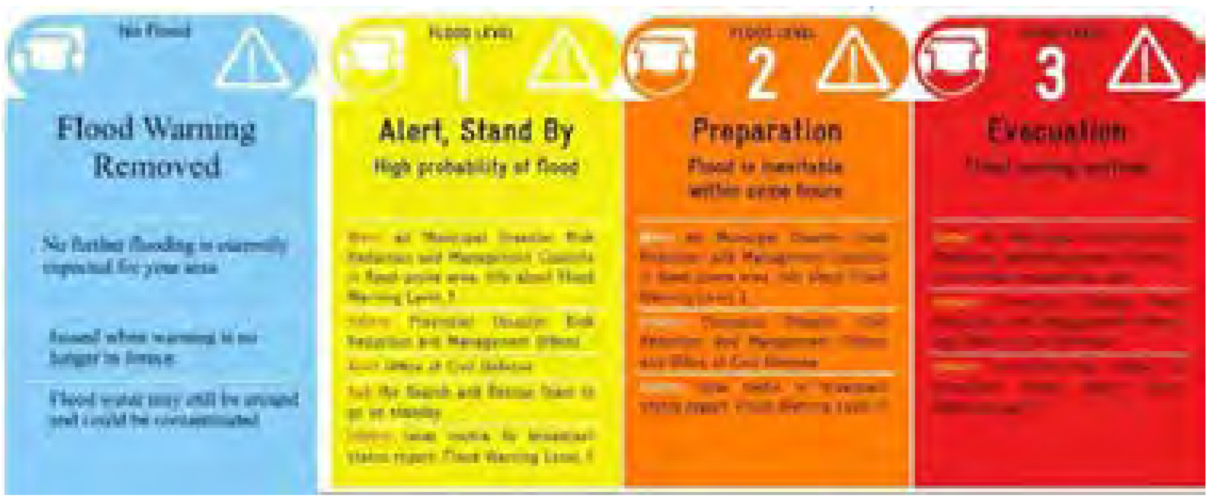


[64] Manual on flood forecasting and warning, World Meteorological Organization (WMO). https://library.wmo.int/records/item/35881-manual-on-flood-forecasting-and-warning

309. The LKHEP flood forecasting and early warning system will broadly follow this framework. The flood model (1D-2D model) will be based on the 3 days WRF forecasted rainfall (considering forecast quality) and present day observed rainfall data and observed water levels at gauge stations. To improve the forecast model, under the LKHEP additional rain gauge stations and water level stations were installed and integrated with the forecasting model for seamless data access. The system run in auto mode fetching data and provide water levels with reference to warning and danger levels and at warning level the 1D-2D couple model with run to show the inundation areas.

310. The warning information will be generated and send in the form of SMS and flood bulletin to registered users. Flood early warnings will follow the stand color code followed by IMD/WMO as show in Figure 60.

Figure 60: Color-coded flood alert and warning



311. Community trainings were provided to understand the colour code and actions to take at different phases of warning. The Standard operating procedures (SOP) for village DM committee during different phases of warning is details in the respective 5 VDMPs in the subsequent sections.

6.2.2. Exigency plan

312. Considering the earthquake vulnerability of the region, APGCL entrusted IIT Roorkee has carried out dam break analysis with the changed (during detail engineering design) and approved parameters. The exigency plan for such catastrophic situation is provided in their report. Following are the key information available in the IIT Roorkee dam break analysis report:

1. Flood extend and velocity in case for dam break
2. Lead time at different stretched of river for evacuation
3. SOP for emergency response
4. Installation of siren (by APGCL) at the dam site which give siren that can reach a radius of about 3 kms.

5. Principal Secretary (i.c), Settlement and Revenue, Dima Hasao Autonomous Council, during the consultative meeting on 13.6.24 suggested to install siren in Panimur also (Annexure 6 : MOM).

6.2.3. Evacuation Plan and Shelter Management

6.2.3.1. Evacuation Plan

313. Evacuation plan for flood to be decentralized (at village level) and commuting distance for community and livestock to be minimum, at the same time ensure safe location. The VDMPs were developed for 5 vulnerable villages which include when to evacuate, responsible person to coordinate during evacuation, shelter needs, availability of shelter locations, contact details Incident Response System (IRS), Incident Response Team (IRT) and emergency service function (ESF) departments (hospital, police, fire department).

314. Awareness activities among communities are required on alert, warning and evacuation stage and 'to do' list at these stages. Awareness can also be given through schools. The VDMPs were prepared for the 5 pilot villages and is provided in the subsequent sections. In similar line, districts need to carry out needs assessment and sensitize village and develop VDMP for rest of the flood vulnerable villages in the basin. The Village Land Management & Conservation Committee (VLCC) needs to be activated and regular DM awareness activities are needed including sensitizing the role and responsibilities of different committee members during various phases of flood disaster. The community should be aware of the evacuation routes and nearest shelter locations.

6.2.3.2. Shelter Management Plan

315. Based on the needs assessment and reviewing of the shelter facilities in the 5 pilot villages following are the recommendations:

i. The existing shelter should be reviewed based on past flood events (last 20 years) and should ensure they are in safe locations.

ii. Shelter facilities should be designed taking into consideration of the diversity of community in the region. Tribal communities and other minority communities living in adjacent villages are not comfortable in sharing shelter facilities.

iii. Schools, community halls and temples are used as shelters during flood situation. These shelter facilities do not have adequate toilet facilities. Many of the school building using as flood shelter (for instance, the Goroimari LP School of Namtaradubi village and Disgaon LP school of Phanglangso village) only has 4 rooms which can hardly accommodate the flood affected population of the village. Ideally, refurbishing and expansion of these schools can help using them for flood situation in addition to improve the educational infrastructure.

iv. There should be coordination between line department and district to ensure the public building facilities constructed/ being constructed in the locality has adequate plinth heights and also can be used for flood shelter in case required. For instance, adjacent to the Goroimari LP School of Namtaradubi village, social welfare department is constructing an Anganwadi. This kind of new buildings should consider the shelter requirements and designed accordingly. For this there is a need of inter departmental coordination.

v. In case of constructing new flood shelter, it should be designed to take care of people, and livestock and with adequate sanitation facilities. Unless sanitation facilities have water connection, it should not be open to public. For instance, a community hall was constructed in Dakhin Kenduguri with toilet facility adjacent to the building. There is no water connection to toilet and now the toilet is dirty and abandoned. Ideally the multi-facility centre should have a building with rooms and toilets and open elevated platform which should have provision to make shift arrangements for putting temporary roofs for livestock and setting up additional mobile toilets for community if necessary.

vi. These multi-purpose facility centres should be put in daily use during normal time which can not only generate some income to meet the maintenance cost of the building but also will be kept clean and functional. For instance, multi-purpose facility centres (in case of buildings) can be used as schools, facilities for self-help entrepreneurs to do tailoring, handicrafts or food processing, etc, and raised platforms can be used as community gathering place, or weekly market place for even for as soccer training centres.

vii. The shelter facilities should also have provision to store grains for community on a nominal payment basis. The grain house should be insulated to protect from humidity and seepage of water and protect from rodents. The custodian of the grain house should keep the grain house under lock and key and keep a register for grain community keeping in grain house and taking out.

viii. Community should also keep livestock feeds in the shelter facilities during alert phase to ensure livestock are taken care during emergency situation.

6.2.4. Resettlement Plan

316. Considering the erosion problems along the Kopili river and its tributaries, structural interventions (construction and strengthening of embankments) is needed. Assam State through WRD is presently constructing embankment in certain stretches of Kopili river. There are several embankment segments which are weak and flood water are entering the village through these locations.

317. Construction or strengthening of embankment need land acquisition as river has eroded the banks in many places. During the community consultation, the communities in general are not ready to relocate except the Phanglangso village which consist of 32

households. They are ready to move to elevated areas if government can make arrangement for relocation.

318. The amount of land that needs to be acquired depends on the river stretches bordering the village, the kind of structural intervention and its design. Once the design is finalized a household survey needs to be carried out in the area to assess the number of households need to be relocated and the amount of land need to be acquired.

319. The Government of Assam has defined compensation norms defined in the “Chief Minister’s Special Scheme for Rehabilitation of Erosion Affected Families in Assam”. Other policy and legislation governing the rehabilitation and resettlement include the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act-2013 (RFCTLARRA, 2013) Assam RFCTLARR Rules, 2015, Land Acquisition through Direct Purchase by way of Negotiated Settlement for Public Purpose of all Departments in the State of Assam dated 7th March 2022, the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act 2006, the Provisions of the Panchayats (Extension to the Scheduled Areas) Act 1996, and Rehabilitation Policy for Erosion Affected Families of Assam, 2020 and ADB SPS, 2009.

6.2.5. Structural Intervention Needed in 5 Pilot Villages

320. Following structural intervention (shelters and embankment construction) are needed for improving the flood resilience of the 5 pilot villages (Table 37).

Table 37: Structural intervention proposed for the 5 villages.

S. No.	Village and District name	Shelter facilities	Embankment	Embank-ment Length	Present status of the Flood shelters and proposed indicative interventions				
					Max flood level (HFL)	Height of the flood shelters (Existing)	Capacity of the flood shelters as against the required space		
						Proposed Interventions	Number of villagers	Number of cattle,	Food and fodder storage
1	Phanglangpso (Dima Hasao)	Reconstruction of Disgaon Lower Primary school as a multipurpose facility centre which can be used as school in normal condition and flood shelter in case of any flood event. Due to reduction in discharge after dam construction, flood risk of this community will be reduced	Structures needed for controlling bank erosion in the village	1.0 km (erosion control structures)	CWC gauge station is 4 km upstream. Estimated HFL is 76 m	The proposed shelter is outside the village and in no flood zone Located at height as per DTM is 93 m	60 Since this is an Lower Primary School and 4 additional class rooms are needed. (Built up area 210 sqm of the building)	Shaded area to accommodate cattle required during rainy season. Need for about 100 cattle Area required 350 sqm	Needed Year round food / fodder storage in the flood shelters Locker system for storage of food grains and important items

S. No.	Village and District name	Shelter facilities	Embankment	Embank-ment Length	Present status of the Flood shelters and proposed indicative interventions				
					Max flood level (HFL)	Height of the flood shelters (Existing)	Capacity of the flood shelters as against the required space		
						Proposed Interventions	Number of villagers	Number of cattle,	Food and fodder storage
2	Dakhin Kenduri (Hojai)	Reconstruction of Jogijan higher Secondary School with at least 1 meter plinth height. A multi purpose facility centre with adequate toilet facilities and grain storage facilities. Toilet facilities for the community hall (that can be used during flood time) is needed Mahadev Bari also need toilet facilities	Embankment construction for about 0.5 km	0.5 km	74 m (CWC station is down stream and HFL at gauge station is 69 m)	School located at 67 m with 0.7 m existing plinth height. The shelter needs to be reconstructed to be elevated above 74 m Mahadev Bari – located at 66 m with 0.9 meter	Present capacity 400. No adequate toilets (Built up area 1400 sqm of the building) Mahadev Bari - Present capacity 100. No toilets (Built up area 350 of the building)	No provision for cattle. Shaded Facilities for about 200 cattle required. Area required 700 sqm	Needed Year round food / fodder storage in the flood shelters Locker system for storage of food grains and important items

<table>
<tr><th rowspan="3">S. No.</th><th rowspan="3">Village and District name</th><th rowspan="3">Shelter facilities</th><th rowspan="3">Embankment</th><th rowspan="3">Embank-ment Length</th><th colspan="5">Present status of the Flood shelters and proposed indicative interventions</th></tr>
<tr><th rowspan="2">Max flood level (HFL)</th><th>Height of the flood shelters (Existing)</th><th colspan="3">Capacity of the flood shelters as against the required space</th></tr>
<tr><th>Proposed Interventions</th><th>Number of villagers</th><th>Number of cattle,</th><th>Food and fodder storage</th></tr>
<tr><td>3</td><td>Namtaradubi (Karbi Anglong)</td><td>Reconstruction of Goroimari LP School (which is an old building) as a multi purpose facility centre with atleast 1.5 meter plinth height and toilet facilities

The temple building and embankment are being used as shelter and need mobile toilets which can be kept at identified safe areas</td><td></td><td>2 km</td><td>66 m</td><td>Goroimari LP School – located at 66.6 m and plinth height of 0.9 meters

Temple – located at 64.7 m with plinth height of 1.0 m</td><td>50 people

Area required 175 sqm</td><td>Presently not available.

Shaded facility required for about 70-100 cattle

Area required 245 sqm to 350 sqm</td><td>Year round food / fodder storage in the flood shelters

Locker system for storage of food grains and important items</td></tr>
</table>

<table>
<tr><th rowspan="3">S. No.</th><th rowspan="3">Village and District name</th><th rowspan="3">Shelter facilities</th><th rowspan="3">Embankment</th><th rowspan="3">Embank-ment Length</th><th colspan="5">Present status of the Flood shelters and proposed indicative interventions</th></tr>
<tr><th>Max flood level (HFL)</th><th>Height of the flood shelters (Existing)</th><th colspan="3">Capacity of the flood shelters as against the required space</th></tr>
<tr><th></th><th>Proposed Interventions</th><th>Number of villagers</th><th>Number of cattle,</th><th>Food and fodder storage</th></tr>
<tr><td>4</td><td>Kakati Gaon (Nagaon)</td><td>There is no flood shelter in this village and needs a multi purpose facility centre. Open land (play ground) behind Kakoti Goan LP School (near the railway station) can be used and the land needs to be elevated atleast 2 meter. Considering large cattle population in this village the facilities should take into consideration for cattle shelter as well.</td><td>Embankment needed for about 0.5 km at Nagaon Border from where the of Kopili river border the village and another 1 km in the tributaries bordering northern part of the village</td><td>1.5 km</td><td>59.6 m</td><td>Need new multi facility centre and location which is at 60.7 m near the railway station adjacent to the railway track</td><td>Present capacity 100 people

Area required 350 sqm</td><td>Not available presently.

Shaded facility required for 400 cattle.

Area required 1400 sqm</td><td>Year round food / fodder storage in the flood shelters

Locker system for storage of food grains and important items</td></tr>
</table>

S. No.	Village and District name	Shelter facilities	Embankment	Embank-ment Length	Present status of the Flood shelters and proposed indicative interventions				
					Max flood level (HFL)	Height of the flood shelters (Existing)	Capacity of the flood shelters as against the required space		
						Proposed Interventions	Number of villagers	Number of cattle,	Food and fodder storage
5	Thengbhanga (Marigaon)	The three locations (1 temple and 2 schools used has shelter does not have adequate toilet facilities. Construction of toilets is required. Considering the temple premise toilet (it can be mobile toilet) needs to be built away from the temple area	Embankment needed for about 1.5 km stretch of Kopili river bordering the village	1.5 km	54.5 m	Temple 1 foot located at 52.7 m with plinth height of 0.3 meters Plinth height to be increased or new shelter to be constructed above the HFL Govt LP school located at height of 55.4 m with a plinth height of 0.7 m	Present capacity 120 people Area required 420 sqm	Presently not available. Shaded facility required for about 400 cattle Area required 1400 sqm	Year round food / fodder storage in the flood shelters Locker system for storage of food grains and important items

Note :

1. Improvement for the flood shelters of the 5 selected villages will be intimated to the DDMA and district administration for implementation. Technical feasibility and availably of land, budget etc. for reconstruction of flood shelters will need to be decided by the District Administration / DDMA, as and when decided to be implemented
2. The full report **'Resource Management and Disaster Resilience on Kopili River'** prepared by RMSI is available at APGCL's office.

321. The guidelines as stated in the ASDMA' Disaster Management Manual 2015' will be adopted in planning the facilities of flood shelters (specific focus including water, sanitation and hygiene (WASH) services) such as :

1. The covered area available per person should be on an average 3.5 to 4.5 square meter.
2. 20 Ltrs of water should be provided to per person per day.
3. Ideally one hand pump should be installed for every 200 persons.
4. Ideally there should be one toilet for 20 persons. Toilet should be minimum 10 mtrs and maximum 50 mtrs away from shelter/tent/room.
5. If there are more than 500 persons in the camp, one ambulance with adviser should be stationed for 24 hrs in the camp.
6. For waste disposal, one communal pit of 2mX5mX2m of size should be dug for 500 persons.
7. Minimum Space Requirement: 3.5 m^2/cow; 2.5m^2/heifer; 1m^2/calf [65]
8. It shall ensure that men and women are supplied food with minimum calories of 2400 Kcal per day and children to be supplied 1700 Kcal per day[69].
9. Drinking water to be provided 3 lts per day per person[66].

[65] Handbook for Management of Animals in Disasters & Emergencies, Version 01 – June 2022, Sphere India. https://www.sphereindia.org.in/sites/default/files/2022-08/HANDBOOK%20%282%29.pdf
[66] NDMA- Guidelines on Minimum Standards of Relief

322. Under this ADB funded project an EWS is being developed and villages in the 5 districts (Hojai, Nagaon, Morigaon, Karbi Anglong, Dima Hasao) will get flood early warning, therefore a mechanism should be devised to disseminate this among the community so that they can take precautions.

323. Community awareness on community roles during different phases of disaster, flood preparedness (including EWS, prepare measures to safeguard valuables, keep medicines and essentials during flood season, evacuate from vulnerable location ahead of time), response and shelter management can improve the flood disaster resilience of the communities.

324. Community should take an initiative to mark high flood water marks in the public area of the villages so that the communities will be aware of flood risk in the locality. Construction of Pucca houses, particularly on the elevated area can reduce flood impacts. Farmers should watch rainfall forecasts (seasonal forecast) and plan the farming activities accordingly. Diversification of livelihood helps in economic resilience which will improve flood disaster resilience of the community as well.

6.2.7. Preparedness plan and Response Plan

6.2.7.1. Disaster Mitigation and Development Plan

325. Disaster Preparedness Plan and Response Plan is developed for all the 5 villages.

Table 38: Activities under Disaster Mitigation and Development Plan

S. No.	Work needs to done	Responsibility
1.	Before the onset of the rainy season, repair village roads and arrange boats in case of emergency	Village Office
2.	DMC should inspect river banks and vulnerable locations and coordinate with DDMA to take protection measures	Village Office
3.	Arrangement of essential items including first aid kits, kerosene for generator, essential food items, drinking water and sanitation facilities in the shelters	DMC in coordination with shelter in-charge
4.	Awareness program at community level and schools	DMC in coordination with Asha workers or any local NGOs and school teachers

6.2.7.2. Village DM Committee and DM Team

326. The village has Village Land Management & Conservation Committee (VLCC) and will function as DMC and DMT.

6.2.7.2.1. Roles and Responsibilities

327. Roles and responsibilities during Normal Condition

- Meet on regular basis (monthly) to discuss about the development issues of the village
- Help village head to prepare documentation to send to revenue circle/district for any support for addressing development issues of the village
- Visit flood vulnerable locations before the rainy season and communicate to DDMA in case there are issues that needs to be addressed
- Maintain the list of contact numbers of team members and owners of resources which can be used for emergency situation
- Make inventory of vulnerable population in the community and ensure arrangement for support and means for transporting such people in case of emergency
- Sensitise community to maintain stock of essential materials and medicines before the start of rainy season.
- Urge community to scan and store important documents online or in digilocker.

328. Roles and responsibilities during Post warning

- Call an emergency meeting of the DMC
- Contact designated shelter buildings and make sure essential facilities are available in case of any emergency
- Communicate with DDMA in case any support is needed in case of any emergency
- Contact DMT and define their responsibilities
- In case if any warning is received for a flood situation, coordinate with DMT and other teams to plan for evacuation of vulnerable communities

329. Roles and responsibilities during Event

- Contact with the concerned authorities (DDMA, Field Officers) on a continuous basis.
- Coordinate with the DMT to minimize life loss and suffering in the community
- Coordinate with the Search and Rescue teams for immediate deployment post event.
- Ensure that the disabled, aged, women are sheltered safely

330. Roles and responsibilities during Post Event

- Need to coordinate with DMTs and various departments on relief and rescue activities
- Prepare situation report and share it with district authorities
- Support Revenue officials in damage assessment
- Facilitate and support officials to disburse relief funds

6.2.7.3. Communication & Warning Dissemination Plan

331. The early warning team will take all the required initiatives to disseminate the message. Identified safe shelters were done for all the 5 villages separately.

6.2.8. Resource planning

332. During rainy season, the DM committee should arrange boats and other vehicles to transport the communities in case of an emergency and they should keep in touch with the DDMA to get updates of flood forecast on a daily basis.

6.2.8.1. Roles and Responsibilities

333. Roles and responsibilities during Normal

- Confirm warnings from district control room/block control room/GP office & inform Village Land Management & Conservation Committee (VLCC) members.
- VLCC approves the dissemination of warning
- First Warning for all to return to their homes - individual and house hold preparedness commences
- Second Warning for VLCC meeting. House hold preparedness to continue
- Third Warning to move to shelter & safe places to commence
- Fourth Warning for all to be indoors except VLCC members.
- Head count and location of vulnerable people and moving them to safer places
- Fifth warning for all to stop moving and remain indoors

334. Roles and responsibilities during event

- Constant communication through mobile phone with District Control Room, Circle Office, Warning Dissemination Centre, Red Cross Control Room, Block Control Room & GP office & Assam Disaster Management Authority and VLCC members

335. Roles and responsibilities during post warning

- Confirm lifting of flood alert from District Control Room/ block control room/GP office & inform Secretary, President, Vice President & DM Team members.
- VLCC members to move out first for a quick assessment of the situation outside & then ask the community to return to their homes

6.2.9. Individual & Household Preparedness Plan

336. Individual & Household Preparedness Plan – After first warning

- Pack important document and valuable items (ornaments, cash) in safe place outside the flood vulnerable area
- Keep easy to cook and eat food and eat without cooking food items, drinking water and essential medicines for at least three days
- Pack clothes including under garments for three days
- Other essentials to keep handy include basic utensils, radio, cell phones with full charge, sticks, lanterns, match boxes, mosquito nets
- Move women, children, old people and sick persons to a safe zone

337. Second warning (VLCC/DMC)

- VLCC/DMC to ensure villagers move the vulnerable people of household to a safe area
- Ensure there is an adequate equipment and vehicles for evacuating people
- Coordinate with District authorities to get updates of flood warning

338. Third warning

- VLCC/DMC ensure all villages in the flood vulnerable zone have evacuated
- Coordinate with Police and Civil Defence to ensure law and order and safety of women and children
- Coordinate with shelter in-charge to ensure essential things are available and shelter is accessible to affected communities
- Coordinate with District authorities to get updates of flood warning

6.2.10. Disaster Management Team: Search and Rescue

6.2.10.1. Roles and Responsibilities

339. Normal

- Acquire training, create cadre of volunteers and impart training on rescue operations
- Participate in the preparation of Village DM plan and have a clear understanding of vulnerable areas and people at risk
- Keep stock of basic equipment (life jacket, life jackets made by indigenous people like float made by 5 litres plastic bottle), first aid box and a list of custodians of rescue instruments especially during monsoon season when there is a high chance of disaster
- Generate awareness among the villagers about various disasters and how to respond in case of any such event
- Organize mock drills

340. Warning phase

- Help in evacuation especially of people with special needs, aged, children, destitute and other vulnerable groups
- Keep rescue equipment ready
- Coordinate with the other DMTs for information

341. During Event

- Give priority to save life over material
- Utilize equipment and tools for rescue operations
- Operate in a calm and coordinated manner. Don’t venture into flood waters without safety guards and equipment
- Involve in rescue operations immediately and coordinate with civil defence and SDRF teams

342. Post Event

- Try to reach the flood affected locations immediately to save the lives of victims and make proper arrangements to shift patients to health centres/hospitals and affected people to shelter homes
- Help the government and para-medical staff
- Support government/ outside (NGO) medical teams to attend to the patients and inform about serious cases
- Stay connected with other teams
- Help people to get back to their homes once it is declared as safe
- Establish proper road communication to facilitate the movement of vehicles bringing medicines and relief.
- Help other teams in restoring normalcy
- Help DMC and Village Panchayat in updating the DM plan and rectify/enhance the plan, if required, based on experience.

6.2.11. Disaster Management Team: Shelter Management Plan

6.2.11.1. Roles and Responsibilities

343. Normal

- Update the list of pregnant women, children, sick people, old and disabled in the village
- Educate people on how to use disinfectants/water purifiers to get purified water and maintain good hygiene
- Make necessary arrangements to keep proper health and sanitation in the shelters
- Visit shelters to ensure that the shelters are in a good condition and has essential facilities like toilet
- Arrange mobile toilet if needed before the rainy season starts
- In case temporary toilet are required they need to be made separately for men and women. Special arrangements should be made for pregnant and ailing women
- Before the onset of flood season check the identified shelters in the community, and availability of keys for the buildings. Emphasis should be given to see whether the doors, windows, electrification, toilets, water tanks etc are in order.

344. Post Warning

- Maintain records of available food grains in ration shops and civil supplies outlet. Arrange dry rations, water, medicines, candles, kerosene, and utensils
- Arrange for prepositioning of the required items in the shelters and coordinate with the authorities regarding the same
- Allocate space for evacuees in the shelters on the basis of gender and special needs
- Ensure that people come to shelters with minimum requirements of food/water/candles/match boxes and other day to day requirements at least for three days

345. During The Event

- Try to accompany rescue teams in getting the victims/sick and ailing safe to the shelters
- Instruct evacuees to take proper food and drinking water
- Assure them not to panic. Steps should be taken to console them and council affected should be prepared to face the adverse situation
- Register the names of the evacuees. If anyone is found missing inform the Search and Rescue Team immediately. Make special arrangements for pregnant women and ailing persons
- The team should strictly maintain health/hygiene in the shelters
- Evacuees should be asked to use their own food stuff first. Ensure there is safe drinking water
- Organise community kitchen to provide food and drinking water for the evacuees
- Emphasis should be given to maintain peace in the shelters, especially people should be motivated /persuaded not to pay heed to any rumours
- A radio should be in use in order to know the current situation of the possible threats as well as its departure to avoid any confusion
- Establish contact with other teams and committee

346. Post Event

- Take proper care to avoid outbreak of epidemics in the community. If any outbreak is noticed, inform the health authority immediately with accurate information regarding the number of affected people and their symptoms
- Provide all the support to affected people in shelter locations till they go back to their homes
- Arrange/collect relief items from other sources to maintain buffer stocks
- Maintain cleanliness inside and outside the shelters
- Make necessary arrangements to provide food and safe drinking water to the people in the shelters
- Make necessary arrangements to immediately repair shelters if got damaged during any event
- Submit expenditure report, if any, to the Village Panchayat
- In case of any casualties dispose the dead bodies in a safe manner, collect details of the deaths, and coordinate with the DMC to provide victims family with eligible compensation

6.2.12. Standard Operating Procedures (SOP) for Village Disaster Management Committee

347. Get into action immediately on receiving a flood warning or information about emergency from DDMA. In case the warning came from any other sources, as a first step, call the DDMA / District Emergency Operation Centre (DEOC) to confirm the information

- Call an emergency meeting with DMC
- Check the flood shelters and availability of keys of the buildings and essentials required in the shelters and for rescue operation

- Inform the DMT and particularly the early warning task force to alert the villagers
- Hire generators, store kerosene/diesel/petrol for running the generator at the shelter location
- Keep a radio with new batteries and smart phones with full charge
- Arrange flash lights/torch lights and keep extra batteries for them
- Inform the fishermen not to venture for fishing in the river or ponds
- Check the flood shelter and store dry food/baby food, clean drinking water etc.
- Check with PHC and other medical institutions in the village to stock medicines, bleaching powder, and halogen tablets. Inform them regarding the warning and request them to be prepared with essential medicines and first aid items.
- Keep a copy of the Village DM map ready
- Inform ration shops and civil supplies shops about the warning and request them to stock food items
- Siren will be installed in all the 5 selected pilot villages.
- DMC will need to coordinate with respective DMT and ensure that all the team members are alerted and aware of their roles and responsibilities in case of an emergency.

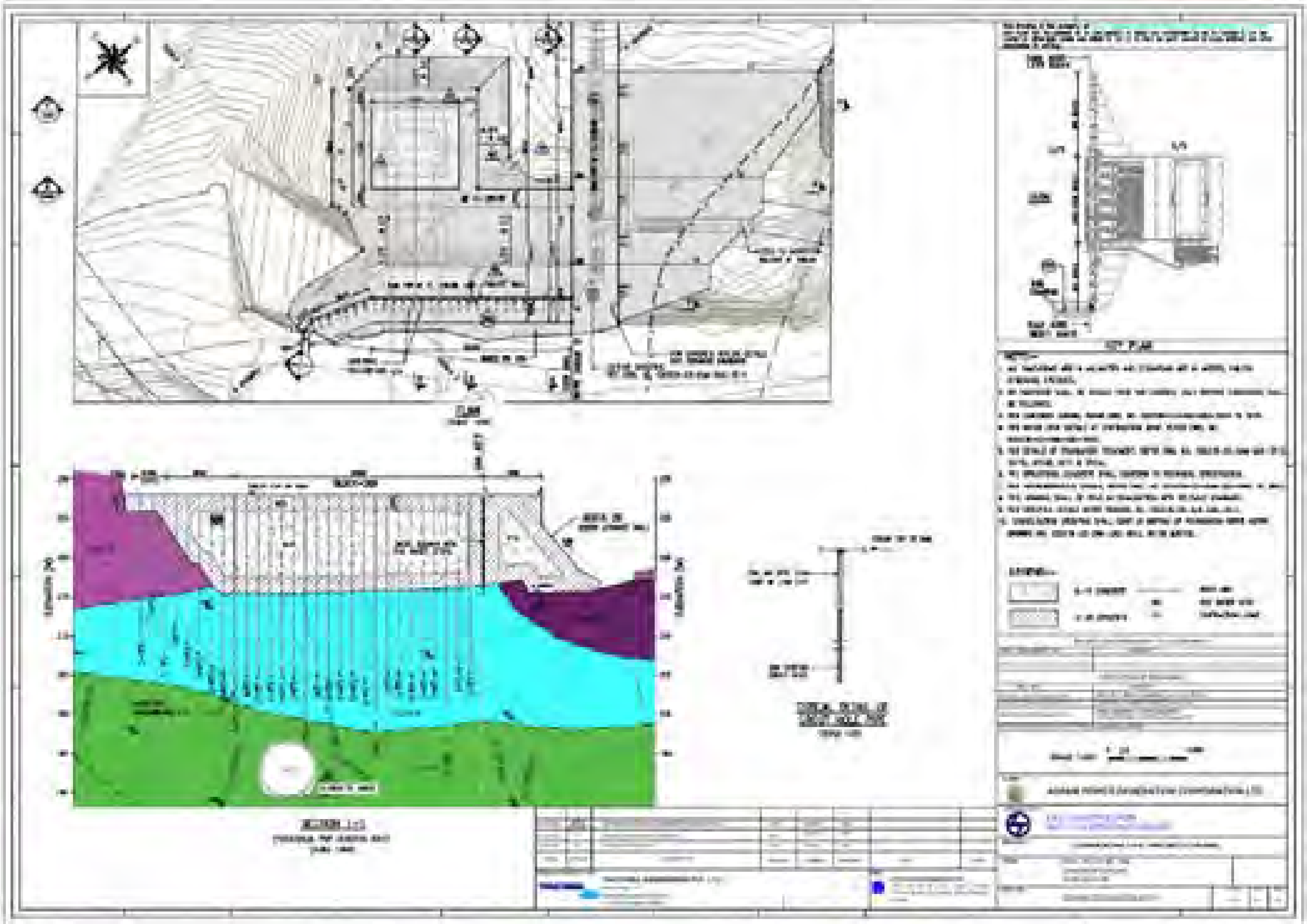
7. Update on Dam Investigation

348. Geological condition of dam – Geological Survey of India is monitoring the geological conditions of the dam. Experts of PMC, Dam engineer of Contractor, APGCL and Dam Safety Expert of External Monitor has also checked the detail design of the dam. After the approval of the CEA, GSI the design is endorsed by the State Dam Safety Committee the construction work started. Additional measures suggested by all the experts are incorporated during finalization of the design. The dam is safe as it was previously assessed during EIA stage.

349. Dam Block 20 has been abutted with a section of rock grade (w3-w4), which is expected to result in increased seepage from the upstream (U/S) to downstream (D/S) on the right bank. To mitigate this seepage, following measures have been proposed. One addition of Block 20A upstream of Block 20. This block is abutted with rock (w2-w3) on the U/S side, thus avoiding the rock grade (w3-w4). Grouting will be performed from the top of the block to minimize seepage.

350. All the dam blocks are checked for stability. As a result, all the concerned blocks have been analyzed as an independent structure which is also supported by IS:11130-1984 Clause 5.4.6.5. The excavated profile at upstream location up to intake gate is above the bottom level of block-18 so Filling the gap between block 18 & 20A is of no significance. There will be no seepage problem as grout curtain will be there as a seepage barrier along 20A and throughout the dam base. Block 20A (report no-O20318-DD-DDR-STR-112) has been designed considering all the load combinations mentioned in IS:6512-2019 (Figure 61). Block 20A has indeed been designed as a cladding wall.

Figure 61: Design of the dam Block No 20A.



8. Treatment of acidic water runoff

351. Design provisions as agreed for treatment of acidic water runoff collected from weep holes in tank with automatic pH meter, dozing apparatus etc before the water is pumped out to the river;

352. Referring to the seepage water generated near MPH, the provision of the side drains in the powerhouse area will collect all the seepage water and will be stored in 2 sump pits / chambers (2.0 m X 2.0 m X 3.0 m). The water will be discharged in the Kopili river through 2 pumps over the flood protection wall. The pH will be monitored in the sump pits and if below 6.5 the water will be neutralized by adding suitable base before releasing the water into the river. Where a neutralizing agent will be added to adjust the pH before discharge into the river complying the standard limit. Installing an automatic pH meter for dosage monitoring and establishing proper cleaning and disposal procedures for the sump area are recommended.

8.1. Neutralizing agent and dosage

353. Based on the data collected over the past two years and discussions with NEEPCO, the pH of the river water varies between 3.5 and 6 depending on various factors. Considering a pH value of 4, NaOH would be an appropriate neutralizing agent, especially since this is already in use by the contractors in the WTP for construction water. The neutralization system already present in the Water Treatment Plant (WTP) unit can be utilized for this purpose. To neutralize 10KLD (10,000 liters) of seepage water with pH 3.2 at maximum will need 200g of NaOH. NaOH or CaO will be used as per requirement.

354. The quantity of seepage water may vary during different season. The quantity of base needed for neutralization is influenced by the initial pH of the water. Even a minor variation in the initial pH can lead to significant changes in the required amount of neutralizing agent. This substance not only helps to accurately regulate the pH of water, but also plays an effective role in preventing the growth of microbes, removing heavy metals, and reducing organic pollutants.

355. To properly handle and dispose of NaOH and waste, several best practices should be followed. These include using appropriate personal protective equipment, such as gloves and goggles, when working with caustic soda. It is important to store and transport the waste in suitable containers to prevent leaks or spills. Disposal methods should adhere to local regulations in secure landfill site, which may include neutralization or treatment processes as per rule.

9. Environment Management Plan

356. Environment Management Plan for the Construction and Operation Phase is updated incorporating the recent findings of rheophytes which are Critical Habitat-qualifying species that might be impacted by the Project. EAP was also prepared after the Dam Break Analysis and accordingly EMP was update in Table 39. Excluding the environment management measures suggested for the rheophytes rest of the construction phase EMP will remain same, Similarly, in the operation phase environment management measures suggested for the rheophytes; additional measures for implementation of EAP and the measures for embankment protection works in 5 selected villages, rest of the measures will remain same. All the plans and subplans of the earlier disclosed EMP plan of 2018 and Feb, 2024 will remain same.

Table 39: Updated Environment Management Plan for LKHEP

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
DESIGN AND PRE-CONSTRUCTION PHASE							
1.	Impact on air, water, noise, soil	Location and design of power house, office, substation and colony	• Siting of colony away from construction areas including plantation all around colony. • Drainage system with de-silting chamber, will be provided all around power house, office, substation and colony. • Solid waste storage bin system will be provided at required location. • All buildings are designed and will be constructed as per seismic zone provision. • The site-specific earthquake study has been completed by Department of Earthquake Engineering, IIT Roorkee. The site-specific design parameters recommended by IIT for MCE and DBE conditions are recommended as 0.36g and 0.18g for horizontal and 0.24g and 0.12g for vertical ground motion, respectively have been considered. The design has been reviewed by independent experienced dam expert appointed by ADB and found to be adequate. • A 3-layer dam design review process will be followed during detailed dam design process (contractor –PMC – external monitor). • Results of geological investigations and detail designs are being and will be monitored by GSI during construction of the dam complex.	Design Check	Document Review	DPR Consultant, PMSC	PMU
	Exposure to safety related risks			Design Check. As agreed 3-layer dam design review process to be followed during detailed dam design process (contractor – PMC – external monitor) as well as surveillance and inspection by the Government of Assam dam safety committee which is already being constituted by gazette notification.	Document R. view	DPR Consultant, PMSC	PMU
			• Dam safety surveillance and monitoring aspects are included. Personnel Safety equipment will be provided at required location.			EMC	APGCL, PMC

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			• Dam Safety Expert, EMC to conduct a site visit to confirm that all coffer dam and permanent dam safety risks including geological risks associated with the reservoir are being adequately addressed by the project.				
		60m bridge on Longku river	• After finalization of the bridge length and design over the river Langku by PWRD, fresh assessment will be done to check requirement of additional EMP measures if required.				
2.	Release of chemicals ashes in receptors (air, water, land)	Equipment specifications and design parameters.	• CFC not used in substation transformers or other project facilities or equipment by concerned agencies. • Processes, equipment, and systems will not use chlorofluorocarbons (CFCs), including halon.	Technical specifications	Document Review	DPR Consultant, PMSC	PMU
3.	Exposure to noise	Power Plant /Substation location	• Design of plant enclosures to comply with IFC EHS noise regulations (85 dB(A) at work sites for heavy industry.	Design Check	Document Review	DPR Consultant, PMSC	PMU
4.	Acquisition of private land	Location of powerhouse, head works.	• Acquisition of agricultural and cultivable land minimized.	Land area requirements	Document Review	PMU	PMU
5.	Social inequities	Involuntary resettlement or land acquisition.	• Compensation will be paid for temporary / permanent loss of productive land as per Govt. rules and regulation. • A list of all the affected persons by type of losses and extent of damages has been prepared through and the same will be compensated as per RTDP prepared as per GoI and ADB's SPS 2009 requirements.	No. of affected people and entitlement provisions	Document Review, Compensation process	PMU	Revenue Department

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
		1. "Longri Rongker", Borolongku 2. Religious structure worshiped by Karbi Community in Longku Nala including the Gate	• Shifting of worship place to Tortelangso after consultation with the villagers. • Replacement cost will be borne by APGCL			Villagers	APGCL
6.	Loss of precious Ecological values/impacts on precious	Encroachment into precious ecological areas.	• Minimize acquisition of forest areas • Minimise forest clearance alongside rights of way and Project infrastructure	Compensatory afforestation process, land	Document Review, Clearance papers	PIU, Forest Department	PMU, Forest Department
	species due to acquisition of 523 ha of forest land, vegetation cover under project footprint, reservoir, quarrier, and muck disposal area.		• Avoid encroachment by careful site and alignment selection of access roads, and transmission lines. • Ensure the construction of the power line is on the east of the existing road, so that it is outside of Krungming Reserve Forest. • Source construction materials from outside of forested areas. • Afforestation of 523 ha (1:1 tree planting ratio) of identified revenue land as per GOI norms. • Considering the requirement of Compensatory Afforestation @ 1:2 ratio as per the original EIA which was considered acceptable for 'No net loss of Biodiversity' NNL at the time of project approval. APGCL has complied the requirement in the ratio of 1: 3.06 covering the plantation area proposed under Catchment Area Treatment Plan (CAT Plan), etc.' • A compensatory afforestation and biodiversity conservation and management plan has been prepared (Annexure 9 of EIA 2018 and Appendix 1 of EIA Addendum of Feb 2024). • Cut only trees marked by the Forest Department • Ensure that the area is cleared as per	take, no. of trees to be cut			

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			directives/delineation of Forestry staff. • Work with government authorities and local communities to develop local Land Use Plan prior to construction to minimize /compensate loss of vegetation cover induced by displacement of agriculture.				
		Peaking power study	• Peaking power study will be updated after obtaining hourly flow data and based on the updated reservoir operation plan which will be available before reservoir filling.				
		Mortality due to collision with, or electrocution by, transmission lines.	• Ensure anti-electrocution measures in line with international good practice guidance. • Add bird flight diverters in line with international good practice guidance as detailed in Annexure -8.	No. of mortalities	Document Review, Clearance papers	PIU, Forest Department	PMU, Forest Department
7.	Nuisance to neighboring properties	Noise related	• Substations, powerhouse, head works designed to ensure noise will not be a nuisance. Noise will be controlled within IFC EHS noise standards. In any case, there is no proximity of residences to these features.	Technical specifications	Document Review	DPR Consultant, PMSC	PMU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
8.	Flooding hazards/ loss of agricultural production	Interference with drainage patterns/ Irrigation channels	• The alignment of river channel and siting of project facilities are done to avoid any flooding hazard. Detailed hydrological assessments have been carried out as part of detailed design. Additional IWRM management plan has been prepared. • Dam Break Analysis and disaster management plan has been prepared (Annex 30 of EIA 2018). This will be revised based on new design and peaking operation study. • A 3-layer dam design review process will be followed during detailed dam design process (contractor –PMC – external monitor). During the safety review if the reviewers recommend to update any studies related to change in design including dam break analysis and emergency response planning, they will be updated accordingly	Design Check	Document Review	DPR Consultant, PMSC	PMU
9.	Environmental pollution	Escape of polluting materials	• Transformers designed with oil spill containment systems, and purpose-built oil, lubricant and fuel storage system, complete with spill cleanup equipment. • Construct 110% fenced and bermed area with impermeable concrete floor. • Powerhouses/substations to include drainage and sewage disposal systems (septic tanks, sewage treatment plant) to avoid offsite land and water pollution.	Design Check, technical specifications	Document Review	DPR Consultant, PMSC	PMU
10.	Contamination of receptors (land, water)	Equipment submerged under flood	• Powerhouses/substations constructed above the high flood level (HFL) i.e. 185.34 m, by raising the foundation pad. This level also includes any possible effects from future climate change.	Design Check	Document Review	DPR Consultant, PMSC	PMU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
11.	Natural disaster frequently observed	Ground subsidence/ landslide	• Civil design and sitting of project facilities has been done with due considerations to earthquake and landslide to avoid any hazard. • A 3-layer dam design review process will be followed during detailed dam design process (contractor –PMC – external monitor). During the safety review if the reviewers recommend to update any studies related to change in design including dam break analysis and emergency response planning, they will be updated accordingly	Design Check	Document Review	DPR Consultant, PMSC	PMU
12.	Fire hazards	Explosions/fire	• Design of Powerhouses/substations has included modern fire control systems/firewalls in accordance with the norms of National Fire Protection Association (NFPA) and Tariff Advisory Committee (TAC). • Provision of firefighting equipment to be located within 20 m of transformers, power generation equipment. Fire protection and Safety practice havebeen prepared (Annex 28, 29 of EIA 2018).	Design Check	Document Review	DPR Consultant, PMSC	PMU
13.	Tree cutting	Cutting of trees during site clearance	• Restricting tree cutting within construction limit. • Avoiding tree cutting at ancillary sites. • Providing and maintaining compensatory tree plantation i.e. three times of cutting. • Compensatory afforestation plan prepared.	No. of trees to be cut	Observations	Forest Dept./PIU	PIU
14.	Removal of vegetation covers (dust, pollution)	Work site clearance	• Use of controlled clearing activities • Use of dust control measures • Collection and disposal of debris and muck.	Vegetation to be cleared	Observations	PIU	Forest Dept./PIU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
15.	Removal of utilities	Work site clearance	• Necessary planning and coordination with concerned authority and local body. • Prior notice to and consultation with concerned authority, local body and public to be affected to ensure that work does not get affected and impact on public is minimum.	Utility shifting plan	Observations	Concerned utility agencies / PIU	CSC/PIU
16.	Religious places	Work site	• Suitable mitigation measures have been incorporated in social impact assessment report. • Archaeological / religious sites assessment including consultation with government and community users will be done as per SPS requirements before reservoir filling starts.	RTDP	Observations	PIU	CSC/PIU
17.	Camp site and contractor facilities	Establishment of contractors' facilities	• Obtain permits and NOCs from ASPBC and other statutory agencies. • Contractor to submit a camp and site office plan defining all facilities to be created. These include human waste disposal facilities and solid waste management facilities. The basic plans provided in Annex 17 of EIA 2018) to be updated and finalized by contractor.	NOCs and permits	Document check.	PMU/PIU/ Contractor	ASPCB, PMU
18.	Project facilities and commencement of construction	Clearances and permits	• Obtain environmental clearance from MoEF&CC • Obtain forest clearance from forest departments • Include EMP in the contract documents.	Clearance letters	Document check.	PMU/PIU/ Contractor	MoEF&CC, Forest Dept., PMU
CONSTRUCTION PHASE							

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
1.	Impact and air, water, noise, soil	Civil construction work for power house, tunnel, office, substation, access roads, colony etc.	**Air Pollution**: • All the vehicles must have valid PUC certificates at all the time during construction phase of the project. • Water sprinkling shall be done to suppress the dust emissions from the site. • All the DG sets used for construction shall have valid consents from Assam State Pollution Control Board and shall have built-in stacks to reduce the air emission impacts. • Refer to Annex 24 of EIA 2018: Measures for Air Pollution Control • conduct water sprinkling at twice per day more if needed due to dry or windy conditions on the NH off-site access route since it is no longer surfaced before works start • extend grievance redress awareness raising to communities along the NH off-site access route in relation to any traffic related grievances • prepare traffic management plan setting out how the contractor will manage the off-site increase in H&S risk due to project vehicles plying on narrow unsurfaced road, including planning and staggering of traffic movements to avoid large increases in the existing HGV traffic flow and at time of peak traffic movement	PM10, Dust pollution, Complaints from local residents Equipment/ vehicle maintenance record Noise level, complaints from local residents, vehicle maintenance record, awareness programs implemented Drainage systems, Total solids and turbidity level	Measurement Observations, public discussions Noise level measurement, field observations, discuss with local residents Review records, site visit and observations, turbidity level and other water quality	Contractor Contractor Contractor	PMSC/PIU PMSC/PIU PMSC/PIU
			• to coordinate with PWD to minimize cumulative impacts of project traffic and their road works		parameters to be checked		

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
	Exposure to safety related risks		**Noise Pollution:** • Construction materials shall be properly maintained and noise barriers, if needed, shall be provided around worksites, to reduce the noise levels. Design of such barriers will be finalized by CSC environment specialist. • All the workers will be provided with personal protective equipment including ear plugs and other necessary provisions by the contractor. • Refer to Annex 25 of EIA 2018: Measures for Noise Pollution Control • to coordinate with PWD to minimize cumulative impacts of project traffic and their road works • extend grievance redress awareness raising to communities along the NH off-site access route in relation to any traffic related grievances • prepare traffic management plan setting out how the contractor will manage the off-site increase in H&S risk due to project vehicles plying on narrow unsurfaced road, including planning and staggering of traffic movements to avoid large increases in the existing HGV traffic flow and at time of peak traffic movement **Water Quality:** • Quality of water (river and wastewater discharged from the construction site) shall be analyzed monthly during	Planning for waste management	Review of planning and practices for waste management, site visit, observations	Contractor	PMSC/PIU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			construction, for its compliance to the disposal standards of pollution control authority. • Refer to Annex 26 of EIA 2018: Measures for Water Pollution Control • Seepage of water near the powerhouse area will be monitored and if Sulphide concentration found beyond the standard limits will be neutralized before release in the river Kopili during construction. • specific measures to be taken for neutralization during construction and operation such as specific quantity of lime addition to be done based on the quantity of water and location. **Others**: • Proper plantation all around colony. Refer to Annex 21 of EIA 2018: Green Belt Development Plan • Drainage with desilting chamber will be provided all around power house, office, substation and colony. • Ensure oil, chemical and solid waste are stored, handled and disposed of by appropriately licensed waste management contractors. • Solid waste storage bins system will be provided at required location. Refer to Annex 22 of EIA 2018: Solid Waste Management Plan • All buildings designed constructed as per seismic zone provision. • Safety system will be provided at required location. Refer to Annex 18, Annex 28, Annex 29 of EIA 2018 for Occupational, Health and Safety Plans.				

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			• If the contractor proposes to compost or landfill solid waste on site then the design, construction and operation of such facilities will follow GOI requirements and the requirements of the IFC EHS Guidelines on Waste Management Facilities. https://www.ifc.org/wps/wcm/connect/5b05bf0e-1726-42b1-b7c9-33c7b46ddda8/Final%2B-%2BWaste%2BManagement%2BFacilities.pdf?MOD=AJPERES&CVID=nPtj.3h&id=1323162538174				
2.	Infrastructure provisions at labor camps	Health and hygiene at workers camps	• Contractor during the progress of work will provide, erect and maintain necessary living accommodation and ancillary facilities for labor as per the requirements of applicable labor regulations of Government of India. • All the work sites and camp sites shall also be provided with basic sanitation and infrastructure as per the requirements of Building and other Construction Workers (regulation of Employment and Conditions of Service) Act, 1996. • Refer to Annex 12 of EIA 2018: Public Health Delivery System • Refer to Annex 18 of EIA 2018: Project Personnel Health Plan • Refer to Annex 28 of EIA 2018: Fire Protection in Labor Camps and Staff Colonies • Refer to Annex 29 of EIA 2018: Safety Practices during Construction	Planning for health and safety, practices being implemented	Review of planning and practices for seepage and spoil disposal, control, site visits	Contractor	PMSC/PIU
		Fire Protection in Labor Camp and Staff Colonies	• Safety Practices During Construction Phase • Refer to Annex 28 of EIA 2018: Fire Protection in Labor Camps and Staff Colonies	Planning for health and safety	Check record, observations, discussion with workers	Contractor	PMSC/PIU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
3.	Solid Waste Management	Construction camps	• Collection and disposal of human waste as per waste management plan. • Refer to Annex 22 of EIA 2018: Solid Waste Management Plan	Quantity of SW collected and disposed	Record check, observations	Contractor	PMSC/PIU
4.	Muck disposal	Tunneling and excavation activities	• Muck generated from various tunnelling and excavation activities would be dumped suitably to designated sites • If materials containing pyrites or any other obnoxious materials are found, they will be either coated / sealant will be applied or neutralized with lime (calcium hydroxide) or other alkaline materials before disposal. • Pyrite-containing materials can also be encapsulated within impermeable barriers in the dumping yard. • Refer to Annex 6 of EIA Addendum: Muck Disposal Plan. • Monitoring provisions for pyrites in excavated slopes, dumped muck, muck generated from tunnel, water draining out of the tunnels etc. • Ground water sampling will be done every six months near the dumping sites to now the sulphide level (Pyrite leaching)	Quantity of muck generated and disposed	Record check, observations	Contractor	PMSC/PIU
5.	Construction sites	Restoration of sites	• Restoration of construction sites. • Refer Annex 19 of EIA 2018: Construction Site Restoration Plan.	Physical inspection of sites	Record check, observations	Contractor	PMSC/PIU
6.	Noise and vibrations	Equipment layout and installation	• Construction techniques and machinery selection seeking to minimize ground disturbance. • Refer to Annex 25 of EIA 2018: Measures for Noise Pollution Control • If there is any damage to the house or structures of the villagers due to blasting / vibration, contractor to repair the damage.	Noise and vibration levels monitoring	Noise and vibration monitoring record	Contractor	PMSC/PIU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			• monitoring cracks, slope instability, soil/ rock loosening like features around blasting sites regularly apart from that of the structures.				
7.	Disturbed farming activity	Physical construction	• Construction activities on cropping land time to avoid disturbance of field crops (within 1 month of harvest wherever possible).	Crops damaged	Observations	Contractor	PMSC/PIU
8.	Noise vibration and operator safety, efficient operation, equipment wear and tear	Mechanized construction	• Construction Mechanized maintenance and turning of plant. • Proper maintenance and turning of plant • Implement environmental mitigation and good-construction as integral component of each civil activity and as day-to-day activity	Planning for health and safety	Record check, observations	Contractor	PMSC/PIU
9.	Increase in airborne dust particles	Construction of access roads	• Existing roads and tracks used for construction and maintenance access to the site wherever possible. • Refer to Annex 24 of EIA 2018: Measures for Air Pollution Control	Dust levels	Record check, observations	Contractor	PMSC/PIU
10.	Increased land requirement for temporary accessibility	Construction of access roads	• New access ways restricted to a single /Intermediate carriageway width. • Refer to Annex 20 of EIA 2018: Road Construction Management Plan	Planning for access roads	Observations	Contractor	PMSC/PIU
11.	Temporary blockage of utilities	Construction work	• Temporary placement of fill in drains/canals not permitted	Water blockage	Observations	Contractor	PMSC/PIU
12.	Loss of vegetative cover	Site clearance	• Marking of vegetation to be removed prior to clearance, and strict control on clearing activities to ensure minimal clearance.	No. of trees to be cut	Review clearance papers, field observations	Contractor/Forest Dept.	PMSC/PIU
13.	Fire hazards	Trimming/cutting of trees	• Trees allowed growing up to a specified height within the work areas by maintaining adequate clearance between the top of tree and the conductor as per the regulations.	No. of trees to be cut	Observations	Contractor	PMSC/PIU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			• Forbid smoking outside designated areas, which will be located away from forests and flammable materials.				
14.	Loss of vegetation and deforestation		• Trees that can survive pruning to comply should be pruned instead of cleared. • Ensure qualified botanist participates in detailed pre-clearance surveys to identify all threatened and Critical Habitat-qualifying species; avoid clearing these where possible. • Where clearance of threatened and Critical Habitat-qualifying species is unavoidable, transfer plants to appropriate restoration plot and/or nursery for care prior to later restoration. • Felled trees and other cleared or pruned vegetation to be disposed of as authorized by the statutory bodies. • Avoid all nighttime driving.	No. of trees to be cut	Review clearance papers, field observations	Contractor	PMSC/PIU
	Loss of vegetation and deforestation	Reservoir clearing	• Removal of maximum commercially viable timber. • All remaining timber, after commercial and salvage logging operations have been completed, will be cut as necessary. • Avoid removing stumps, as disturbed soil may release far more nutrients in water. • Phase wise clearance after obtaining requisite permission from Forest Department is to be done in such a way that soil erosion due to uprooting and GHG emission due to left over stump of terrestrial species both are minimal.	Area to be cleared	Review clearance papers, field observations	Contractor	PMSC/PIU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			• Vegetation clearance of reservoir area shall be completed prior to impounding of the reservoir				
15.	Loss of vegetation and deforestation	Wood/vegetation harvesting	• Construction workers prohibited from harvesting wood in the project area during their employment, (apart from locally employed staff continuing current legal activities). • Contractor should arrange LPG gas for cooking of food for their workers.	Fuel supply to workers	Review clearance papers, field observations	Contractor	PMSC/PIU
			• Refer to Annex 17 of EIA 2018: Plan for Construction Camp Management				
		Degradation of vegetation due to introduction of invasive alien species.	Avoid introduction of new invasive species to, and spread of existing invasive species within, the Project area through: - washing of vehicles, equipment and supplies before entry to the Project area; - monitoring for invasive species; and - control/eradication of invasive species where found.	Field observations	Review clearance papers, field observations	Contractor	PMSC/PIU
		Loss and degradation of vegetation due to induced influx of people, and increased access to forests.	• The Contractor will prepare an Influx Management Plan, which will include a focus on local employment and working with local authorities to identify and remove any spontaneous settlements near to the Project (which would be illegal). • Install staffed access control to project-specific roads, allowing access to no-one except company or contractor staff, or government officials, and inspecting departing vehicles for wildlife and forest products. Temporary roads will be closed after the construction phase.	Field observations	Review clearance papers, field observations	Contractor	PMSC/PIU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
16	Loss of Biodiversity, Disturbance/accidents/injury, to wildlife and avian fauna	Construction and clearing of forest areas	• Implementation of Compensatory afforestation plan. • Creation of a greenbelt around the perimeter of various project appurtenances, selected stretches along reservoir periphery, access roads to compensate for the loss of habitat. • Provisions of adequate signages and speed limit on road sections within forest areas to avoid accidental road kills. • Poaching activities should be monitored in workers areas and well	Incidences of wildlife loss	Review clearance papers, field observations	Contractor	PMSC/PIU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			as community areas (as per Annex 9 of EIA 2018). • Forbid smoking outside designated areas, which will be located away from forests and flammable materials. To guard against the risk that (illegal) smoking occurs, enclosed metal rubbish bins will be provided across all active work areas so that any cigarettes can be disposed of safely, and disposal of cigarettes outside of these rubbish bins will be strictly penalized. • Implementation of Biodiversity Conservation and Management Plan (Annex 9 of EIA 2018 and Appendix 1 of EIA Addendum of Feb 2024) • Compliance with guidelines issued by the National Wildlife Board of India for linear intrusion in natural area pertaining to roads and power lines. • Compliance with guidelines issued by the CEA for laying transmission lines in areas critical from the point of view of saving wildlife. • Provision of wild fruit plantation for wildlife • Annual bird count of migratory birds by involving locals and bird experts • Rehabilitation with local fruit bearing species in gaps • Anti-grazing drive in drawdown area to protect the bird breeding areas in proximity to reservoir during breeding season – only in winter season. Grazing by local people will be allowed during dry season. • Construction of check posts/watch towers in key locations				

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			• Avoid spoil disposal in forested areas, including downhill of roads. • Source construction materials from outside of forested areas. • Conservation actions as proposed by IUCN (during construction and during the initial project operation) such as conducting a comprehensive survey and monitoring in and around the project area to establish range, distribution and population status of vulnerable and critical habitats in the project area for assessing its habitat requirements and identifying threats are proposed. • Establishment of biodiversity conservation committee. • Refer to Annex 9 of EIA 2018: Biodiversity Conservation and management Plan • Refer to Annex 4 of EIA Addendum: Biodiversity Annex • Refer to Annex 21 of EIA 2018: Green Belt Development Plan				
		Fragmentation of vegetation by road improvements and the reservoir.	• Minimize forest clearance alongside rights of way (including avoiding pushing soil downhill from roads into forest); retain canopy cover across roads wherever feasible.	Field observations	Review clearance papers, field observations	Contractor	PMSC/PIU
17.	Runoff to cause water pollution, solid waste disposal	Surplus earth work/soil	• Excess fill from excavations disposed of next to roads or on barren land or personal in agreement with the local community or landowners. • Soil excavated from power houses will be disposed as safe & scientific manner by placement on barren land or along back fill trench weir etc. • Avoid spoil disposal in forested areas, including downhill of roads.	Vehicle maintenance record, review plans for waste management and oil handling practices	Review of planning and practices for seepage and spoil disposal, control, site visits	Contractor	PMSC/PIU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
18.	Loss of soil and water pollution	Substation construction	• Fill for the substation foundation obtained by creating or improving local water supply ponds or drains, with the agreement of local communities. • Construction activities involving significant ground disturbance (i.e., substation land forming) not undertaken during the monsoon season. • In disturbed soil areas, ensure use of compacted straw (straw bales), silt fence, fiber rolls, gravel bags, or other approved sediment control. At a minimum, protected all bare soil prior to rain. • Dewater and clean coffer dams to prevent siltation, by pumping from cofferdams to a settling basin or a containment unit. • In disturbed soil areas, ensure use of compacted straw (straw bales), silt fence, fiber rolls, gravel bags, or other approved sediment control. At a minimum, protected all bare soil prior to rain.	Planning for soil conservation	Record check, observations	Contractor	PMSC/PIU
19.	Contamination of receptors (land, water, air)	Storage of chemicals and materials	• Fuel and other hazardous materials securely stored above high flood level with safety measures. • Refer to Annex 18 of EIA 2018: Project Personnel Health Plan	Vehicle maintenance record, review plans for waste management and oil handling practices	Record check, observations	Contractor	PMSC/PIU
20.	Noise nuisance	Construction schedules	• During work near settlements construction activities only undertaken during the day and local communities will be informed of the construction schedule.	Noise level monitoring	Record check, observations	Contractor	PMSC/PIU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
21.	Contamination of receptors (land, water, air)	Provision of facilities for construction workers	• Construction workforce will be provided for certain facilities it includes proper sanitation, water supply and waste disposal facilities. • Refer to Annex 17 of EIA 2018: Construction Camp Management Plan	Planning for health and safety	Review of planning and practices for seepage and spoil disposal, control, site visits	Contractor	PMSC/PIU
22.	Loss of agricultural productivity	Encroachment into agricultural land	• Use of existing roads wherever possible. • Ensure existing irrigation facilities are maintained in working condition. • Protect/Preserve topsoil and reinstate after construction completed. • Repair/reinstate damaged bunds, etc. after construction completed	loss of agricultural products	Record check, observations	Contractor	PMSC/PIU
23.	Social inequities	Encroachment into agricultural land	• Compensation for temporary loss in agricultural production as per provisions of Resettlement and Tribal Development Plan	RTDP	Record check, observations	Contractor	PMSC/PIU
24.	Soil loss, downstream siltation; etc.	Uncontrolled erosion/silt runoff	• Need for access tracks minimized, use of existing roads. • Ensure no periods of zero flow during construction or operation. • Limit site clearing to work areas regeneration of vegetation to stabilize works areas on completion (where applicable). • Avoidance of excavation in wet seasons. • Water courses protected from siltation through use of bunds and sediment ponds. • Refer to Annex 26 of EIA 2018: Water Pollution Control Measures • Release an E-flow which is scientificallycalculated, based on the local ecosystem and ecology of species of conservation concern, and downstream inflows from tributaries.	Soil erosion planning and cases	Record check, observations	Contractor	PMSC/PIU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
25.	Losses to neighbouring land uses/values	Nuisance to nearby properties.	• Contract clauses specifying careful construction practices on every stage. • Maximum existing access ways will be used. • Productive land will be reinstated following completion of construction.	Construction planning	Record check, observations	Contractor	PMSC/PIU
26.	Social inequities	Nuisance to nearby properties.	• Compensation will be paid for loss of production, if any as per provisions of Resettlement and Tribal Development Plan	CRTDP	Record check, complaints, observations	Contractor	PMSC/PIU
27.	Flooding and loss of soils, contamination of receptors (land, water)	Flooding hazards due to construction impediments of natural drainage.	• Avoid natural drainage pattern/facilities being disturbed/ blocked/ diverted by ongoing construction activities. • Refer to Annex 30 of EIA 2018: Dam Break Analysis and Disaster Management Plan • The emergency response plan for community during construction is also incorporated in the Disaster management Plan (Annexure -39) • Contractor to take care of all staff and workers within the project area in the event of flood during construction and DLP period as per emergency response plan of the contractor. • Project proponent, APGCL to implement the provisions of disaster management plan during breach of coffer dam during construction beyond the Project site if communities are impacted downstream. APGCL through Revenue department will repair and restore the properties damaged due to cofferdam breach in the downstream during flood. (Annexure -39)	Construction planning	Record check, observations	Contractor, APGCL	PMSC/PIU
28.	Contamination of receptors (land, water)	Equipment submerged under flood	• Equipment stored at secure place above the high flood level (HFL) i.e. 185.34 m..	Construction planning	Record check, observations	Contractor	PMSC/PIU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
29.	Loss of land values	Inadequate siting of borrow areas	• Existing sites (if available) will be used, therefore, no need to develop new sources of aggregates.	Construction planning	Record check, observations	Contractor	PMSC/PIU
30.	Injury and sickness of workers and members of the public.	Environment, Health and safety	• Arrangement of Environment awareness programme. • Contract provisions specifying minimum requirements for construction camps. • Preparation and implementation of health and safety plan. • Arrangement of primary health centre with medicine and instrument with a knowledgeable health staff. • Arrangement for health and safety training sessions. • Refer to Annex 12 of EIA 2018: Public Health Delivery System • Annex 16 of EIA 2018: Plan for Environmental Training of Workers • Refer to Annex 17 of EIA 2018: Plan for Construction Camp Management • Refer to Annex 18 of EIA 2018: Project Personnel Health Program • Refer to Annex 22 of EIA 2018: Solid Waste Management Plan • Refer to Annex 23 of EIA 2018: Emergency Plans for Hazardous Materials • Refer to Annex 24 of EIA 2018: Measures to Control Air Pollution • Refer to Annex 25 of EIA 2018: Measures to Control Noise Pollution	Training and awareness programs, Health and safety plans	Review of planning and practices for seepage and spoil disposal, control, site visits	Contractor	PMSC/PIU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			• Refer to Annex 26 of EIA 2018: Measures to Control Water Pollution • Refer to Annex 27 of EIA 2018: Energy Conservation Measures • Refer to Annex 28 of EIA 2018: Fire Protection In Labor Camp And Staff Colonies • Refer to Annex 29 of EIA 2018: Safety Practices During Construction Phase • Refer to Annex 30 of EIA 2018: Dam Break Analysis and Disaster Management Plan				
31.	Likely to maximize damages	Inadequate construction stages monitoring.	• Training to personal of implementing agency for environmental monitoring work. • Implementation of effective environmental monitoring and reporting system using checklist of all contractual environmental requirement. • Appropriate contact clauses to ensure satisfactory implementation of contractual environmental mitigation measures.	Training and awareness programs, Environment monitoring plans	Record check, observations	Contractor	PMSC/PIU
32.	Water processing plant	RO Plant, Water treatment plant of CP2, Water treatment CP1 for permanent colony	• Candles to be sent to the recyclers • Treatment of sewage sludge may include a combination of thickening, digestion, and dewatering processes.	Training and awareness programs on water treatment for the maintenance staff	Record check, observations	Contractor	PMSC/PIU
33.	Safety of the workers in the underground works	Underground work sites (HRT, Adit, Surge shaft, Pen stock, etc	• Use of colour code (Tag in Tag out) • Regular monitoring of obnoxious gases • Proper ventilation of underground works (average air velocity in the largest excavated profile is not less than 0.3 m/s.) • Area to be adequately illuminated	Training and awareness programs on safety. Accident records, Root Cause Analysis,	Record check, observations	Contractor	PMSC/PIU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			• Access to communication system • First aid facilities, Rescue team and ambulance to be kept near tunnel work site. • Refer to Annex 29 of EIA 2018: Safety Practices During Construction Phase	Risk Assessment.			
34	Degradation/ mortality of rheophilic vegetation due to introduction of invasive alien species.	Identified rheophilic species locations U/s and D/S of Dam	Take care to avoid introduction of new invasive species to, and spread of existing invasive species within, the Project area through: - washing of vehicles, equipment and supplies before entry to the Project area; - monitoring for invasive species; and - control/eradication of invasive species where found.	Periodic Monitoring		Contractor / Forest Department	Forest Department, APGCL, PMC
35	Degradation of rheophilic vegetation from accidentally spilled fuel/oil/chemicals or surface runoff.	Identified rheophilic species locations U/s and D/S of Dam	• Use coffer dams and silt screens/fences to prevent migration of silt during construction within the river. • Dewater and clean coffer dams to prevent siltation, by pumping from cofferdams to a settling basin or a containment unit. • Appropriately secure construction materials and chemicals during wet weather to avoid accidental release to the natural environment. • Stockpile materials and waste (including spoil) so as to avoid erosion and washing off into the river; establish drainage trenches to divert surface runoff from the site. • Ensure no waste materials are dumped in the river, including re-enforced concrete debris. • Prevent dumping of waste from concrete mixers in the river. • Prevent refuelling of all vehicles and machinery within 50 m of any watercourse, drain or channel leading to a	Periodic Monitoring		Contractor	APGCL, PMC

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			water course. • Locate temporary fuel tanks at least 50 m away from any watercourse, drain, or channel leading to a water course. Place tanks in covered areas with berms or dikes installed to intercept spills, if any. Immediately localize and clean up any spills with absorbent materials. • Ensure oil, chemical and solid waste are stored, handled and disposed of by appropriately licensed waste management contractors.				
36	Degradation of downstream rheophilic vegetation due to peaks and fluctuations in water flow, and consequent fluctuations in sediment and acidity release, scouring, and armouring.	D/S of Dam	• Ensure absolutely no periods of zero flow during construction. • Offset and in-situ management will be planned as per the detail assessment. • In situ conservation of existing populations within the area of influence , if taken up, should involve a comprehensive study of the five species in question and modification of the hydrological regime in order to meet their habitat requirements • Steps that can be followed to decide on the requirement of offset management and guidelines for plan formulation are: Step 1. Assess whether any of the apparently Critical Habitat-qualifying rheophilic plants have significantly broader distributions than currently known. Consultation with experts involved in description of, or previous surveys for, these four species should identify any river stretches beyond the Kopili which may potentially hold these species but have not yet been surveyed. Surveys in those locations could potentially reveal much wider distributions for these species, thus reducing the relative significance of Project	Periodic Monitoring		Contractor/ Ecology expert/ PMC/ APGCL / Forest Department	APGCL / Forest Department

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			impacts. If species are found to be very widespread, they would no longer qualify the Project EAAA as Critical Habitat and thus require no specific offset actions. Step 2. Assess the scale of direct impacts to Critical Habitat-qualifying rheophilic plants under the Project footprint (including the reservoir). This will require surveys by expert botanists at appropriate seasons for identification (during flowering seasons for each species), at least throughout the entire reservoir area. It is not necessary to count each individual plant which will be lost – estimates can be extrapolated from mapped areas of rheophilic vegetation and counts of individuals within sample plots. However, it will be necessary to ensure some of the Critical Habitat-qualifying rheophilic plant species are not missed in the Project footprint. Step 3. Assess the scale of downstream impacts to Critical Habitat-qualifying rheophilic plants from the Project's power generation plans. This will require environmental/ecological flow modelling. Step 4. Consult an expert botanist on the findings of Steps 1-3 (above) to identify whether Project impacts are significant. This requires botanical and ecological expertise, to assess – on a precautionary basis – if impacts might be relevant at the population level for each species. As a rule of thumb, however, loss of 5% of known populations would likely be considered significant, whereas smaller losses may not be.				

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			Step 5. Modify the Project power generation plan to avoid any significant impacts on Critical Habitat-qualifying rheophilic plants The challenge of offsetting any such impacts is so high (see Step 8) that the most realistic approach is to avoid them in the first place, or the Project is unlikely to be able to meet ADB safeguard requirements. Step 6. Where significant impacts are possible for any Critical Habitat-qualifying rheophilic plant species, assess offset options. Offset options for these species would comprise either (i) areas in which these plants have previously been lost/reduced (for non-Project reasons), and where they can be reintroduced/ expanded because threats have been/can be removed, or (ii) areas in which threats to these plants are clear, imminent and predictable, and could be prevented. The scale of an offset will depend on the type of offset and the specific context of each site – offsets do not require a simple 1:1 ratio of area. In option (i), the area of offset will depend upon the recovery/growth/expansion rate feasible for plants over the life of offset. For example, if plants are being reintroduced to an area and can only re-establish rheophilic vegetation at 50% of the quality of a natural vegetation community during the life of the offset, at least a 2:1 area ratio would be necessary. For option (ii), in a similar way, the offset size will depend upon the predictable rate of loss expected during the life of offset. For example, if habitat is expected to be degraded by 25% without the offset, during its life, at least a 4:1 area ratio would be necessary.				

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			Step 7. If offset options exist, implement offsets. This will involve (i) restoration and/or protection work (see Step 6, above). The success of both of these will depend upon security of tenure of the areas, so the Project through concerned authority at district or state level. Step 8. Assess whether the Project has achieved No Net Loss for any significantly impacted Critical Habitat-qualifying rheophilic plant species. Further actions will be to conduct Intensive surveys to :- 1. cover all the patches for identification of the species of endemic rheophytes with qualified botanist and plant physiologist. 2. identify any existing populations that are outside of the project's area of influence and consider their suitability for conservation. Identification of offset locations. 3. Extent of occurrence of the species. 4. Selection of propagation method.etc.				
37		Aquatic ecology survey upto 95 km downstream	• There is fluctuation of water level till 95 km downstream. As a precautionary measure during the August September study for the rheophytes, baseline aquatic life upto 95 km will also be considered.		Investigation of water quality and aquatic life (Fish, Plankton, Benthos, etc)	APGCL, PMC	APGCL
38	Submergence of village road	In the Reservoir Spread area in Revenue Land.	• The two village roads likely to be submerged between Borolongku to Lorelangsu and road from NH 627 to Tortelangso needs to be raised or bridge / culvert to be constructed prior to impoundment of reservoir. • The bridge at NH672 is proposed to be	Maintain the connectivity		APGCL	APGCL, PMC

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			elevated by PWD prior to submergence				
39	Wetland Management Plan for reducing the flood risk	Downstream	• Wetland Management Plan for creating a cushion for flood water is being prepared by APGCL through RMSI. This will be shared with eth district authorities for implementation as would be applicable			RMSI for preparation. District Administration for implementation as per applicability	APGCL, District Administration through concerned departments like Revenue department , Fisheries Department
40	Conduct awareness campaigns consultations with downstream villagers on emergency response and disaster management plan.		• After finalization of EAP, APGCL through DDMA and ASDMA to carryout the community awareness raising and mock drills prior to reservoir inundation.			DDMA, ASDMA	APGCL
41	Flood shelters (under VDMP)	• 5 selected villages	• Shaded area to accommodate cattle required during rainy season in Phanglangpso (350 sqm), Dakhin Kenduri (700 sqm), Namtaradubi (350 sqm), Kakati Gaon (1400 sqm), Thengbhanga (1400 sqm). • Phanglangpso - 4 additional class rooms are needed in existing LP with total proposed built up area of 210 sqm • Dakhin Kenduri - The shelter needs to be reconstructed to elevation above 74 m with total BUA of 1750 sqm • Namtaradubi needs a shelter of 175 sqm BUA for 50 person above the HFL of 66 m. • Kakati Gaon - Need new multi facility centre of 350 sqm BUA for 100 people and near the railway station adjacent to	Before every monsoon checking the facilities in the relief camps		DDMA, District authorities	DDMA, District authorities

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			the railway track where elevation is above HFL i.e. 60.7 m • Thengbhanga - Plinth height to be increased or new shelter of 420 sqm BUA to be constructed above the HFL54.5 m. • Year round food / fodder storage in the flood shelters • Locker system for storage of food grains and important items • Maintenance of records of food grain stored by individuals and taken out from the shelter to avoid conflict amongst villagers.				
OPERATION PHASE							
1.	Loss of vegetation and deforestation	Wood/vegetation harvesting	• Staff working at site prohibited from harvesting wood in the project area during their employment, (apart from locally employed staff continuing current legal activities). • APGCL/Contractor should arrange LPG gas for cooking of food for their workers.	Loss of forests	Record, observations	Forest Dept./PIU	APGCL
2.	Tree plantation	-	• Compensatory afforestation plan.	Survival rate of trees (70% minimum)	Field observations	Forest Dept./PIU	APGCL
3.	Wildlife and Biodiversity	Loss of wildlife / biodiversity	• Implementation and monitoring of biodiversity conservation plan activities.	Change in habitats	Field observations	Forest Dept./PIU	APGCL
	Mobile terrestrial fauna (especially birds and mammals)	Displacement of species due to noise from normal traffic or maintenance activities.	• Regularly maintain and inspect/certificate all vehicles, equipment and machinery to ensure that noise levels conform to prescribed standards.	Change in habitats	Field observations	Forest Dept./PIU	APGCL
	Medium-/large-sized birds (especially Amur Falcon)	Mortality due to collision with, or electrocution by, transmission lines.	• Ensure anti-electrocution measures in line with international good practice guidance. • Add bird flight diverters in line with international good practice guidance.	Change in habitats	Field observations	Forest Dept./PIU	APGCL

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			(Annexure 8)				
	Exploited terrestrial species (particularly Blond-bellied Langur & Amur Falcon)	Mortality due to increased access.	• Install staffed access control to project-specific roads, allowing access to no-one except company or contractor staff, or government officials, and inspecting departing vehicles for wildlife and forest products. Temporary roads will be closed after the construction phase.	Change in habitats	Field observations	Forest Dept./PIU	APGCL
	Riverine habitat, including parts of the Pobitora Wildlife Sanctuary and KBA	Degradation of downstream aquatic habitat due to fluctuations in water flow, and consequent fluctuations in sediment and acidity release.	• Ensure no periods of zero flow during operation. • Release an E-flow which is scientificallycalculated, based on the local ecosystem and ecology of species of conservation concern, and downstreaminflows from tributaries. • Ramp up to peaking operations at a speed slow enough to ensure that (i) aquatic species, particularly those of conservation concern, can seek refuge in lower-flowing parts of the river; (ii) scouring of the riverbed and resulting armoring is minimized; and (iii) there are not surging peaking "waves" of water downstream which cannot be mitigated by downstream inflows from tributaries.	Change in habitats	Field observations	Forest Dept./PIU	APGCL
	Environmental Awareness	Awareness programme in all the villages along the project corridor including the transmission line.	• Conduct periodic awareness programmes related to local wildlife, their conservation significance, their role in maintaining ecosystem integrity in the villages inside PIA including the use of scientific dissemination materials in local language	Training and awareness programs	Record, observations	Forest Dept./PIU	APGCL

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
	Road kills	To prevent road kills	• Conduct monitoring and listing of such incidents and the records should be shared with the forest department to strategize mitigation action. The equipped rescue team recommended below is to be prepared to address such incidents.	Road kill incidents	Record, observations	Forest Dept./PIU	APGCL
	Rescue and rehabilitation	Rescue team stationed at Panimur Range Office	• A wildlife rescue rapid response team should be established with the help of forest department, local NGOs/Institutions, and experts to address rescue and other snake bite incidents.	Wildlife rescue rapid response team established	Record, observations	Forest Dept./PIU	APGCL
	Wetland management	Coordination between various stakeholders having an interest in the wetland. Define monitoring requirements and research needs in future.	• The Dam will create a type of wetland and may support migratory avifauna in future thus futuristic wetland management plan to be prepared	Wetland Management Plan	Record, observations	Forest Dept./PIU	APGCL
4.	Contamination of receptors (land, water)	Equipment may submerge under flood	• Equipment will be installed above the high flood level (i.e. 185.34 m) by raising the foundation pad. This level also includes climate change factors.	Pollution levels	Record, observations	APGCL	APGCL
5.	Soil Erosion	-	• Implementation and monitoring of Catchment Area Treatment Plan (Annex 10 of EIA 2018) prepared.	Catchment Area Treatment	Record, observations	APGCL	APGCL
6.	Dam Break and Disaster management	Dam Break and Disaster management	• Installation of alert system in control room • Setting up of communication system in various villages • Flood Forecasting Arrangements • Follow Disaster Management Plan (Refer to Annex 30 of EIA 2018) • Operation phase Disaster Management Plan is being prepared under JFPR grant. DMP being updated and it will be	Disaster Management Plan	Record, observations	IIT, Roorkee, JFPR consultants / APGCL, ASDMA	ASDMA, APGCL

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			implemented and rolled out to community before impoundment. • Siren to be installed near Dam, Near Power House, Panimur and in 5 selected villages downstream before the impounding of the Reservoir.. • VDMP has suggested few measures which has to be implemented through the respective departments. (Ref Table No. 32)				
7.	Water Quality	Water quality change	• Monitoring once in every season at various locations • Monitoring of water quality restoration plan • Seepage of water near the Powerhouse area will be monitored and if Sulphide concentration found beyond the standard limits will be	Water quality parameters	Record, observations	APGCL	APGCL
			neutralized before release in the river Kopili during construction. • Cement/ lime lined channels for operations period for treatment of water before release in Kopili River				
	Water Quality (Eutrophication)	From the reservoir to U/S 5.5 km, water impoundment will occur once the reservoir is filled causing chances of nutrient release absorbed with sediments.	• Monitoring of water quality • Removal of algae from reservoir (through aeration, mixing, ultrasonic control etc., use of ecotoxic aquatic herbicides (algaecides) used to treat algal bloom will not be permitted). • Control Jhum cultivation in the areas immediate to submergence area • Cover the exposed soil with vegetation to reduce excess load of sediments	• Quality Parameters • Growth of periphyton/ Phytoplankton and blue green algae	Record observation near the dam site especially in summer and winter season	APGCL	APGCL

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
8.	Ecology	-	• Monitoring of Ecology of the project area shall be done once in each season. • Monitor Critical Biodiversity Areas in the forest and in the river continuously • Conduct bird survey after the Transmission Line is completed	Biodiversity Conservation Plan	Record, observations	APGCL Forest Department	APGCL
9.	Land use Pattern	-	• Monitoring of Land use pattern once in a year	Land use pattern	Record, observations	APGCL	APGCL
10.	Injury and sickness of staff/workers	Inadequate provision of staff/workers health and safety during operations	• Careful design using appropriate technologies to minimize hazards. • Safety awareness raising for staff. • Preparation of emergency plan and training given to staff, for their implementation. • Adequate sanitation and water supply facilities will be provided.	Training and awareness plan, safety plans	Record, observations	APGCL	APGCL
11.	Injury/mortality to staff and public	Electric shock Hazards	• Careful design using appropriate technologies to minimize hazards. • Security fences around substations/ powerhouse/ head works. • Barriers to prevent climbing on/dismantling of transmission towers. • Appropriate warning sign on facilities. • Electric safety awareness rising in project areas. • Fire hydrant point and fire extinguisher may be placed at appropriate places.	No. of incidences	Record, observations	APGCL	APGCL
12.	Unnecessary environmental losses of various types	Operation and maintenance staff skills less than acceptable	• Adequate training in O&M to all relevant staff of substations and transmission line maintenance crews. • Preparation and training in the use of O&M manuals and standard operating practices.	Training plans	Record, observations	APGCL	APGCL
13.	Diminished ecological and social values.	Inadequate periodic environmental monitoring.	• Proper environmental monitoring of project operations and maintenance activities.	Environment parameters	Monitoring Records, observations	APGCL	APGCL

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
14.	Release of chemicals and gases in receptors (air, water, land)	Equipment periodic environmental monitoring	• Processes, equipment and systems using chlorofluorocarbons (CFCs), including halon, should not be used in any stage of equipment.	Environment parameters	Record, complaints, observations	APGCL	APGCL
15.	Nuisance to neighbouring properties.	Noise related	• Powerhouses/substations sited and designed to ensure noise will not be a nuisance	Equipment performance	Record, complaints	APGCL	APGCL
16.	Operational performance	All environmental aspects	• APGCL shall monitor the operational performance of the various mitigation measures implemented in the project.	Environment and ecological parameters	Record, complaints, observations	APGCL	APGCL
17	Vibration		Dam instrumentation already done or planned as per Technical Specification of Dam Instrumentations along with drawings complying the Guidelines of CWC, Central • Dam Safety Organization for Large Dams(Jan 2018).	Vibration monitoring will be carried out through Dam instruments	Record observation near the dam site	APGCL	APGCL
	Additional Measures for the Operation Phase						
		Kopili River	***In-situ* conservation**				
18	**Improvement of aquatic diversity**	Dima Hasao, West Karbi Anglong, Hojai, Nagaon Marigaon	**Green zone:** Selected portion (minimum 5 km river path length) of the non-impact zone (downstream of Station 7) of the river may be declared as green zone where fishing activities may be restricted to provide breeding/nesting/feeding ground for the indigenous fish population of the river.		Review	Fisheries Department / Forest Department / APGCL	District administration
19		Dima Hasao, West Karbi Anglong, Hojai, Nagaon Marigaon	**Fishing ban during the breeding period:** Strict regulations may be enforced to ban fishing activities in the river specially during breeding period of the fishes (mostly in the monsoon period- June to August)		Review	Fisheries Department / Forest Department / APGCL	District administration

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
20		Dima Hasao, West Karbi Anglong, Hojai, Nagaon Marigaon[67]	**Mesh size regulation:** Mesh size of the nets operated in the rivers must be regulated as per the law for conservation of indigenous fish species / germplasm.		Review	Fisheries Department / Forest Department / APGCL	District administration
21		Dima Hasao, West Karbi Anglong, Hojai, Nagaon Marigaon	**Community awareness:** Awareness and training programmes on importance of indigenous fish germplasm and its conservation may be organized in nearby localities (nearby villages of Karbi Anglong & Dima Hasao to the LKHEP) to sensitize the local population. Awareness programmes may be organized in the form of mass scale meetings using AV aides.		Review	Fisheries Department / Forest Department / APGCL	District administration
22		LKHEP u/s and d/s	**Downstream monitoring plan:** Since the current study was carried out for only for 4 months, the complete picture of aquatic life including indigenous ichthyofauna of the study river stretch may not emerge in this report Hence a more comprehensive monitoring study of the downstream impacts on aquatic life covering all the seasons may be planned to obtain a detailed understanding of downstream impact on aquatic life. **Approximate budget requirement:** Rs.10,00,000.00 **Timeline:** Regular monitoring after commissioning of the project	**Complete One year monitoring to cover all seasons**	**Sampling and analyzing**	Fishery department/ Professional fisheries institute	APGCL
23		LKHEP u/s and d/s	**Downstream management plan:** Based on the downstream monitoring study, a downstream management plan may be	Checking	Review of the Implementation every 6 months	Fishery department/ Professional fisheries institute	APGCL/ Fisheries expert

[67] Assam Fisheries Rule, 1953 has prohibited use of Berjal / Mahajal or Fasijal or any type of net with meshes less than 7 cm Bar / 14 cm mesh during breeding season w.e.f. 1st April to 15th July in any proclaimed fisheries under Rule 23(1). The use of net less than 1 cm Bar / 2 cm mesh in the size (Mohajal) is prohibited in any fishery throughout the year under Rule 23 (2).

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			prepared to safeguard the aquatic life of the river in the non-impact zones. Declaration of restricted zones, breeding grounds etc. may be considered as management plans. **Approximate budget requirement:** Rs.15,00,000.00 **Timeline:** Regular monitoring after commissioning of the project				
24		LKHEP u/s and d/s	**Dedicated river ecology monitoring team:** After commissioning of the dam and during its operation, it is expected that there will be a regular fluctuation of water quality parameters which may affect the aquatic organisms downstream. Considering this fact, a dedicated river ecology monitoring team comprising of fisheries experts, aquatic ecologists may be engaged to regularly monitor the impacts during operation of the dam and also to initiate immediate response whenever required. **Approximate budget requirement:** Recurring expenditure. **Timeline:** Regular monitoring after commissioning of the project	Checking	Review of the Implementation every 6 months	Fishery department/ Professional fisheries institute	APGCL or their representatives
25		LKHEP u/s and d/s	**Periodic fish based bioassay:** Periodic regular fish based bioassay of the Kopili river water should be conducted during construction and after commissioning of the dam in the impact as well as in the non-impact zone of the river to assess the suitability of the river environment for aquatic lives. **Approximate budget requirement:** Rs.5,00,000.00 per year **Timeline:** Regular monitoring	**Checking**	**Review of the Implementation every 6 months**	Fishery department/ Professional fisheries institute	APGCL/Professional fisheries institute

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
26		LKHEP u/s and d/s	**Alternative fish centric livelihood options for local fisherfolks:** As the previous reports suggested, the river was the habitat of many indigenous fish species. But in recent years, the indigenous fish population has been declining at an alarming rate which ultimately affects the livelihood of the local fisherfolks. Considering this fact, fish culture-based livelihood options may be promoted in villages proximity to the river for self-employment of the local fisherfolks	**Checking**	**Review of the Implementa tion every 6 months**	Fishery department/ Professional fisheries institute	APGCL/Professi onal fisheries institute
27			**Inventory of aquatic life:** An inventory of aquatic flora and fauna of River Kopili may be prepared comprising updated information for use of the future scholars and reserachers interested to work in this area. **Approximate budget requirement:** Rs.5,00,000.00 **Timeline:** After commissioning of the project	Checking	Review of the Implementati on every 6 months	Fishery department/ Professional fisheries institute	APGCL/Professi onal fisheries institute
			Ex-situ conservation				
28		Downstream area from Station 7	Captive breeding: Captive breeding set-up (hatcheries) of indigenous fish species of River Kopili may be established for its seed production and reintroduction into the river. Cyprinid is the dominant group of fish recorded from the study stretch of River Kopili. This group also exhibit migration during various stages of life. Considering, earlier occurrence of these fishes in the study river hatchery construction may considered as a measure for captive breeding of these fishes in a suitable location (may be non-impact zones) proximity to the river for reintroduction of the fishes to the river.	Checking technical specifications	Review of the Breeding center every 6 months	Fishery department/ Professional fisheries institute	APGCL

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			Following forms hatcheries may be considered: A) Mahseer hatchery: For Golden & Chocolate Mahseer (DCFR Mahseer hatchery model) B) Carp hatchery: For species like *Labeo pangussia*, *Bangana dero* etc. (AAU Carp hatchery model) C) Wet lab facility for other Small Indigenous fishes. Approximate budget requirement: Rs.70,00,000.00 Timeline: Within two years of commissioning of the project.				
29		Upstream & downstream of LKHEP	**Ranching:** Scientific indigenous fish ranching programmes may be planned regularly in the river. Ranching can be considered as an effective measure for reintroduction of indigenous fishes. However, care must be taken to ensure that the seed of the indigenous fishes must be obtained from reputed hatcheries otherwise it may also lead to problems like inbreeding depression. **Approximate budget requirement:** Rs.3,00,000.00 **Timeline:** Every year.	Number of individuals of each species released	Review	Fishery department/ Professional fisheries institute	APGCL/ Fisheries expert
30		Upstream & downstream of LKHEP	**Cryopreservation:** Cryopreservation approach may be considered for conservation of germplasm of endangered, vulnerable, threatened and near threatened fish species of the River Kopili. **Approximate budget requirement:** Rs.20,00,000.00 **Timeline:** After commissioning of the project		Review	Fishery department/ Professional fisheries institute	APGCL/ Fisheries expert

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
31	Rheophytes conservation	Upstream & downstream of LKHEP upto Amring River	Raising nurseries, plantation in the upstream beyond the reservoir spread of LKHEP and downstream up to Amring river. Maintenance for 10 years. Covered under CAT Plan. The area of offset plantation will need to be protected, survival rate monitored, requisite measures for maintaining, replacement of dead plants etc will have to be done as per the offset management plan	Survival rate	Observation/ counting/ measurement of plant height	Forest Department	APGCL / Forest Department
32	Degradation of downstream rheophilic vegetation due to peaks and fluctuations in water flow, and consequent fluctuations in sediment and acidity release, scouring, and armouring.	D/S of Dam	• Ensure absolutely no periods of zero flow during operation.	Periodic Monitoring		Contractor, APGCL	APGCL, PMC
			• Put in place a power generation plan that ensures both that peak flows are sufficiently low, and that they are ramped up to sufficiently slowly, such that (i) aquatic species, particularly those of conservation concern, can seek refuge in lower-flowing parts of the river for the duration of peaking flows; (ii) scouring of the river bed and resulting armouring is minimised; (iii) there are not surging peaking "waves" of water downstream which cannot be mitigated by downstream inflows from tributaries; and (iv) downstream impacts do not reach aquatic Critical Habitat. Note : In the absence of information on current river flows, a detailed understanding of the Project's planned operational flows/peaking regime, and an understanding of inflows from downstream tributaries, precise mitigation (i.e., an appropriate power	Periodic Monitoring		Contractor, APGCL	APGCL, PMC

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			generation plan) cannot currently be prescribed.				
33	Awareness generation plan for Emergency Management Plan	5 downstream villages	• Awareness generation plan for dissemination of EAP information in the downstream villages will be prepared and implemented prior to impounding of dam which is prepared as per Guidelines for Developing Emergency Action Plans for Dams, CEA, 2016. • EAP includes responsibilities, notification flowcharts, inundation maps, possible emergency conditions, preventive actions to be taken, supplies and resources, implementation procedures			DDMA	ASDMA, APGCL, PMC
34	Flood Management through strengthening embankments	Downstream areas	• Potential Vulnerable Areas in the downstream areas (with no Existing Embankment) along Kopili River which needs attention from district authorities are 1. Baghuli, Diprang, Assam 2. Hathimara, Tumpreng, Assam 3. Rengthama, Kumurakata Reserve, Assam 4. Lankajan, Dakhin Laskar Pathar, Assam At locations with strong currents and sharp meandering, robust embankments with necessary revetment and scour protection are necessary. (Appendix 1)			WRD, District Administration	WRD, ASDMA, District Administration
35	Awareness generation on Ground water rejuvenation	Upstream & downstream of LKHEP	• Awareness for rejuvenation of the existing sources of ground water in the downstream villages to be carried out through CGWA. • CGWA to aware the people at the grass root level about co-operative management of the aquifer in an equitable manner by community efforts	No. of villages covered, No. of training conducted, no. of villagers responding positive to learning, no.	Regular interview/ written records, Monitoring the ground water table	CGWA	APGCL, CGWA

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			and aware the local communities on water conservation, finding indigenous solutions for meeting the water demands under their annual programme.	of villages implementing the measures			
	Ground water recharge	Upstream & downstream of LKHEP	• Management provision for recharging the ground water table/ rejuvenation of wells etc. to be initiated on pilot basis in few downstream villages in collaboration with the CGWB based on feasibility	Changes ground water table	Monitoring the ground water table	APGCL/ CGWA	APGCL / CGWA/District Administration
36	Peaking power flow and water level fluctuation on hourly basis may impact safety of tourist at Panimur	Panimur water fall, adventure camp etc.	To continue with the tourist activities, the operating partners will need to follow a strict protocol of timings, do's and don'ts in conformance with the dam operations plan. Also the tourist need to be made aware of the conditions prior to entering the sites or venturing for boating and rafting. Best option however would be to avoid tourist activities in the reservoir or downstream to ensure safety.			Forest Department/ Tourism Department	Forest Department/ Tourism Department/ APGCL

(Note: Annexures mentioned in the above table are in the EIA of June 2018)

273. Environment Management Plan for 220 kVA transmission line will be same as disclosed earlier in Feb, 2024.

10. Environment Monitoring Plan

357. Environment Monitoring Plan will be followed during Construction and operation phase as mentioned in EIA 2018. Additional measures (Table 40) will also be followed as per the addendum of Feb 2024 and outcome of the study.

Table 40: Additional Environmental Monitoring Plan

Environmental Features / stage	Parameters and Standards	Location	Frequency	Duration	Action Plan in case criteria exceeds the Standards/ does not achieve as planned	Responsible party	
Operation Phase						**Implementation**	**Supervision**
Regular monitoring provisions for pyrites in excavated slopes, dumped muck, muck generated from tunnel, water draining out of the tunnels etc (Mentioned in the EIA addendum, Feb 2024)	pH, SO4, Fe++	Deep tube well ground water from dump sites, tunnel water, seepage water from Powerhouse (covering runoff); and soil / muck samples From sump during operation	Once in a season for 2 years	-	Necessary treatment will be taken so that contamination of ground water can be averted. Discharge to Kopili river after compliance of the standard limits.	ContractorThrough approved monitoringagency	PMSC, PMU
Regular monitoring of ground water level	Survey of the wells and tube well along the Kopili River downstream of LKHEP. Monitoring of ground water level in selected wells	2 villages each district	Monsoon and post monsoon	5 years	Necessary awareness for ground water recharge	APGCL District Administration / CGWA CGWA	PMU
Durability and efficacy of Bird Flight Divertors		BFD installed sections (near reservoir) of 33 kVA, 220 kVA line	Once in a year before the bird migration time (before the winter)	10 years	Replacement of diverters as per CEA technical Specifications of BFD	APGCL (PIU)	PMU

Environmental Features / stage	Parameters and Standards	Location	Frequency	Duration	Action Plan in case criteria exceeds the Standards/ does not achieve as planned	Responsible party	
Operation Phase						**Implementation**	**Supervision**
Rheophytes monitoring	Survival rate monitoring of Rheophytes	Downstream and offset areas	6 monthly	5years	Replacement of plants; improvement in techniques if deemed necessary	Forest Department	APGCL
In situ conservation :- (during operation)	Survival rate monitoring of the existing plants.	Up stream and downstream of LKHEP	6 monthly	5 years	Revisit reservoir operation plan	Forest Department / APGCL	APGCL / Forest Department

11. Environmental Management and Monitoring Budget

358. A budget of Rs. 1849.182 million (US$23.39 million) has been estimated for implementation of EMP and will remain same. The details of environmental management budget are given in Table 41. Overall budget remains the same.

359. The originally EMP Budget (as per disclosed EIA) was US$12.90 m and now it will be US$23.39 million incorporating the revised compensatory afforestation cost, biodiversityconservation cost, cost for external monitor, LAD etc. Local Area Development (LAD) cost will be covered under RP / CRTDP as they are overlapping in the EMP and CRTDP. The cost of monitoring remains the same. Environment Clearance budget includes Resettlement and Rehabilitation plan Rs. 1821.94 million which is not considered in the EMP budget of ADB as it is included in CRTDP.

Table 41: Cost Estimate for Implementing Environmental Management Plan*

Sl. No.	Item Cost	Original as per EIA 2018	Revised as per interim Addendum February 2024	Remarks
		(INR million)	(INR million)	
1a	Compensatory Afforestation (CA), andBiodiversity Conservation (BC), etc	191.035	469.969	CA-159.42, OH-79.71, BC-190.979, SMC-39.86
1b	Net Present Value, Boundary pillar of Forest diverted area, Tree extraction / cutting cost (inForest land)		537.19	NPV- 491.14, BP-1.59, TE-44.46
1c	Additional biodiversity conservation measuresas part of CHA		1.84	(USD 25000)
2	Catchment Area Treatment	122.370	282.96	
3	Public health delivery system	42.360	42.36	
4	Muck management	34.000	34	
5	Stabilization of quarry sites	11.500	11.5	
6	Restoration and Landscaping of constructionsites	10.000	10	
7	Environmental management in road construction	16.952	16.952	
8	Greenbelt development	2.000	2	
9	Solid Waste Management	23.484	23.484	
10	Water pollution control	18.500	18.5	

Sl. No.	Item Cost	Original as per EIA 2018 (INR million)	Revised as per interim Addendum February 2024 (INR million)	Remarks
11	Energy Conservation measures	10.000	10	
12	Disaster Management Plan	37.000	37	
13	Local Area Development (LAD) Plan	58.100	37.4	As per approved CRDTP (May 2017)
14	Plan to preserve cultural identity of the locals	12.286	12.286	
15	Environmental Monitoring during constructionphase	10.992	10.992	
16	Monitoring and Evaluation Aspects	6.000	6	
17	Purchase of meteorological instruments	1.000	1	
18	Purchase of noise meter	0.100	0.1	
19	Water Quality Restoration Plan	65.000	65	Additional measures for improvement of aquatic life (12.8 INR million)
20	Training and Awareness Building	2.000	2	
21	External Monitor	94.510	159.8	As per PAM
22	Pre-construction baseline monitoring	50.000	50	
23	Environmental Monitoring during operationphase (for initial three years)	6.849	6.849	
	Total	**826.038**	**1849.182**	

Note:

- Bird diverters are incorporated in the EPC contract of CP-4 for the 33 kVA and 220 kVA lines. For the 400 kVA line APGCL has requested the INDIGRID i.e. the owner of the Silchar Missa Line crossing the Reservoir area. (Annexure 7)
- Pyrites testing, pyrite neutralization in water and muck will be covered under EPC contract ofCP 2.
- Cost of Rheophytes management will be covered under CAT Plan and Soil and Moisture Conservation Plan
- Management measures for improvement of the aquatic life and pilot rejuvenation of groundwater sources in the downstream (if feasible) will be covered under the Water quality restoration Plan.

12. Conclusion and Recommendation

360. This addendum to the EIA (disclosed in June 2018 and interim EIA Addendum of Feb 2024) has been prepared to cover the additional baseline data collected as part of pre-construction monitoring and biodiversity surveys (Annual bird count, survey of the rheophytes) including downstream and backwater aquatic ecology, considering the update in the dam design of the project as per the recommendation of Geological Survey of India, GOI, update on the Dam Break Analysis and the Emergency Action Plan. The assessment of the additional baseline data collected as part of the pre-cons and construction monitoring has been analysed to validate the data incorporated in the EIA report which was disclosed on ADB website.

361. The additional baseline biodiversity surveys conducted in February 2024 and May, 2024 reported additional species of flora (Rheophytes) and fauna (Bird species). A prior Critical Habitat Assessment identified the Project landscape to be possible or actual Critical Habitat for: two birds, one mammal, four plants, a unique forest assemblage, and two protected areas/internationally-recognized sites (Pilgrim 2022). New information on rheophilic plants leads to identification in this addendum that the Project landscape is Critical Habitat for an additional four plant species. Without mitigation, the Project might possibly have significant impacts on some Critical Habitat-qualifying biodiversity, most importantly loss and degradation of forests and rare/threatened plants under and around the Project footprint/quarries, degradation of downstream aquatic habitat owing to fluctuating flows/sediment/acidity during peaking operations, electrocution of birds on power infrastructure, spread of invasive alien species, and further habitat loss/degradation and wildlife disturbance/exploitation impacts owing to induced population influx and access to the area. Several general or standard mitigation/enhancement measures outlined in the disclosedEIA have been reviewed and additional mitigation and management measures necessary to reduce residual impacts on Critical Habitat-qualifying biodiversity and Natural Habitat to levelsin line with the ADB Safeguard Policy Statement (ADB 2009) has been included in the updatedproject EMP as formulated in this Final Addendum. For the most part, these are not anticipated to result in any significant Project time delays.

362. Aquatic and Migratory fish study was carried out under Downstream and Back water assessment as per MOEF&CC's requirement stipulated in the EC amendment in 3rd Jan 2024 by involving a Government Institute. Dam break analysis andemergency response plan was prepared by IIT, Roorkee based on the approved designs of the Dam and analysis of the recent flow series of 18 years. Reservoir Operation Plan prepared based on the 10 daily flow data. Bird Flight Divertors will be installed in the selected sections on the 220 kVA, 33 kVA and requested the owner of 44 kVA line for the installation of the same. Important rheophytic plant species were identified in the downstream and upstream of the dam. In the downstream there is no impact on the water level fluctuation. Although one important species of rhgeophyte has its distribution upstream of the LKHEP dam also which will be submerged. For that conservation initiative is proposed for creation of nursery for propagation of the species in the rocky river sections of Kopili under the

CAT Plan.

363. Moreover, additional in-depth studies are being carried out on few of the above aspects and expected to be completed before reservoir filling. And till then the hydro-electric plant will operate at base flow. During the implementation process if there is a change in the design of the project components, the EIA will be further updated.

364. For components which are not yet finalized such as provision of bridge over the submerged section of the national highway, APGCL is coordinating with Assam PWD to finalize the design and ensure that PWD is implementing the bridge construction in compliancewith provisions made in the project EMP for road components.

365. The APGCL PMU will ensure that the additional measures proposed in the updated EMP as part of this addendum are implemented prior to impounding of reservoir and there is adequate budgetary provisions of the Hydro Power Plant.

366. Habitat suitability in reservoir area and downstream locations (and elsewhere in Assam in relation to offset potential) for the distribution of the 4 endemic rheophyte species along with commitment to formulate and implement the offset management plan demonstrating how ADB's Safeguard Policy Statement 2009 critical habitat requirements will be met as would be applicable prior to dam impounding. Unless the commitments as agreed for rheophytes are met the hydro power plant will operate on base flow and not as peaking power plant to prevent potential impacts of diurnal variation in water levels and flow. Updated environment mitigation and monitoring plan along with other commitments in the report will be implemented prior to impounding of the reservoir.

Annexure 1 : Emergency Level Determination (Action Data Sheet Index)

RED ALERT	Event Description: UNEXPECTED FAILURE	SHEET A

RECOMMENDED ACTIONS

Emergency Planning Manager (May be split responsibilities, i.e. One person at the dam handling on Dam Site actions and a different person who can make notifications. APPLICABLE TO ALL ACTION DATA SHEETS)

A. Implement the "Failure Condition Notification Flowchart", using pre-scripted message.
B. Activate the Emergency Operations Center
C. Recommend to the Districts Collectors and Disaster Management authorities IMMEDIATE EVACUATION downstream of the dam and affected areas as per Local Evacuation Plan
D. Stay a safe distance away from the dam. The immediate concern is the safety of the downstream public.
E. Record all information, observations, and actions on an Event Log Form (FORM 1).

Dam Site Engineers

F. Stay a safe distance away from the dam
G. Observe conditions in Dam Site periodically and provide decision support as appropriate.

Dy.General Manager/ General Manager

H. Communicate and keep informed the Chairman/MD/Director, NEEPCO LIMITED.
I. Provide decision support and technical support to the Emergency Planning Manager as appropriate.

Evaluate conditions CONTINUOUSLY and determine if:

A. The event warrants downgrade if there is no longer an impending threat of dam failure with no additional rainfall occurring YET there is damage to the dam that prevents safe impoundment of water. All contacts on Event Level (Red) Notification Flow Chart shall be notified of downgrade to Event Level (Blue)
B. Event may be Terminated only when either:
- There is no longer an impending threat of dam failure with no additional rainfall occurring and it has been determined by Dam Safety staff safe to impound water or;
- The dam has failed AND there is no longer a threat to the downstream public All contacts on Notification Flow Chart shall be updated of changes.

Based on this evaluation, follow the appropriate action

A. EVENT LEVEL DOWNGRADE	B. TERMINATION	
Monitor conditions until damage is repaired	Go to Termination and Follow-up	

BLUE ALERT	**Event Description:** High intensity rainfall in the catchment area of reservoir, Reservoir level rising and rain continuing (inflow range more than 1500 Cumec and Dam Level from 90.00 to 95.2 m)	SHEET B1

RECOMMENDED ACTIONS

Emergency Planning Manager

A. Implement the "Watch Condition Notification Flowchart", using pre-scripted message.

B. Make careful observation and inspection of every part of the dam; this should be done to monitor without compromising the safety of anyone performing the tasks.

C. Record all information, observations, and actions on an Event Log Form (FORM 1).

D. Contact the Deputy General Manager/ General Manager at least daily to report the latest observations and conditions. If conditions change significantly, go to re-evaluation/decision section and follow relevant steps immediately.

Dam Site Engineers

E. Stay a safe distance away from the dam

F. Observe conditions in Dam Site periodically and provide decision support as appropriate.

Dy.General Manager/General Manager

G. Communicate and keep informed the Head of Power Station, NEEPCO LIMITED.

H. Provide decision support and technical support to the Emergency Planning Manager as appropriate.

RE-EVALUATION / DECISIONS

Evaluate conditions CONTINUOUSLY and Determine if:

A. The event can be terminated when the intensity of rainfall is dwindling as per the Forecast.

B. The event warrants escalation to ORANGE alert if the reservoir level reaches one meter below FRL.

All contacts on Notification Flow Chart shall be updated of changes.

Based on this evaluation, follow the appropriate action

A. EVENT LEVEL DOWNGRADE	B. TERMINATION	C. EVENT LEVEL ESCALATION
Monitor conditions until damage is repaired	**Go to Termination and Follow-up**	**Go to SHEET B2 (ORANGE Alert)**

ORANGE ALERT	Event Description: Either Large inflow to reservoir more than 2900 Cumec or Outflow from Dam above 2900 Cumec and Dam level is continuing to rise	SHEET B2

RECOMMENDED ACTIONS

Emergency Planning Manager

A. Implement the "Failure Condition Notification Flow Chart", using pre-scripted message.
B. Identify the areas that would be potentially impacted by the emergency events
C. Make careful observation and inspection of every part of the dam; this should be done without compromising the safety of anyone performing these tasks. Monitor water level in the reservoir in every hour.
D. Record all information, observations, and actions on an Event Log Form (FORM 1).
E. Contact the Deputy General Manager/General Manager hourly to report the latest observations and conditions. If conditions change significantly, go to re-evaluation/decision section and follow relevant steps immediately

Dam Site Engineers

F. Observe conditions in Dam Site periodically and provide decision support as appropriate.
G. Provide corrective actions or work as required.

Dy.General Manager/General Manager

H. Direct specific and appropriate procedures for reservoir operations.
I. Provide decision support and technical support to the Emergency Planning Manager as appropriate.

RE-EVALUATION / DECISIONS

Evaluate conditions CONTINUOUSLY and Determine if:

A. The event warrants downgrade to BLUE alert if rainfall is dwindling as per the Forecast.
B. The event remains at the current Event Level (No change in situation).
C. The event warrants escalation to RED alert if the integrity of the dam appears to be threatened by sudden or rapidly proceeding movements/displacements.
D. All contacts on Notification Flow Chart shall be updated of changes

Based on this Evaluation, follow the appropriate action

A. EVENT LEVEL DOWNGRADE	B. EVENT LEVEL REMAINS THE SAME	C. EVENT LEVEL ESCALATION
Go To SHEET B1 (BLUE ALERT)	Continue Recommended Actions on this sheet	Go To SHEET B3 (RED ALERT)

RED ALERT	**Event Description:** Large inflow to reservoir approach towards design flood discharge i.e (9000 Cumec); Water level has crossed FRL or Inflow or/and Spilling ≥ 4450 cumec	SHEET B3

RECOMMENDED ACTIONS

Emergency Planning Manager

A. Implement the "Failure Condition Notification Flowchart", using pre-scripted message.
B. Identify the areas that would be potentially impacted by the emergency events
C. Recommend to the Districts Collectors and Disaster Management Authorities IMMEDIATE EVACUATION downstream of the dam and affected areas as per Local Evacuation Plan.
D. Stay a safe distance away from the dam. The immediate concern is the safety of the downstream public
E. Record all information, observations, and actions on an Event Log Form (FORM 1).

Dam Site Engineers

F. Observe conditions from a safe place at dam Dam Site periodically and provide decision support as appropriate.

Dy.General Manager/General Manager

G. Provide decision support and technical support to the Emergency Planning Manager as appropriate.
H. Communicate and keep informed the Chairman/ED/Director (Technical), NEEPCO LIMITED

RE-EVALUATION / DECISIONS based upon ANNEX TABLE I

Evaluate conditions CONTINUOUSLY and Determine if:

A. the event warrants downgrade to ORANGE alert if there is no longer an immediate impending threat of dam failure and water level reduced to 1 m below FRL.
B. The event remains at the current Event Level (No change in situation).
C. All contacts on

Notification Flow Chart shall be updated of changes.

Based on this determination, follow the appropriate action

A. EVENT LEVEL DOWNGRADE	**B. EVENT LEVEL REMAINS THE SAME**	
Go to SHEET B2 (ORANGE ALERT)	**Continue Recommended Actions on this sheet**	

BLUE ALERT	**Event Description:** STRUCTURE CRACKING: Minor cracks (bigger than ¼ cm.) in the masonry/concrete structure, without leakage.	SHEET C1

RECOMMENDED ACTIONS

Emergency Planning Manager

A. Implement the "Watch Condition Notification Flowchart", using pre-scripted message.
B. Make careful observation and inspection of every part of the dam; this should be done to monitor without compromising the safety of anyone performing the tasks.
C. Monitor water levels in the reservoir. Install a measurement device to monitor progress/movement in crack(s).
D. Classify and describe the type of crack pattern and evaluate possible causes.
E. Record all information, observations, and actions on an Event Log Form (FORM 1).
F. Contact the DGM (Technical)/ HOP at least daily to report the latest observations and conditions. If conditions change significantly, go to re-evaluation/decision section and follow relevant steps immediately.

Dam Site Engineers

G. Photograph and record the location, direction (longitudinal, vertical, diagonal etc.), depth, length, width and offset of each crack that has been discovered. Compare observations with earlier results.
H. Closely monitor the crack for changes and look for structural damage, including mis-alignment, settlement, vertical and horizontal displacements.

Dy. General Manager/ Chief General Manager/HOP

I. Review the pertinent information in order to recommend appropriate actions to Emergency Planning Manager. Provide corrective actions or works as required.
J. Provide decision support and technical support to the Emergency Planning Manager as appropriate.

RE-EVALUATION / DECISIONS

Evaluate conditions CONTINUOUSLY and Determine if:

A. The event can be terminated if it is determined that the dam no longer pauses an immediate threat to downstream.
B. The event remains at the current Event Level.
C. The event warrants escalation to ORANGE alert if the cracks are enlarging AND leakage begins to flow from cracks.

All contacts on Notification Flow Chart shall be updated of changes.

Based on this evaluation, follow the appropriate action

A. TERMINATION	**B. EVENT LEVEL REMAINS THE SAME**	**C. EVENT LEVEL ESCALATION**
Go to Termination and Follow-up	**Continue recommended actions on this sheet.**	**Go to SHEET C2 (ORANGE ALERT)**

RED ALERT	**Event Description:** STRUCTURE CRACKING: Enlarging cracks with sudden or rapidly proceeding movements/ displacements in the masonry/concrete structure with severe leakage passing through.	SHEET C3

RECOMMENDED ACTIONS

Emergency Planning Manager

A. Implement the "Failure Condition Notification Flowchart", using pre-scripted message. B. Identify the areas that would be potentially impacted by the emergency events

C. Recommend to the Districts Collectors and Disaster Management Authorities IMMEDIATE EVACUATION downstream of the dam and affected areas as per Local Evacuation Plan.

D. Stay a safe distance away from the dam. The immediate concern is the safety of the downstream public

E. Record all information, observations, and actions on an Event Log Form (FORM 1).

Dam Site Engineers

F. Observe conditions from a safe place at dam Site periodically and provide decision support as appropriate.

Dy.General Manager/General Manager

G. Provide decision support and technical support to the Emergency Planning Manager as appropriate.

H. Communicate and keep informed the CMD/Director (Technical), NEEPCO LIMITED

RE-EVALUATION / DECISIONS based upon ANNEX TABLE I

Evaluate conditions CONTINUOUSLY and Determine if:

I. The event warrants downgrade to ORANGE alert if there is no longer an immediate impending threat of dam failure and water level reduced to 1 m below FRL.

J. The event remains at the current Event Level (No change in situation).

K. Event may be Terminated only when:

   a The dam has failed AND there is no longer a threat to the downstream public

All contacts on Notification Flow Chart shall be updated of changes.

Based on this determination, follow the appropriate action

A. EVENT LEVEL DOWNGRADE	B. EVENT LEVEL REMAINS THE SAME	C. TERMINATION
Go To SHEET C2 (ORANGE ALERT)	Continue Recommended Actions on this sheet	Go To Termination and Follow-up

BLUE ALERT	**Event Description:** INSTRUCTION: Instrumentation readings are beyond threshold values.	SHEET D1

RECOMMENDED ACTIONS

Emergency Planning Manager

A. Implement the "Watch Condition Notification Flowchart", using pre-scripted message.
B. Make careful observation and inspection of every part of the dam related with the instruments' measurements.
C. Monitor water levels and instrument readings for changes or anomalies.
D. Record all information, observations, and actions on an Event Log Form (FORM 1).
E. Contact the Deputy General Manager/General Manager at least daily to report the latest observations and conditions.
F. If instrumentation readings at the dam are determined to indicate a potentially dangerous situation, go to the re-evaluation/decision section and follow relevant steps immediately.

Dam Site Engineers

G. Contact the Quality assurance/monitoring Division to inform the anomalies.
H. Closely monitor the instruments' performance and increase frequency readings to determine negative/ dangerous trends.

Dy. General Manager/General Manager

I. Review all pertinent information in order to recommend appropriate actions to Emergency Planning Manager. Provide corrective actions or works as required.
J. Provide decision support and technical support to the Emergency Planning Manager as appropriate.

RE-EVALUATION / DECISIONS

Evaluate conditions CONTINUOUSLY and Determine if:

D. The event can be terminated if instrumentation readings back to normal or if instrument reading determined to be invalid.
E. The event remains at the current Event Level.
F. The event warrants escalation, if instrumentation readings at the dam are determined to indicate a potentially dangerous situation.

All contacts on Notification Flow Chart shall be updated of changes.

Based on this evaluation, follow the appropriate action

A. TERMINATION	B. EVENT LEVEL REMAINS THE SAME	C. EVENT LEVEL ESCALATION
Go to Termination and Follow-up	Continue Recommended Actions on this sheet.	Monitor conditions until damage is repaired.

BLUE ALERT	**Event Description:** MALFUNCTIONING OF GATES: Structural member of a gate, either broken or severely damaged, which prevent operation of the gate(s). No leakage or uncontrolled discharge is detected. Flood can be routed without damaged/ non-operational gate(s).	SHEET E1

RECOMMENDED ACTIONS

Emergency Planning Manager

A. Implement the "Watch Condition Notification Flowchart", using pre-scripted message.
B. Make careful observation and inspection of every part of spillways, gates etc.
C. Monitor water levels in the reservoir and flood forecasting reports continuously.
D. Record all information, observations, and actions on an Event Log Form (FORM 1).
E. Contact the Deputy Chief Engineer/Chief Engineer at least daily to report the latest observations and conditions. If conditions change significantly, go to re-evaluation/decision section and follow relevant steps immediately.
F. If forecasting reports bring about the need to operate the damaged/nonoperational gate(s) go to the re-evaluation /decision section and follow relevant steps immediately.

Dam Site Engineers

G. Contact the Hydro-Mechanical officials for rectifying defects
H. Monitor and supervise any remedial action and inform Emergency Planning Manager I. Assure forecast data is transmitted at a higher frequency than normal operations

Dy.General Manager/ Chief General Manager (Technical)/HOP

J. Review the pertinent information in order to recommend appropriate actions to Emergency Planning Manager. Provide corrective actions or works as required.
K. Provide decision support and technical support to the Emergency Planning Manager as appropriate.

RE-EVALUATION / DECISIONS

Evaluate conditions CONTINUOUSLY and Determine if:

A. The event can be terminated if the anomalies has been rectified and the gates back to normal operation
B. The event remains at the current Event Level.
C. The event warrants escalation to ORANGE alert if the forecast data indicate that it is impossible to handle the flood without the operation of damaged gate All contacts on Notification Flow Chart shall be updated of changes.

Based on this evaluation, follow the appropriate action

A. TERMINATION	**B. EVENT LEVEL REMAINS THE SAME**	**C. EVENT LEVEL ESCALATION**
Go To Termination and Follow-up	**Continue recommended actions on this sheet.**	**Go to SHEET E2 (ORANGE ALERT)**

<table>
<tr><td>ORANGE ALERT</td><td><u>Event Description:</u>
MALFUNCTIONING OF GATES: Structural member of a gate, either broken or severely damaged, which prevents operation or malfunction of the gate(s). Considerable leakage or uncontrolled discharge is detected. Flood cannot be routed without damaged/non- operational gate(s).</td><td>SHEET E2</td></tr>
</table>

RECOMMENDED ACTIONS

<u>Emergency Planning Manager</u>

A. Implement the "Failure Condition Notification Flow Chart", using pre-scripted message.
B. Identify the areas that would be potentially impacted by the emergency events
C. Make careful observation and inspection of every part of spillways, gates etc.
D. Monitor water levels in the reservoir and flood forecasting reports continuously.
E. Record all information, observations, and actions on an Event Log Form (FORM 1).
F. Contact the Deputy Chief Engineer/Chief Engineer hourly to report the latest observations and conditions. If conditions change significantly, go to re-evaluation/decision section and follow relevant steps immediately.

<u>Dam Site Engineers</u>

G. Observe conditions in Dam Site periodically and provide decision support as appropriate.
H. Provide corrective actions or work as required.

<u>Dy. General Manager/ Chief General Manager/HOP</u>

I. Study an emergency lowering of the reservoir.
J. Provide decision support and technical support to the Emergency Planning Manager as appropriate.

RE-EVALUATION / DECISIONS

Evaluate conditions CONTINUOUSLY and Determine if:

A. The event warrants downgrade to BLUE alert if leakage was stopped and but still repair action should be done.
B. The event remains at the current Event Level.
C. The event warrants escalation to RED alert if the leakage is rapidly increasing through gates or the failure of gate is imminent. Unexpected discharges during non-flood season should be considered as high-risk events where an escalation in the level of alert is necessary. All contacts on Notification Flow Chart shall be updated of changes

Based on this Evaluation, follow the appropriate action

A. EVENT LEVEL DOWNGRADE	B. EVENT LEVEL REMAINS THE SAME	C. EVENT LEVEL ESCALATION
Go to SHEET E1 (BLUE ALERT)	Continue Recommended Actions on this sheet	Go to SHEET E3 (RED ALERT)

RED ALERT	**Event Description:** MALFUNCTIONING OF GATES: Structural member of a gate, either broken or severely damaged, which prevents operation or malfunction of the gate(s). Unexpected high discharge is occurring. Flood cannot be routed without damaged/non-operational gate(s).	SHEET E3

RECOMMENDED ACTIONS

Emergency Planning Manager

A. Implement the "Failure Condition Notification Flowchart", using pre-scripted message.

B. Identify the areas that would be potentially impacted by the emergency events

C. Recommend to the Districts Collectors and Disaster Management Authorities IMMEDIATE EVACUATION downstream of the dam and affected areas as per Local Evacuation Plan.

D. Stay a safe distance away from the dam. The immediate concern is the safety of the downstream public

E. Record all information, observations, and actions on an Event Log Form (FORM 1).

Dam Site Engineers

F. Observe conditions from a safe place at Dam Site periodically and provide decision support as appropriate.

Dy. General Manager/ Chief General Manager (Technical)/HOP

G. Provide decision support and technical support to the Emergency Planning Manager as appropriate.

H. Communicate and keep informed the CMD/Director (Technical), NEEPCO LIMITED

RE-EVALUATION / DECISIONS based upon ANNEX TABLE I

Evaluate conditions CONTINUOUSLY and Determine if:

A. The event warrants downgrade to ORANGE alert if there is no longer an immediate impending threat of dam failure and water level lowered below the crest level of spillway.

B. The event remains at the current Event Level (No change in situation).

C. Event may be Terminated only when:

a. The gate has failed AND there is no longer a threat to the downstream public All contacts on Notification Flow Chart shall be updated of changes.

Based on this determination, follow the appropriate action

A. EVENT LEVEL DOWNGRADE	B. EVENT LEVEL REMAINS THE SAME	C. TERMINATION
Go To SHEET E2 (ORANGE ALERT)	Continue Recommended Actions on this sheet	Go To Termination and Follow-up

BLUE ALERT	Event Description: EARTHQUAKE: Measurable earthquake felt or reported and dam appears to be stable.	SHEET F1

RECOMMENDED ACTIONS

Emergency Planning Manager

A. Implement the "Watch Condition Notification Flowchart", using pre-scripted message. B. Make careful observation and inspection of every part of dam.
C. Be prepared for after shocks
D. Record all information, observations, and actions on an Event Log Form (FORM 1).
E. Contact the Deputy General Manager/General Manager at least daily to report the latest observations and conditions.
F. If inspection has determined a potentially dangerous situation, go to the re-evaluation /decision section and follow relevant steps immediately.

Dam Site Engineers

G. Conduct a comprehensive Dam Site inspection of the dam and appurtenant elements and make a report on most important finding.
H. Monitor and supervise any remedial action and inform Emergency Planning Manager

Dy.General Manager/Chief General Manager (Technical)/HOP

I. Review the pertinent information in order to recommend appropriate actions to Emergency Planning Manager. Provide corrective actions or works as required.
J. Provide decision support and technical support to the Emergency Planning Manager as appropriate.

RE-EVALUATION / DECISIONS

Evaluate conditions CONTINUOUSLY and Determine if:

A. The event can be terminated if the dam is determined to be stable and a sufficient amount of time has passed. After shocks are not expected.
B. The event remains at the current Event Level.
C. The event warrants escalation to ORANGE alert if the inspection has determined a potentially dangerous situation

All contacts on Notification Flow Chart shall be updated of changes.

Based on this evaluation, follow the appropriate action

A. TERMINATION	B. EVENT LEVEL REMAINS THE SAME	C. EVENT LEVEL ESCALATION
Go To Termination and Follow-up	Continue Recommended Actions on this sheet.	Go To SHEET F2 (ORANGE ALERT)

ORANGE ALERT	**Event Description:** EARTHQUAKE: Earthquake resulting in visible damage to the dam or appurtenances which can cause a potentially dangerous situation	SHEET F2

RECOMMENDED ACTIONS

Emergency Planning Manager

A. Implement the "Failure Condition Notification Flow Chart", using pre-scripted message.
B. Identify the areas that would be potentially impacted by the emergency events
C. Be prepared for after shocks
E. Make careful observation and inspection of every part of dam.
F. Monitor water levels in the reservoir and development of new damages or movements.
G. Record all information, observations, and actions on an Event Log Form (FORM 1).
H. Contact the Deputy Chief Engineer/Chief Engineer hourly to report the latest observations and conditions.
I. If visible damages aggravate, rapidly go to re-evaluation/decision section and follow relevant steps immediately.

Dam Site Engineers

J. Observe conditions in Dam Site periodically and provide decision support as appropriate.
K. Conduct a comprehensive Dam Site inspection of the dam and appurtenant elements and make a report on most important finding.
L. Provide corrective actions or work as required.

Dy.General Manager/Chief General Manager (Technical)/HOP

M. Study an emergency lowering of the reservoir.
N. Provide decision support and technical support to the Emergency Planning Manager as appropriate.

RE-EVALUATION / DECISIONS

Evaluate conditions CONTINUOUSLY and Determine if:

A. The event warrants downgrade to BLUE alert if the water level in the reservoir is lowered below the bottom level of the damaged section
B. The event remains at the current Event Level.
C. The event warrants escalation to RED alert if one or multiple of the conditions have been observed;

Uncontrolled release of water over dam/rapidly developing flow through cracks

All contacts on Notification Flow Chart shall be updated of changes

Based on this Evaluation, follow the appropriate action

A. EVENT LEVEL DOWNGRADE	B. EVENT LEVEL REMAINS THE SAME	C. EVENT LEVEL ESCALATION
Go To SHEET F1 (BLUE ALERT)	Continue Recommended Actions on this sheet	Go To SHEET F3 (RED ALERT)

<table>
<tr><td>RED ALERT</td><td><u>Event Description:</u>

EARTHQUAKE: Earthquake resulting in uncontrolled release of water over dam or rapidly developing flow through cracks or rapidly developing erosion through increased seepage</td><td>SHEET F3</td></tr>
</table>

RECOMMENDED ACTIONS

Emergency Planning Manager

A. Implement the "Failure Condition Notification Flowchart", using pre-scripted message.
B. Identify the areas that would be potentially impacted by the emergency events
C. Recommend to the Districts Collectors and Disaster Management Authorities IMMEDIATE EVACUATION downstream of the dam and affected areas as per Local Evacuation Plan.
D. Stay a safe distance away from the dam. The immediate concern is the safety of the downstream public
E. Record all information, observations, and actions on an Event Log Form (FORM 1).

Dam Site Engineers

F. Observe conditions from a safe place at dam site periodically and provide decision support as appropriate.

D Dy.General Manager/Chief General Manager (Technical)/HOP

G. Provide decision support and technical support to the Emergency Planning Manager as appropriate.
H. Communicate and keep informed the Chairman/MD/Director (Technical), NEEPCO LIMITED

RE-EVALUATION / DECISIONS based upon ANNEX TABLE I

Evaluate conditions CONTINUOUSLY and Determine if:

A. The event warrants downgrade to ORANGE alert if there is no longer an immediate impending threat of dam failure and water level lowered below the leakage level in the water.
B. The event remains at the current Event Level (No change in situation).
C. Event may be Terminated only when:
    a. The dam has failed AND there is no longer a threat to the downstream public

All contacts on Notification Flow Chart shall be updated of changes.

Based on this determination, follow the appropriate action

A. EVENT LEVEL DOWNGRADE	B. EVENT LEVEL REMAINS THE SAME	C. TERMINATION
Go to **SHEET F2** (ORANGE ALERT)	Continue Recommended Actions on this sheet	Go to Termination and Follow-up

<table>
<tr><td>BLUE ALERT</td><td><u>Event Description:</u>
SECURITY THREAT/ SABOTAGE: Unverified bomb threat or verified damage to the dam/ appurtenances with no impacts in the functioning of the dam</td><td>SHEET G1</td></tr>
</table>

RECOMMENDED ACTIONS

Emergency Planning Manager

A. Implement the "Watch Condition Notification Flowchart", using pre-scripted message.
B. Notify Law Enforcement Authorities to help to evaluate the situation.
C. Make careful observation and inspection of every part of dam.
D. Record all information, observations, and actions on an Event Log Form (FORM 1).
E. Contact the Deputy General Manager/General Manager at least daily to report the latest observations and conditions
F. If inspection has determined a potentially dangerous situation go to the re-evaluation /decision section and follow relevant steps immediately.

Dam Site Engineers

A. Access the dam only if the area has been cleared by Law Enforcement.
B. Observe the conditions from a safe place at dam site periodically and provide decision support as appropriate.

Dy.General Manager/Chief General Manager (Technical)/HOP

A. Review the pertinent information in order to recommend appropriate actions to Emergency Planning Manager. Provide corrective actions or works as required.
B. Provide decision support and technical support to the Emergency Planning Manager as appropriate.

RE-EVALUATION / DECISIONS

Evaluate conditions CONTINUOUSLY and Determine if:

A. The event can be terminated if the dam is determined to be stable and damages have been repaired. Local law enforcement authority has confirmed that there is no threat in the dam structure and surroundings.
B. The event remains at the current Event Level.
C. The event warrants escalation to ORANGE alert if the inspection has determined a potentially dangerous situation

All contacts on Notification Flow Chart shall be updated of changes.

Based on this Evaluation, follow the appropriate action

A. TERMINATION	B. EVENT LEVEL REMAINS THE SAME	C. EVENT LEVEL ESCALATION
Go to Termination and Follow-up	Continue recommended actions on this sheet.	Go to SHEET G2 (ORANGE ALERT)

ORANGE ALERT	Event Description: SECURITY THREAT/SABOTAGE: Verified bomb threat that if carried out, could result in damage of the dam/appurtenances that impacts the functioning of the dam OR verified damages due to vandalism that impacts the normal operation of the dam.	SHEET G2

RECOMMENDED ACTIONS

Emergency Planning Manager

A. Implement the "Failure Condition Notification Flow Chart", using pre-scripted message.
B. Notify Law Enforcement Authorities to help to evaluate the situation.
C. Identify the areas that would be potentially impacted by the emergency event
D. Make careful observation and inspection of every part of dam.
E. Record all information, observations, and actions on an Event Log Form (FORM 1).
F. Contact the Deputy Chief Engineer/Chief Engineer hourly to report the latest observations and conditions.
G. If inspection has determined a potentially dangerous situation go to the re-evaluation/decision section and follow relevant steps immediately

Dam Site Engineers

H. Access the dam only if the area has been cleared by Law Enforcement.
I. Conduct a comprehensive Dam Site inspection of the dam and appurtenant elements and make a report on most important finding.
J. Provide corrective actions or work as required.

Dy.General Manager/Chief General Manager (Technical)/HOP

K. Study an emergency lowering of the reservoir.
L. Provide decision support and technical support to the Emergency Planning Manager as appropriate.

RE-EVALUATION / DECISIONS

Evaluate conditions CONTINUOUSLY and Determine if:

The event warrants downgrade to BLUE alert if the water level in the reservoir is lowered below the bottom level of the damaged section

A. The event remains at the current Event Level.
B. The event warrants escalation to RED alert if one or multiple of the conditions have been observed;
C. Uncontrolled release of water over dam/rapidly developing flow through cracks

All contacts on Notification Flow Chart shall be updated of changes

Based on this Evaluation, follow the appropriate action

A. EVENT LEVEL DOWNGRADE	B. EVENT LEVEL REMAINS THE SAME	C. EVENT LEVEL ESCALATION
Go To SHEET G1 (BLUE ALERT)	Continue recommended actions on this sheet	Go To SHEET G3 (RED ALERT)

RED ALERT	Event Description: SECURITY THREAT/SABOTAGE: Detonated bomb resulting in visible damage to the dam or appurtenances OR verified damages due to vandalism causing an uncontrolled water release	SHEET G3

RECOMMENDED ACTIONS

Emergency Planning Manager

A. Implement the "Failure Condition Notification Flowchart", using pre-scripted message. B. Identify the areas that would be potentially impacted by the emergency events

C. Recommend to the Districts Collectors and Disaster Management Authorities IMMEDIATE EVACUATION downstream of the dam and affected areas as per Local Evacuation Plan.

D. Stay a safe distance away from the dam. The immediate concern is the safety of the downstream public

E. Record all information, observations, and actions on an Event Log Form (FORM 1).

Dam Site Engineers

H. Observe conditions from a safe place at dam Dam Site periodically and inform Emergency Planning Manager

Dy.General Manager/Chief General Manager (Technical)/HOP

I. Provide decision support and technical support to the Emergency Planning Manager as appropriate.

II. Communicate and keep informed the Chairman/MD/Director, NEEPCO LIMITED

RE-EVALUATION / DECISIONS

Evaluate conditions CONTINUOUSLY and Determine if:

A. The event warrants downgrade to ORANGE alert if there is no longer an immediate impending threat of dam failure and water level lowered below to a safe level.

B. The event remains at the current Event Level (No change in situation).

C. Event may be Terminated only when:

- The dam has failed AND there is no longer a threat to the downstream public

All contacts on Notification Flow Chart shall be updated of changes.

Based on this determination, follow the appropriate action

A. EVENT LEVEL DOWNGRADE	B. EVENT LEVEL REMAINS THE SAME	C. TERMINATION
Go To SHEET G2 (ORANGE ALERT)	Continue Recommended Actions on this sheet	Go To Termination and Follow-up

ORANGE ALERT	Event Description: Overtopping Failure	SHEET H1

RECOMMENDED ACTIONS

Emergency Planning Manager

A. Implement the "Failure Condition Notification Flow Chart", using pre-scripted message.
B. Identify the areas that would be potentially impacted by the emergency events
C. Make careful observation and inspection of every part of the dam; this should be done without compromising the safety of anyone performing these tasks. Monitor water level in the reservoir in every hour.
D. Record all information, observations, and actions on an Event Log Form (FORM 1).
E. Contact the Deputy Chief Engineer/Chief Engineer hourly to report the latest observations and conditions. If conditions change significantly, go to re-evaluation/decision section and follow relevant steps immediately

Dam Site Engineers

F. Observe conditions in Dam Site periodically and provide decision support as appropriate.
G. Provide corrective actions or work as required.

Dy.General Manager/Chief General Manager (Technical)/HOP

H. Direct specific and appropriate procedures for reservoir operations.
I. Provide decision support and technical support to the Emergency Planning Manager as appropriate.

RE-EVALUATION / DECISIONS

Evaluate conditions CONTINUOUSLY and Determine if:

A. The event warrants downgrade to BLUE alert if rainfall is dwindling as per the Forecast.

B. The event remains at the current Event Level (No change in situation).

C. The event warrants escalation to RED alert if the integrity of the dam appears to be threatened by sudden or rapidly proceeding movements/displacements.

All contacts on Notification Flow Chart shall be updated of changes

Based on this Evaluation, follow the appropriate action

A. EVENT LEVEL DOWNGRADE	B. EVENT LEVEL REMAINS THE SAME	C. EVENT LEVEL ESCALATION
Go To SHEET B1 (BLUE ALERT)	Continue Recommended Actions on this sheet	Go To SHEET B3 (RED ALERT)

RED ALERT	Event Description: Overtopping Failure	SHEET H2

RECOMMENDED ACTIONS

Emergency Planning Manager (May be split responsibilities, i.e. One person at the dam handling on Dam Site actions and a different person who can make notifications. APPLICABLE TO ALL ACTION DATA SHEETS)

A. Implement the "Failure Condition Notification Flowchart", using pre-scripted message.
B. Activate the Emergency Operations Center
C. Recommend to the Districts Collectors and Disaster Management authorities IMMEDIATE EVACUATION downstream of the dam and affected areas as per Local Evacuation Plan
D. Stay a safe distance away from the am. The immediate concern is the safety of the downstream public.
E. Record all information, observations, and actions on an Event Log Form.
F. Stay a safe distance away from the dam
G. Observe conditions in Dam Site periodically and provide decision support as appropriate.

Dy.General Manager/Chief General Manager (Technical)/HOP

A. Communicate and keep informed the Chairman, NEEPCO LIMITED.

B. Provide decision support and technical support to the Emergency Planning Manager as appropriate.

RE-EVALUATION / DECISIONS based upon ANNEX TABLE I

Evaluate conditions CONTINUOUSLY and determine if:

A. The event warrants downgrade if there is no longer an impending threat of dam failure with no additional rainfall occurring YET there is damage to the dam that prevents safe impoundment of water.
B. All contacts on Event Level (RED) Notification Flow Chart shall be notified of downgrade to Event Level(Blue).

Event may be Terminated only when either:

- There is no longer an impending threat of dam failure with no additional rainfall occurring and it has been determined by Dam Safety staff safe to impound water or;
- The dam has failed AND there is no longer a threat to the downstream public
- All contacts on Notification Flow Chart shall be updated of changes.

Based on this evaluation, follow the appropriate action

A. EVENT LEVEL DOWNGRADE	B. TERMINATION	
Monitor conditions until damage is repaired	**Go To Termination and Follow-up**	

BLUE ALERT	Event Description: Piping Failure	SHEET I1

RECOMMENDED ACTIONS

Emergency Planning Manager

A. Implement the "Watch Condition Notification Flowchart", using pre-scripted message.
B. Make careful observation and inspection of every part of the dam; this should be done to monitor without compromising the safety of anyone performing the tasks.
C. Record all information, observations, and actions on an Event Log Form (FORM 1).
D. Contact the Deputy General Manager/General Manager at least daily to report the latest observations and conditions. If conditions change significantly, go to re-evaluation/decision section and follow relevant steps immediately.

Dam Site Engineers

E. Stay a safe distance away from the dam
F. Observe conditions in Dam Site periodically and provide decision support as appropriate.

Dy.General Manager/Chief General Manager (Technical)/HOP

G. Communicate and keep informed the Director (Technical), NEEPCO LIMITED.
H. Provide decision support and technical support to the Emergency Planning Manager as appropriate.

RE-EVALUATION / DECISIONS

Evaluate conditions CONTINUOUSLY and Determine if:

A. The event can be terminated when the intensity of rainfall is dwindling as per the Forecast.
B. The event warrants escalation to ORANGE alert if the reservoir level reaches one meter below FRL.

All contacts on Notification Flow Chart shall be updated of changes.

Based on this evaluation, follow the appropriate action

A. EVENT LEVEL DOWNGRADE	B. TERMINATION	C. EVENT LEVEL ESCALATION
Monitor conditions until damage is repaired	**Go to Termination and Follow-up**	**Go to SHEET B2 (ORANGE ALERT)**

ORANGE ALERT	Event Description: Piping Failure	SHEET I2

RECOMMENDED ACTIONS

Emergency Planning Manager

A. Implement the "Failure Condition Notification Flow Chart", using pre-scripted message.
B. Identify the areas that would be potentially impacted by the emergency events
C. Make careful observation and inspection of every part of the dam; this should be done without compromising the safety of anyone performing these tasks. Monitor water level in the reservoir in every hour.
D. Record all information, observations, and actions on an Event Log Form (FORM 1).
E. Contact the Deputy Chief Engineer/Chief Engineer hourly to report the latest observations and conditions. If conditions change significantly, go to re-evaluation/decision section and follow relevant steps immediately

Dam Site Engineers

F. Observe conditions in Dam Site periodically and provide decision support as appropriate. G. Provide corrective actions or work as required.

Dy.General Manager/Chief General Manager (Technical)/HOP

G. Direct specific and appropriate procedures for reservoir operations.
H. Provide decision support and technical support to the Emergency Planning Manager as appropriate.

RE-EVALUATION / DECISIONS

Evaluate conditions CONTINUOUSLY and Determine if:

A. The event warrants downgrade to BLUE alert if rainfall is dwindling as per the Forecast.

B. The event remains at the current Event Level (No change in situation).

C. The event warrants escalation to RED alert if the integrity of the dam appears to be threatened by sudden or rapidly proceeding movements/displacements.

All contacts on Notification Flow Chart shall be updated of changes

Based on this Evaluation, follow the appropriate action

EVENT LEVEL DOWNGRADE	EVENT LEVEL REMAINS THE SAME	EVENT LEVEL ESCALATION
Go to SHEET B1 (BLUE ALERT)	Continue recommended actions on this sheet	Go to SHEET B3 (RED ALERT)

RED ALERT	Event Description: Piping Failure	SHEET I3

RECOMMENDED ACTIONS

Emergency Planning Manager (Maybe split responsibilities, i.e. One person at the dam handling on Dam Site actions and a different person who can make notifications. APPLICABLE TO ALL ACTION DATA SHEETS)

A. Implement the "Failure Condition Notification Flowchart", using pre-scripted message.
B. Activate the Emergency Operations Center
C. Recommend to the Districts Collectors and Disaster Management authorities IMMEDIATE EVACUATION downstream of the dam and affected areas as per Local Evacuation Plan
D. Stay a safe distance away from the dam. The immediate concern is the safety of the downstream public.
E. Record all information, observations, and actions on an Event Log Form (FORM 1).

Dam Site Engineers

F. Stay a safe distance away from the dam
G. Observe conditions in Dam Site periodically and provide decision support as appropriate.

Dy.General Manager/Chief General Manager (Technical)/HOP

H. Communicate and keep informed the Chairman/ Director (Technical), NEEPCO LIMITED.
I. Provide decision support and technical support to the Emergency Planning Manager as appropriate.

RE-EVALUATION / DECISIONS

Evaluate conditions CONTINUOUSLY and determine if:

A. The event warrants downgrade if there is no longer an impending threat of dam failure with no additional rainfall occurring YET there is damage to the dam that prevents safe impoundment of water. All contacts on Event Level (RED) Notification Flow Chart shall be notified of downgrade to Event Level (BLUE).
B. Event may be Terminated only when either:
   - There is no longer an impending threat of dam failure with no additional rainfall occurring and it has been determined by Dam Safety staff safe to impound water or;
   - The dam has failed AND there is no longer a threat to the downstream public

All contacts on Notification Flow Chart shall be updated of changes.

Based on this evaluation, follow the appropriate action

A. EVENT LEVEL DOWNGRADE	B. TERMINATION	
Monitor conditions until damage is repaired	**Go To Termination and Follow-up**	

Was the annual inspection conducted?	☐ Yes ☐ No	If Yes, has the EAP been revisited to include any signs of failures observed during the inspection	☐ Yes ☐ No
Was weed cleaning, animal burrow removal, or other maintenance required?	☐ Yes ☐ No	If yes, describe actions taken and date:	
Was the outer gate operable?	☐ Yes ☐ No	If no, describe actions taken and date:	
Does the Notification Flowcharts require revision? (Note: Revision of contact information will not require EAP approval; however, the revised contact information pages will need to be redistributed as replacement pages)	☐ Yes ☐ No	If yes, list the dates of the contact information revision and redistribution:	
Was annual training or a tabletop drill conducted?	☐ Yes ☐ No	Circle: 1. Training 2. Tabletop Drill Date Conducted:	
Are inspection and training records included in the EAP?	☐ Yes ☐ No		
Was the EAP reviewed?	☐ Yes ☐ No	If yes, review date:	
Were changes required to the EAP	☐ Yes ☐ No		

Name and Title of Appropriate Manager for Owner　　　　Date

Annexure 3 : Training Record

Use this form to record training sessions. File the completed form in the appropriate Tab of the EAP. All items in the EAP should be thoroughly reviewed during training. Appropriate Dam Owner employees and EAP team members should attend a training session annually (or participate in a stimulated drill).

TRAINING LOCATION:	
DATE: **TIME:**	**INSTRUCTOR:**
CLASS SIGN-IN:	
Types of Simulation Conducted:	Circle Emergency Type: 1. Emergency water release 2. Watch condition 3. Possible dam failure 4. Imminent dam failure 5. Actual dam failure
Comments. Results of Drill:	
Revisions Needed to EAP Based on Results of Drill? Yes No If Yes, list revisions required:	

Annexure 4 : SOP for Table Top Exercise

Definition: A discussion-based exercise where personnel with roles and responsibilities in this EAP meet in a classroom setting or in breakout groups to validate the content of the plan by discussing their roles during an emergency and their responses to a particular emergency situation.

Objective: The main objective of this exercise is to emphasize on the role clarity and to make feel of the tension, anxiety and train the staff for actual emergency situations.

Place: Specific Dam Site

Who all participate: This exercise could be done internally involving Dam Site personnel and train on a quarterly or half-yearly before calling for external stakeholders.

Preparation: Such table-top drill involves a meeting of Head of Power Station / DGM (Technical), APGCL with other stakeholders, in particular District Disaster Management (DDMA) officials in a conference room. A date and time need to be fixed to enable all stakeholder's participation.

How to Kick-start: A facilitator initiates the discussion by presenting a scenario and asking questions based on the scenario. One may follow a four-phased approach to tabletop exercises tailored to your business needs and in collaboration with your team and stakeholders:

- Determine exercise objectives and scenarios
- Design scenarios for team
- Execute tabletop testing
- Deliver exercise report

The drill begins with a description of simulated event and proceeds with discussions by the participants to evaluate the EAP and response procedures, and to resolve concerns regarding coordination and responsibilities. Any problems identified during a drill should be included in revisions to the EAP.

Now, develop realistic scenarios - Test your response Evaluate outcomes, strengths, and challenges. Refine your plan. Test again.

- While enacting this exercise, bit by bit, each one should focus on their EMERGENCY Role and Responsibilities and try to deliver at your best.
- Go Slow and Steady; you may not deliver at first, you should improve upon each repetition
- Understand your strengths, your upper level and lower level for communication and coordination
- You will come across the challenges,
    - It could be dark day, no power and communication working on that day. Weather conditions maybe adverse. E.g., all landline phones maybe disturbed, OR all mobile networks maybe cut or shutdown, due to long powercut; now think of an alternative.
    - Now, check your preparations – do you have your intercom working, do you have your walkie-talkie system functional OR is your VSAT phone working, is the battery drained

- Jot down a checklist and a timeline for monitoring to ensure all your backup systems – remember to check that your backup system is working at least once or twice in a month.
- In a similar way, you may **Check, Monitor, Test** and **Rectify** your systems using a checklist

Once you complete each trial of the Tabletop Exercise, it's time to review the EAP:

- Note down your observations – it could be a new role, new timing, new requirement
- Present it before the HOP or his representative and ensure it is procured/available for use at the Dam Site

Duration/Timing: Tabletop Exercises need to be taken a bit seriously but enacted in a relaxed way. It may take 2 hours, and a Friday or Saturday afternoon is an ideal time for this drill, such that Management staff from APGCL, Guwahati or Shillong make it convenient to participate and ensure it is done systematically. HQ Senior staff's participation will bring seriousness, and s/he will also endorse and carry your message to HQ to refill the gaps.

Outcome/Advantages

Tabletop exercises will help clarify critical elements of your strategy for crisis planning and preparedness, including:

- Roles and responsibilities
- Information collection
- Prioritization
- Implications

Tabletop exercises can help reduce that anxiety and increase individual and collective team confidence in your response capabilities. When an unplanned event strikes, your team will feel better prepared to tackle a crisis — because you've done it before.

- Experience as a global crisis leader
- Understanding of leading industry practices
- Knowledge and skill developed preparing for and responding to major crises

Annexure 5 : MOM with DFO, Guwahati WL division

Meeting with the DFO, Guwahati, Wildlife Division on the impact of LKHEP on Pabitora WLS

Date : 11.06.2024

Venue : Office of the Divisional Forest Officer, Guwahati WL Division

Basistha, Guwahati

Minutes of the Meeting

At the onset of the meeting a brief introduction was presented on the project by APGCL and PMC. Possible impact to be arised due to the operation of LKHEP on the Pabitora WLS was discussed based on the Dam Hydrograph and Dam Break Analysis carried out by IIT, Roorkee.

DFO wants to know the river network in the Kopili River basin which was explained by APGCL & PMC. Mostly the flood in Pabitora is due to the rise in water level of Brahmaputra river. It was also explained that there is no impact of LKHEP on Pabitora WLS during operation in Lean, Monsoon, non lean non monsoon period. One part of Pabitora (Excluding Bura Mayang Hills) will be inundated during Standard Project Flood (SPF), Probable Maximum Flood (PMF) and 100 years scenario (Map 44). Average depth will be 1.14 m to 1.37 m. Moreover, there will be a rise of additional 19 cm in certain sections of the sanctuary due to the extreme PMF condition. Arrival time of the PMF to the WLS will be 94 hours 30 minutes. Early warning system will be available for the Kopili River and the information will be deiminated through the ASDMA and respective DDMAs in the downstream districts well in advance.

DFO appraised about the existing 6 artificial highlands in the park which are constructed after 2020 :

	Length	Width	Height
1	1500 m	4 m	2.5 m
2	800 m	4 m	2.5 m
3	50 m	4 m	1.5 m
4	50 m	4 m	1.5 m
5	50 m	4 m	1.5 m
6	50 m	4 m	1.5 m

The highlands and the selected patrolling paths are adequate for the conservation of wildlife during flood in Pabitora.

In the above scenario, additional mitigation measures are not proposed for the Pabitora WLS.

The meeting ended with the vote of thanks from APGCL .

Meeting with the DFO, Guwahati, Wildlife Division on the impact of LKHEP on Pabitora WLS
Date : 11.06.2024
Attendance sheet

SL No.	Name	Designation	Mobile No	Email	Signature
1	P. Monica Kishor, IFS	DFO, Guwahati WL	[illegible]	[illegible] @forest.com	[illegible]
2	Dr Deepak K Baruah	Env. Expert- APGCL	[illegible]	[illegible] @gmail.com	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	Dr Jayanta Das	Sr. Scientist PNC	[illegible]	[illegible]	[illegible]

Annexure 6 : MOM with Revenue Department, Tourism Department, Forest Department of Dima Hasao.

Meeting with the Settlement & Revenue Department, Tourism Department, Forest Department of Dima Hasao Autonomous Council and APGCL on the impact of LKHEP operation on Panimur.

Date : 13.06.2024

Venue : Officer's Conference Hall of Dima Hasao A/Council, Haflong

Time : 02:00 PM

Minutes of the Meeting

At the onset of the meeting Principle Secretary (i/c), Revenue, NCHAC welcomed all the members. A brief introduction was presented on the project by APGCL and PMC. Panimur in Dima Hasao district and Koka, located in West Karbi Anglong are renowned location owing its reputation to the multitude of waterfalls and rapids along the Kopili river. Tourists come here to see the water falls from both the banks of the river where boating and rafting are done. As it is also a picnic spot often people take bath in the river.

Due to Lower Kopili Hydro Power Plant operation there will be change in the water flow regime. Possible impact to be arised due to the operation of LKHEP on the Panimur recreational / tourism activities was discussed based on the Dam Hydrograph and Dam Break Analysis carried out by IIT, Roorkee. Based on the 10 daily inflow, Reservoir Operation Plan was prepared and subsequently water level fluctuations were derived on downstream river bed cross sections through HEC RAS analysis. There is a difference of Water Surface Elevation and water depth at Panimur during high and low flow events which is likely to be ranged between 0.54 m (Maximum increase during high flow) to 0.21 m (Maximum reduction during low flow during monsoon).

The Divisional Forest Officer and the deputy Director Tourism explained that the tourism activities in Panimur is neither run by Forest nor by the Tourism department. Forest Department prepares an SOP and as per the SOP the local youths carryout the boating. As per the existing SOP the boating in Panimur is only allowed during the lean period from October to April and all the boating activities has to be closed by 4.30 PM to 5.00 PM depending on the weather condition.

APGCL further explains that based on the hourly flow data available from the upstream gauging site reservoir operation plan will be updated and final flow information at Panimur will be shared with the respective departments through the DHAC. As the Lower Kopili Hydro Electric Project (LKHEP) is run of the river project with reservoir and is designed for pecking power generation, there will be variation in the water level during operation of the Auxiliary and Main power house. Daily operational information will be shared with the Council and the Officer in Charge of Panimur to be nominated by the Council before commissioning of the plant. Early warning system is also being prepared and it will be implemented through ASDMA and DDMA.

Additional Secretary, Revenue, NCHAC suggested for installation of one siren at Panimur in addition to the early warning system.

APGCL also apprised about the recent studies carried out by the College of Fisheries, Raha as per the suggestion from MoEF&CC. As per their report, pH of the river Kopili is not conducive for the survival of fishes and other aquatic life upto the confluence of Diyung river. Between the confluence zone of Amring river and Diyung river few planktons were reported. One Conservation Management Plan for the fishes was also prepared by the Fisheries college. APGCL will involve the Fisheries Department of the DHAC for implementation and monitoring of the Conservation Management Plan for the fishes in the Kopili river after the commissioning of the LKHEP.

The meeting ended with the vote of thanks from the Chair.

ATTENDANCE SHEET ON

Meeting on 13-06-2024 (Thursday) at 2.00 PM at Officers Conference Hall of DHAC, Haflong in connection with fluctuation of water levels at Panimur during operation of 120 MW. LKHEP.

Sl No.	Name	Designation	Signature
1	Rajib Vangoor	Survey NEEPCO	[illegible]
2	Rohan Das	AGM (Civil)	[illegible]
3	Sudipta Bhattacharjee	DM (Civil)	[illegible]
4	Dr Deepak Baruah	Env. Expert-	[illegible]
5	H. Nriame	Secy. NCHAC	[illegible]
6	Nirmal Kemprai	Deputy Director of Tourism Haflong	[illegible]
7	Bhabajyoti Kemprai	Asst. Engineer	[illegible]
8	Tuhin Langthasa	D.F.O DHFD(W)	[illegible]
9	Binoti Shoni	T. Developer.	[illegible]
10	Jayanta Das	Env. Exp. WRPY	Jayanta
11			
12			


CONFERENCE ROOM

Annexure 7 : Letter to INDIGRID to install the BFD in the section of the 400 kVA line over the Reservoir of LKHEP

ASSAM POWER GENERATION CORPORATION LIMITED

Registered Office: Bijulee Bhawan, Paltanbazar, Guwahati-781 001, Assam
[illegible]

[illegible]

Date: [illegible]

To,

The Project Manager, (Silchar Misa Transmission Line 400 KVA)
India Grid Trust (Principal Place of Business)
Unit No. 101, First Floor, Windsor, Village KoleKalyan,
off CST Road, Vidyanagari Marg, Kalina, Santacruz (East), Mumbai – 400 098

Sub : Installation of Bird Diverter on Transmission Lines as per Supreme Court Directives

Ref : Letter from Central Electrical Authority dated 19.10.2023

Sir,

With reference to the subject cited above, please find herewith a letter from Central Electricity Authority regarding compliance of Technical Specification for bird flight diverter (BFD) on transmission lines as directed by the Hon'ble Supreme Court of India. The said Technical Specifications have been prepared by the monitoring committee appointed by Hon'ble Supreme Court of India in consultation with CEA. Therefore, you are requested to make arrangements to install bird fly diverters on the Silchar Misa 400 KVA transmission line in the project area of Lower Kopili Hydro Electric Project 120 MW in Dima Hasao and West Karbi Anglong under your jurisdiction.

This is for favour of your kind information and necessary action. Please confirm it within 15 days.

Enclosed as stated.

Yours sincerely,

B. Bhuyan
Managing Director,
APGCL

Cc To
1. The Project Manager, (Silchar Misa Transmission Line 400 KVA) [illegible]

Assam Power Generation Corporation Limited
[illegible]

Annexure – 8 : Bird Flight divertors

1. International good practice for averting bird collisions involves making transmission lines more obvious to birds, through measures to make them larger and/or visible. As per the directions of Hon'ble Supreme Court, the Bird Flight were to be installed on Power Transmission & Distribution lines by the power utilities, as per the technical specification prepared by Monitoring Committee appointed by Hon'ble Supreme Court in consultation with CEA from the Power System Engineering & Technology Development Division, Ministry of Power, GOI vide Letter No. File No.CEA-PS-14-75/2/2022-PSETD Division dated 19.10.2023.

2. Some of the design parameters to be considered are:

1. Bird Flight Diverter must be dynamic type and shall consist of warning disc (2-D or 3-D in design) and associated clamps & connectors.
2. The dynamic solar-powered LED type Bird Flight Diverter shall be preferred in areas where foggy/dusty weather persists, or the intensity of light is low, or the sections of the lines lying in the route of migratory birds.
3. The utility may install a mixture of LED and Non-LED BFD on their powerlines, where at least one in five (20% of total) BFD on a line should be LED type.
4. Have glow in the dark feature. Glow in the dark shall remain activated for at least 12 hours after exposure to sunlight. If glow in the dark sticker is used, the same shall be of high quality with strong adhesive property, laminated, and suitable for all weather conditions.
5. The warning disk in the BFD should have strong luminescence properties that emit immense light to provide enhanced visibility to the birds at night.
6. Have contrasting coloured (combination of any two colours from White, Black, Red, Yellow, Orange,) retro-reflective surface with Sun and Moonlight reflectors on both faces.
7. Since the warning disc is to be designed to rotate, the colour change, while revolving, shall provide significant forewarning.
8. Swing, sway and rotate easily.
9. Must not flip on the powerline in high wind velocity.
10. Be resistant to all weather conditions
11. Be made of UV stabilised plastic. The bearing shall be made of stainless steel and should allow free spinning at a minimum wind speed of 1 km/hour.
12. Be made of a sealed bearing to avoid deposition of sand and/or soil particles and helps in smooth rotation.
13. Have a diameter of not less than 150 mm for a circular disc. If the warning disc is quadrilateral or trapezoid or of any other shape, then the shortest arm length shall not be less than 90 mm. The total surface area of the warning disc should not be less than 15,000 mm2 (including air vents).
14. The thickness of not less than 3 mm.
15. The reflective area on each face of the warning disc should not be less than 3500 mm2. And the glow in the dark area should not be less than 3500 mm2 for the LED type BFD, and not less than 7500 mm2 for the non-LED type BFD.

16. The total weight of the Bird Flight Diverter shall not be more than 800 gm. Light Emitting Diode (LED) type bird flight diverter should not weigh more than 1000 gm.
17. From connection point to end, the length of the bird diverter should not be more than 430 mm.
18. The clamp for holding conductor/ optical ground wire (OPGW) / earth wire shall be spring type and shall be made of UV stabilised engineered composite plastic (polymer) or metal or carbon fibre and shall be suitable for live line installation by hot stick or drone.
19. The holding clamp must be suitable for gripping the conductor/OPGW/ earth wire strongly; otherwise, due to aeolian vibrations/high wind speed, diverters may shift and move from their original position and get collected at mid-span (lowest sagging point). Rubber/polyurethane lining shall be used in the gripping area of the clamp as per the requirement of the conductor type.
20. More than 50% of the clamp gripping area shall be in contact with earth wire/ optical ground wire (OPGW)/Conductor.
21. Clamp shall be free from sharp ends or edges, abrasions, projections, grit or materials; and shall not cause chafing or damage to the conductor/earth wire/OPGW during fitting or during continued operation. Annual maintenance will be done.
22. Parts of the clamp touching conductor must be able to withstand temperature ranges from -15 °C to +85 °C for conventional conductors. In case of installation on HTLS conductor, the utility shall specify maximum operating temperature under emergency loading conditions.
23. The clamp must be able to bear a pulling load of at least 50 kg, and it is to be tested on Universal Testing Machine by a National Accreditation Board for Testing and Calibration Laboratories (NABL) accredited laboratory.
24. In the case of metallic bird diverters, the parts of the clamp touching conductor/earth wire/OPGW must be made of a material which is a bad conductor of electricity.
25. For solar-powered LED type diverter, the following additional requirement shall be fulfilled:
    (a) LED shall be of Orange or White colour or a combination of both (one white followed by one orange arrangement system) with adequate light intensity so that it is clearly visible from a distance (>300 m) even during foggy/dusty weather/under the low intensity of light.
    (b) The battery shall guarantee a service life of 5 years and be suitable for at least 100 hrs of flashing operation by a single charge.
    (c) An automatic power cut-off electronics circuit shall be provided to improve battery life so that during daytime (due to the high intensity of light from the sun), the circuit gets cut off & stops flashing, and the circuit switches on automatically under low-intensity light conditions.
    (d) The position of the solar cells shall be such that it gets sunlight irrespective of the direction of the diverter face, and the dust & snow does not decrease its efficiency.
26. The buyer/purchaser/utility/power agency must get reports/certificates for all the tests prescribed in the ***Technical standards for Bird Flight Diverters*** and the

tests to be conducted by the testing laboratory accredited by NABL or any accreditation body as per relevant ISO/ IEC/ IS standards. All of the tests shall be conducted on the same sample. However, No. of Samples for type tests shall be as per the relevant standard or procedure specified. Type test report/ certificate shall be valid for 10 years from the date of successful completion of tests for manufacturing.

2. BFD to be installed in the following sections.

3. The Project will install high-quality bird flight diverters which meet CEA guidelines and are guaranteed against failure. These will be placed at least every 5 m along the earth wire (or, if there are two static wires, at 10 m spacing on each wire, staggered). This is the wire which causes most collision risks, so it is considered optimal to focus on this wire rather than, per CEA guidance for Great Indian Bustard (Critically Endangered), on spreading diverters across the earth wire and conductors. Bird Flight Diverters are design for expected service life of at least fifteen years (ref. page 2. (d)[68]: General Technical requirement as per Guideline issued by SC Committee in consultation with Central Electricity Authority) and bird diverters comes with a warranty period of at least 5 years (Technical specification as per Guideline issued by SC Committee in consultation with Central Electricity Authority, page no7. 4.2 Warranty periods) which fulfilled the requirement of durability of five years. Also, as per the guidelines (ref. page 2. (b): General Technical requirement as per Guideline issued by SC Committee in consultation with Central Electricity Authority) the utility may install a mixture of LED and Non-LED BFD on their powerlines, where at least one in five (20% of total) BFD on a line should be LED type.

4. Eccleston & Harness (2022)[69] recommend marking power lines within 500 m of the reservoir, comprising approximately 4.204 km of the 33kV construction line and the southernmost 0.9 km of the 220kV power evacuation line (Map 1). An existing 400kV line is being retained above the reservoir. The length of this within 500 m of the reservoir which should be retrofitted with bird flight diverters is estimated to be c.4.82 km. Retrofitting of this line is outside of Project control, but the Project will make best efforts to coordinate with the line owner to install diverters on this line prior to impounding the LKHEP reservoir. Eccleston & Harness (2022) estimate that the 33kV line will require approximately 840 diverters out of which 168 numbers will be LED, and the 200kV line would require approximately 180 divertors out of which 36 numbers will be LED. Assuming similar densities on the 220kV and 400kV line, the latter would require approximately 700 markers. During the annual maintenance and shut down prior to impounding the BFD will be installed and INDIGREED has agreed to install the same.

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[68] Technical Specifications for Bird Flight Diverter (BDF) issued by SC Committee in consultation with Central Electricity Authority vide File No.CEA-PS-14-75/2/2022-PSETD Division/274-338 dated 16.06.2022.

[69] Eccleston, D. & Harness, R. (2022) Draft Avian Risk Observations and Recommendations: Lower Kopili Hydroelectric Project. Unpublished report by EDM International Inc. to ADB.

Map 1: Showing the location of Bird Flight Divertors

5. Sample Bird Flight Divertor approved for the similar transmission line in Northeast India are shown in the figure 1 with technical specification in figure 2.

Figure 1: Types of Bird Flight Divertors
(approved for other projects in the Region)

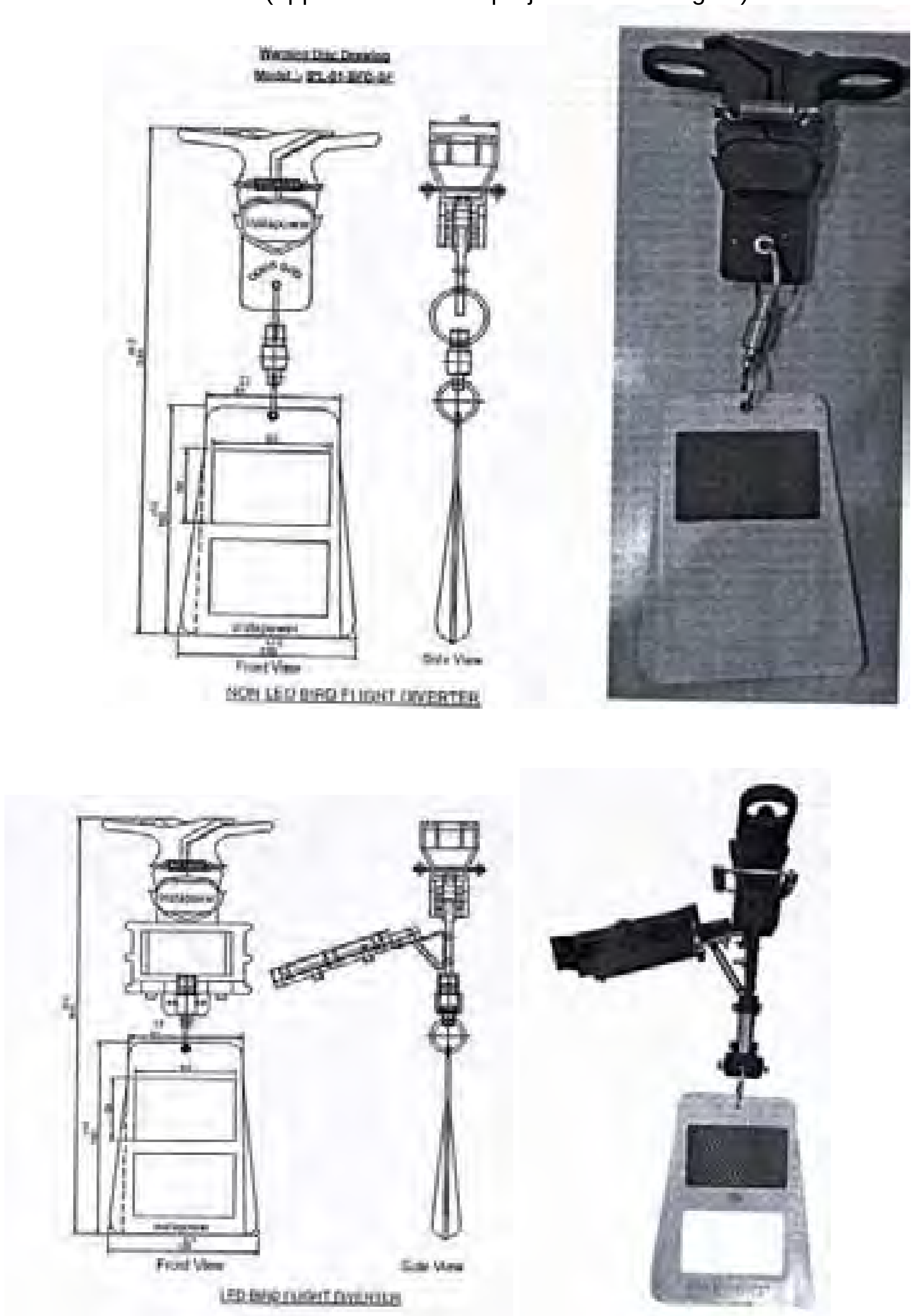

Figure 2: Technical specification of the sample BFD