एनटीपीसी
NTPC
A Maharatna Company

KOLDAM HYDRO ELECTRIC POWER PROJECT

(4 X 200 MW)

TARIFF OF KOLDAM HEP FOR THE PERIOD FROM 01.04.2024 TO 31.03.2029

Summary of Issues:

Tariff determination petition (2024-29) of Koldam Hydro Electric Project (4 X 200 MW)

(In compliance with CERC notice dated 07.06.2024)

The major highlights of the tariff determination petition of Koldam Hydro Electric Project (4 X 200 MW) for tariff period 2024-29 are as follows:-

KOLDAM was declared Commissioned on 18.07.2015.
The present petition is being filed under Section 62 and 79 (1) (a) of the Electricity Act, 2003 read with Chapter-III of the Central Electricity Regulatory Commission (Conduct of Business) Regulations, 2023 and Chapter-3, Regulation-9 of Central Electricity Regulatory Commission (Terms and Conditions of Tariff) Regulations, 2024 for approval of tariff of Koldam Hydro Electric Project (4 X 200 MW) for the period from 01.04.2024 to 31.03.2029.

The tariff of the Koldam HEP for the tariff period 1.4.2019 to 31.3.2024 was determined by the Hon'ble Commission vide its order dated 14.01.2024 in Petition No. 412/GT/2020. The capital cost allowed for tariff determination included the projected additional capital expenditure admitted by the Hon'ble Commission after prudence check. The petitioner had filed a separate true up petition for the period 01.04.2019 to 31.03.2024 for revision of tariff in line with the applicable provisions of Tariff Regulations 2019.

It is submitted that Hon'ble Commission vide order dated 14.01.2024 in Petition no 412/GT/2020 has allowed a capital cost of Rs 7243.2496 Cr. as on 31.03.2024 based on the admitted projected capital expenditure for the 2019-24 period. It is further submitted that CERC vide order dated 19.05.2024 in Review Petition No. 1/RP/2024 in Petition. No. 363/GT/2020 has revised the truing-up of tariff of Koldam for the period from COD (18.7.2015) to 31.3.2019. Accordingly, capital cost as on 01.04.2019 has been considered as closing capital cost as on 31.03.2019 as allowed by Hon'ble CERC vide order dtd 19.05.2024 in Review Petition No. 1/RP/2024 in Petition. No.

363/GT/2020. However, the actual closing capital cost as on 31.03.2024 has been worked out in the foresaid true-up petition as Rs 7,18,8.7163 Crs based on the actual expenditure after truing up exercise for the period 2019-24. Accordingly, the Petitioner has adjusted an amount of Rs. 54.533 Cr from the admitted capital cost as on 31.03.2024 and accordingly the opening capital cost as on 01.04.2024 has been considered as Rs 7,18,8.7163 Cr. in the instant petition.

The projected additional Capital Expenditure for the FY 2024-25, 2025-26, 2026-27, 2027-28 and 2028-29 are Rs 214.42Cr, Rs 143.8Cr, Rs 4.5Cr, Rs 4.5Cr and Rs 4.5Cr respectively amounting to total of Rs 371.72 Crores during the 2024-29 period. The same has been depicted year wise in Form 9A of the Appendix-I along with applicable regulations and justification for the claims. It is humbly requested to approve the projected Additional Capital expenditure during the period of 2024-29.

The Hon'ble Commission is requested to allow the claims for security expenses, and Insurance expenses for the instant station as estimated by the Petitioner in Form 3A of Appendix-I. These claims shall be subject to retrospective adjustment based on actual expenditures during the truing-up process.
Furthermore, the consumption of capital spares shall be claimed at the time of truing up based on the actual consumption of spares during the period 2024–29.

The petitioner seeks permission to approach the Commission to recover the impact of wage revisions effective from 1.1.2027, as allowed under Tariff Regulations 2024, during the tariff true-up based on actual payments made.

The petitioner requests the Commission's approval to recover the filing and publication fees directly from the beneficiaries, as permitted under Regulation 94(1) of the Tariff Regulations 2024.

In the light of above submission and as per the Petition being filed by the Petitioner for determination of tariff of Koldam Hydro Electric Project (4 X 200 MW) (2000 MW),the Hon'ble Commission may please approve tariff for the tariff period 2024-29 as per provision of Regulation 9(2) of Tariff Regulations 2024.

General Manager (Commercial)
NTPC Limited

BEFORE THE HON'BLE CENTRAL ELECTRICITY REGULATORY COMMISSION
NEW DELHI

PETITION NO.....

IN THE MATTER OF : Petition Under Section 62 and 79 (1) (a) of the Electricity Act, 2003 read with Chapter-III of the Central Electricity Regulatory Commission (Conduct of Business) Regulations, 2023 and Chapter-3, Regulation-9 of Central Electricity Regulatory Commission (Terms and Conditions of Tariff) Regulations, 2024 for approval of tariff of ***Koldam Hydro Electric Project (4 X 200 MW)*** **for the period from 01.04.2024 to 31.03.2029.**

INDEX

BEFORE THE HON'BLE CENTRAL ELECTRICITY REGULATORY COMMISSION

NEW DELHI

PETITION NO.....

IN THE MATTER OF : Petition Under Section 62 and 79 (1) (a) of the Electricity Act, 2003 read with Chapter-III of the Central Electricity Regulatory Commission (Conduct of Business) Regulations, 2023 and Chapter-3, Regulation-9 of Central Electricity Regulatory Commission (Terms and Conditions of Tariff) Regulations, 2024 for approval of tariff of ***Koldam Hydro Electric Project (4 X 200 MW)*** **for the period from 01.04.2024 to 31.03.2029**.

AND

IN THE MATTER OF

Petitioner: : NTPC Ltd.
NTPC Bhawan
Core-7, Scope Complex
7, Institutional Area, Lodhi Road
New Delhi-110 003.

Respondents

1. Uttar Pradesh Power Corp. Ltd. (UPPCL)
   Shakti Bhawan
   14, Ashok Marg
   Lucknow – 226 001

2. Jaipur Vidyut Vitran Nigam Ltd. (JVVN)
   Vidyut Bhawan, Janpath,
   Jaipur 302 005

3. Ajmer Vidyut Vitran Nigam Ltd. (AVVN)
   Old Power House, Hathi Bhata

मनीष कुमार वर्मा / Manish Kumar Verma
अपर महाप्रबंधक (वाणिज्यिक)
Addl. General Manager (Commercial)

Jaipur Road,
Ajmer

4. Jodhpur Vidyut Vitran Nigam Ltd. (JdVVN)
New Power House, Industrial Area,
Jodhpur

5 Tata Power Delhi Distribution Ltd. (TPDDL)
Grid Substation, Hudson Road
Kingsway Camp
Delhi – 110009

6 BSES Rajdhani Power Ltd. (BRPL)
BSES Bhawan, Nehru Place
New Delhi – 110019

7 BSES Yamuna Power Ltd. (BYPL)
Shakti Kiran Building
Karkardooma
Delhi- 110092

8.
Haryana Power Purchase Centre. (HPPC)
Shakti Bhawan
Sector – VI,
Panchkula
Haryana – 134 109

9. Punjab State Power Corporation Ltd. (PSPCL)
The Mall
Patiala – 147 001

10. Himachal Pradesh State Electricity Board Ltd. (HPSEB Ltd.)

Add. General Manager (Commercial)

Kumar Housing Complex Building-II
Vidyut Bhawan
Shimla – 171 004

11. Power Development Department (PDD-J&K)
Govt. of J&K ,
Civil Secretariat
Srinagar

12. Electricity Department (Chandigarh)
Union Territory of Chandigarh
Addl. Office Building
Sector-9 D
Chandigarh

13. Uttarakhand Power Corporation Ltd. (UPCL)
Urja Bhavan
Kanwali Road
Dehradun – 248 001

The Petitioner humbly states that:

1) The Petitioner herein NTPC Ltd. (hereinafter referred to as '**Petitioner**' or '**NTPC**'), is a company incorporated under provisions of the Company Act, 1956 and a Government Company as defined under Section 2(45) of the Companies Act, 2013. Further, NTPC is a 'Generating Company' as defined under Section 2(28) of the Electricity Act, 2003.

2) In terms of Section 79(1)(a) of Electricity Act, 2003, the Hon'ble Commission has been vested with the functions to regulate the tariff of NTPC, being a Generating Company owned and controlled by the Central Government. The regulation of the tariff of NTPC is as provided under Section 79(1)(a) read with

Addl. General Manager (Commercial)
Regional Office / NTPC Limited

Section 61, 62 and 64 of the Electricity Act, 2003 and the Regulations notified by the Hon'ble Commission in exercise of powers under Section 178 read with Section 61 of the Electricity Act, 2003.

3) The Petitioner is having power stations/ projects at different regions and places in the country. Koldam Hydro Electric Plant (4 X 200 MW) (hereinafter referred to as Koldam HEP) is one such station located in the State of Himachal Pradesh. The power generated from Koldam HEP is being supplied to the respondents herein above.

4) The Hon'ble Commission has notified the Central Electricity Regulatory Commission (Terms & Conditions of Tariff) Regulations, 2024 (hereinafter 'Tariff Regulations 2024') which came into force from 01.04.2024, specifying the terms & conditions and methodology of tariff determination for the period 01.04.2024 to 31.03.2029.

5) Regulation 9(2) of Tariff Regulations 2024 provides as follows:

"(2) In case of an existing generating station or unit thereof, or transmission system or element thereof, the application shall be made by the generating company or the transmission licensee, as the case may be, by 30.11.2024 , based on admitted capital cost including additional capital expenditure already admitted and incurred up to 31.3.2024 (either based on actual or projected additional capital expenditure) and estimated additional capital expenditure for the respective years of the tariff period 2024-29 along with the true up petition for the period 2019-24 in accordance with the CERC (Terms and Conditions of Tariff) Regulations, 2019."

In terms of above, the Petitioner is filing the present petition for determination of tariff for Koldam HEP for the period from 01.04.2024 to 31.03.2029 as per the Tariff Regulations 2024.

6) The tariff of the Koldam HEP for the tariff period 1.4.2019 to 31.3.2024 was determined by the Hon'ble Commission vide its order dated 14.01.2024 in Petition No. 412/GT/2020 in accordance with the CERC (Terms & Conditions

Manish Kumar Verma
Addl. General Manager (Commercial)
NTPC Limited

of Tariff) Regulations 2019. The petitioner vide affidavit dated 23.11.2024 had filed a separate true up petition for the period 01.04.2019 to 31.03.2024 for revision of tariff in line with the applicable provisions of Tariff Regulations 2019.

7) It is submitted that Hon'ble Commission vide order dated 14.01.2024 in Petition no 412/GT/2020 has allowed a capital cost of Rs 7243.2496 Cr. as on 31.03.2024 based on the admitted projected capital expenditure for the 2019-24 period. It is further submitted that CERC vide order dated 19.05.2024 in Review Petition No. 1/RP/2024 in Petition. No. 363/GT/2020 has revised the truing-up of tariff of Koldam for the period from COD (18.7.2015) to 31.3.2019. Accordingly, capital cost as on 01.04.2019 has been considered as closing capital cost as on 31.03.2019 as allowed by Hon'ble CERC vide order dtd 19.05.2024 in Review Petition No. 1/RP/2024 in Petition. No. 363/GT/2020. However, the actual closing capital cost as on 31.03.2024 has been worked out in the foresaid true-up petition as Rs 7,18,8.7163 Crs based on the actual expenditure after truing up exercise for the period 2019-24. Accordingly, the Petitioner has adjusted an amount of Rs. 54.533 Cr from the admitted capital cost as on 31.03.2024 and accordingly the opening capital cost as on 01.04.2024 has been considered as Rs 7,18,8.7163 Cr. in the instant petition. The Hon'ble Commission may be pleased to accordingly adopt this adjustment in the admitted capital cost as on 31.3.2024 and determine the tariff in the present petition for the period 2024-29.

8) The capital cost claimed in the instant petition is based on the opening capital cost as on 01.04.2024 considered as above and projected estimated capital expenditures claimed for the period 2024-29 under Regulation 19 and Regulation 24, 25 and 26 of the Tariff Regulations, 2024.

9) The Petitioner further respectfully submits that as per Regulation 36(2)(c) of the Tariff Regulations 2024, the security expenses, insurance expenses and capital spares consumed for Hydro generating stations are to be allowed separately. The Petitioner is claiming the security expenses and insurance expenses based on the estimated expenses for the period 2024-29, the same shall be subject to retrospective adjustment based on actuals at the time of truing up. In respect of

Manish Kumar Verma
Addl. General Manager (Commercial)
NTPC Limited

capital spares consumption, it is submitted that the same shall be claimed at the time of true-up in terms of the provision to the Regulation 36(2)(c) based on actual consumption of spares during the period 2024-29.

10) Additional Plunge pool Strengthening Works

i. Koldam Hydro Station is located on river Sutlej in Bilaspur District of the State of Himachal Pradesh. As the project is situated in the Himalaya region, one of the world's most geologically and seismically active mountain ranges transacted by a multitude of steep, fast-flowing, silt-laden rivers, it is naturally hazard-prone. Earthquakes, landslides, and floods are recurrent phenomena in this region.

ii. It is submitted that the Dam & Spillway structures are constructed to regulate the downstream river water flow, through the Powerhouse and/or through the Spillway. The Koldam HEP consists of a Chute Spillway having Flip Bucket and a pre excavated Plunge Pool lined with concrete cladding at the end, for dissipation of the energy.

iii. It is submitted that during spillway operation in monsoon of every year from 2015 (CoD) onwards, the under scouring occurred at the extreme side of the right & left cladding walls of plunge pool, resulting in cavity formation, rock sliding and instability of slopes in plunge pool area. The said issue of plunge pool area and the required strengthening work were immediately taken up by NTPC with the Panel of Experts (PoE) constituting experts from field of hydro engineering, who visited site from time to time and recommended strengthening works inter-alia by way of providing secant piling, rock anchors, grouting & concreting etc.

iv. On the recommendation of Panel of Experts (POE), concreting works to fill the cavities beneath the cladding walls in the plunge pool area, strengthening works like cable anchoring works on the vertical face of flip

bucket and consolidation grouting on and above El 516.5 meter bench of concrete cladding of plunge pool were carried out from time to time.

v. It is submitted that the dynamic behavior of the Sutlej River flow and the complex spillway flow pattern have resulted in a significant damage to the extent that some of the protection measures were also washed away.

vi. It is submitted that during subsequent surveys of plunge pool carried out by the Panel of Experts (PoE), PoE has recommended long term measures like grouted Rock Anchors in slope of plunge pool cladding walls, grouting work for consolidating the rock mass of plunge pool area, Secant poling in plunge pool area and certain other protection works etc. for the protection of the plunge pool and flip bucket area. Details of the recommendations of the PoE is attached as **Annexure - A**

vii. It is further submitted that the issue of the plunge pool area was reviewed by an inspection team of Dam Safety Organization under Central Water Commission (CWC) during their visit to Koldam HEP during 27.06.2022 to 28.06.2022. The inspection team in its report has also recommended for arresting the movement and erosion near plunge pool area on priority. The inspection report/recommendations of the CWC Team is attached as **Annexure -B**

viii. It is prayed that the work relating to the long-term measures for protection of the plunge pool area, which is necessarily required to be executed keeping in view of the safe and successful continuous operation of Koldam HEP, got delayed from the tariff period 2019 – 24 has spilled over to the present tariff period 2024 – 29 due to uncontrollable factors. The said work is expected to be completed in FY 2025-26.

ix. The above mentioned additional plunge pool strengthening works has been considered as the additional capitalization in the Form-9A of the current tariff sheet for the year 2024-29 in terms of the clause (1) of the Regulation 25 of

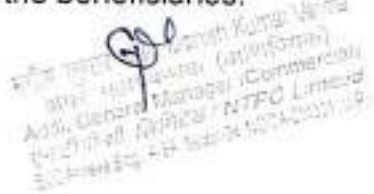
CERC Tariff Regulations, 2024. NTPC also prays Hon'ble Commission to allow the said expenditure by exercising Power to Relax in terms of Regulations 102 of the CERC Tariff Regulations, 2024.

11) The Petitioner further respectfully submits that the pay/wage revision for the employees of the Petitioner will be due with effect from 01.01.2027. Further, the wage/pay revision of CISF will also be due for revision during the tariff period 2024-29. Regulation-36(1)(8) of CERC (Terms & Conditions of Tariff) Regulations-2024 provides as below:

"In the case of a generating company owned by the Central or State Government, the impact on account of implementation of wage or pay revision shall be allowed at the time of truing up of tariff."

In accordance with the above said regulation, the Petitioner shall approach the Hon'ble Commission for allowing the impact of Pay/wage revision of employees of the Petitioner i.e. NTPC Limited, CISF as additional O&M at the time of truing-up of tariff for the control period 2024-29. Hon'ble Commission may be pleased to consider the impact of wage/pay revision as an additional impact on O&M and allow the same as additional O&M over and above the normative O&M.

12) It is submitted that the Petitioner has already paid the requisite filing fee vide Transaction Id 37c568eba62158b7b321 on 24.04.2024 for the year 2024-25 and the details of the same have been duly furnished to the Hon'ble Commission vide our letter dtd. 17.04.2024. For the subsequent years, it shall be paid as per the provisions of the CERC (Payment of Fees) Regulations, 2012 as amended. Further, the proof of payment of fees is being submitted in Form I specified under Regulation 12 of the Central Electricity Regulatory Commission (Payment of Fees) Regulations, 2012, as amended from time to time. Further Regulation 94 (1) of Tariff Regulations 2024 provides that the application fee and publication expenses may be allowed to be recovered directly from the beneficiaries at the discretion of the Hon'ble Commission. Accordingly, it is prayed that Hon'ble Commission may be pleased to allow recover filing fee and publication fee directly from the beneficiaries.



13) The petitioner has accordingly calculated the tariff for 2024-29 period based on the above and the same is enclosed as **Appendix-I** to this petition.

14) It is submitted that the Petitioner has uploaded the copy of the Petition at CERC site (Saudamini), the access of which is available to all the Respondents mentioned herein above and therefore the petition stands served to all the respondents. Further, the petitioner has also posted the Petition on the company website i.e. www.ntpc.co.in.

15) In accordance with the 'Conduct of Business Regulations 2023' of the Hon'ble Commission, the Petitioner shall, within 7 days after filing the tariff petition, publish a notice about such filing in at least two daily leading digital newspapers one in English language and another in any of the Indian languages, having wide circulation in each of the States and Union Territories where the beneficiaries are situated, as per Form 14 appended to these regulations. Subsequently, the Petitioner shall submit the proof of publications as soft copies of the publications under an affidavit through the e-filing portal of the Hon'ble Commission within one week from the date of publication. Further, the Petitioner shall also submit the detail of expenses incurred for publication of the notice alongwith the prayer for recovery of Publication Expenses as per Regulation-94 of CERC Tariff Regulations 2024.

16) It is submitted that the petitioner is filing this tariff petition subject to the outcome of its various appeals/ petitions pending before different courts. Besides, the petition filed by NTPC for determination of capital base as on 31.3.2024 through true-up exercise is pending before the Hon'ble Commission and would take some time. The Petitioner, therefore, reserves its right to amend the tariff petition as per the outcome in such appeals/ petitions, if required.

Prayers

In the light of the above submissions, the Petitioner, therefore, prays that the Hon'ble Commission may be pleased to:

i) Approve tariff of Koldam Hydro Electric Project (4 X 200 MW) for the tariff period 01.04.2024 to 31.03.2029.

ii) Allow the recovery of filing fees as & when paid to the Hon'ble Commission and publication expenses from the beneficiaries.

iii) Allow the recovery of pay/wage revision as additional O&M over and above the normative O&M.

iv) Pass any other order as it may deem fit in the circumstances mentioned above.

Petitioner

Addl. General Manager (Commercial)
एन.टी.पी.सी. लिमिटेड / NTPC Limited

Noida:

BEFORE THE CENTRAL ELECTRICITY REGULATORY COMMISSION

NEW DELHI

PETITION NO.....

IN THE MATTER OF : Petition Under Section 62 and 79 (1) (a) of the Electricity Act, 2003 read with Chapter-III of the Central Electricity Regulatory Commission (Conduct of Business) Regulations, 2023 and Chapter-3, Regulation-9 of Central Electricity Regulatory Commission (Terms and Conditions of Tariff) Regulations, 2024 for approval of tariff of ***Koldam Hydro Electric Project (4 X 200 MW)*** **for the period from 01.04.2024 to 31.03.2029.**

Petitioner: : NTPC Ltd.
NTPC Bhawan
Core-7, Scope Complex
7, Institutional Area, Lodhi Road
New Delhi-110 003

Versus

1. Uttar Pradesh Power Corporation Limited (UPPCL)
   Shakti Bhawan
   14, Ashok Marg
   Lucknow-226 001

   & Others

Respondents

NOTARY GOVT. OF INDIA

AFFIDAVIT

I, Manish Kumar Verma, son of Sh. Narendra Narayan Verma aged about 52 years resident of V-2004, Hyde Park, Sector-78, NOIDA do hereby solemnly affirm and state as under:

1. I am the Additional General Manager (Commercial) in NTPC Ltd. and am well conversant with the facts of the case and am competent to swear the present affidavit.
2. That I have read the contents of the accompanying petition filed by NTPC & have understood the contents of the same.
3. That the contents of the accompanying petition being filed by NTPC are based on information available with the Petitioner in the normal course of business and believed by the deponent to be true.

NOTARY GOVT. OF INDIA

DEPONENT

Addl. General Manager (Commercial)
NTPC Limited

VERIFICATION

I, Manish Kumar Verma, the deponent above named, do hereby verify that the contents of the above affidavit are true to the best of my knowledge, no part of it is false and nothing material has been concealed therefrom.

Verified at Noida (UP) on this 28th day of Nov... 2024.

DEPONENT

Addl. General Manager (Commercial)
NTPC Limited

NOTARIAL NOTARIAL

ATTESTED
YOGENDRA SINGH
NOTARY NOIDA
G.B. NAGAR (U.P.) INDIA

28 NOV 2024

Appendix-I

TARIFF FILING FORMS (HYDRO)

FOR DETERMINATION OF TARIFF

PART-I

Checklist of Forms and other information/ documents for tariff filing for Hydro Stations

Form No.	Title of Tariff Filing Forms (Hydro)	Tick
FORM-1	Summary Sheet	√
FORM-1(I)	Statement showing claimed capital cost	√
FORM-1(II)	Statement showing Return on Equity	√
FORM-1(IV) *	Computation of Saleable Design Energy	√
FORM-2	Details of COD, Type of Hydro Station, Normative Annual Plant Availability Factor (NAPAF) & Other normative parameters considered for tariff calculation	√
FORM-3	Salient Features of Hydroelectric Project	√
FORM-4	Details of Foreign loans	NA
FORM-4A	Details of Foreign Equity	NA
FORM-5	Abstract of Admitted Capital Cost for the existing Projects	√
FORM-5B	Break-up of Capital Cost for New Hydro Power Generating Station	NA
FORM-5C	Break-up of Capital Cost for Plant & Equipment (New Projects)	NA
FORM-5D	Break-up of Construction/Supply/Service packages	NA
FORM-5E(i)	In case there is cost over run	NA
FORM-5E(ii)	In case there is time over run	NA
FORM-5F	In case there is claim of additional RoE	NA
FORM-6	Financial Package upto COD	NA
FORM-7	Details of Project Specific Loans	NA
FORM-8	Details of Allocation of corporate loans to various projects	NA
FORM-9A	Statement of Additional Capitalisation after COD	√
FORM-9B	Statement of Additional Capitalisation during fag end of the useful life of Project	NA
FORM-9Bi	Details of Assets De-capitalised during the period	NA
FORM-9C	Statement showing reconciliation of ACE claimed with the capital additions as per books	NA
FORM-9D	Statement showing items/assets/works claimed under Exclusions	NA
FORM-9E	Statement of Capital cost	√
FORM-9F	Statement of Capital Woks in Progress	√
FORM-10	Financing of Additional Capitalisation	√
FORM-11	Calculation of Depreciation	√
FORM-12	Statement of Depreciation	√
FORM-13	Calculation of Weighted Average Rate of Interest on Actual Loans	√
FORM-13A	Calculation of Interest on Normative Loan	√
FORM-13B	Calculation of Interest on Working Capital	√
FORM-13C	Other Income as on COD	√
FORM-13D	Incidental Expenditure during Construction	√
FORM-14	Draw Down Schedule for Calculation of IDC & Financing Charges	NA
FORM-14A	Actual cash expenditure	NA
FORM-15A	Design Energy and peaking capability (month wise) - ROR with Pondage / Storage type new stations	√
FORM-15A-I *	Month wise 10-day Design Energy Data	NA
FORM-15B	Design Energy and MW Continuous (month wise) - ROR type stations	NA
FORM-16	Liability Flow Statement	NA

PART - II

Summary Sheet

Name of the Petitioner : NTPC Ltd.
Name of the Generating Station : Koldam Hydro Electric Power Project
Station COD : 18.07.2015

(₹ Lakhs)

S.No.	Particulars	Form No.	2024-25	2025-26	2026-27	2027-28	2028-29
1	2	3	4	5	6	7	8
1	Depreciation	12	35,318.34	36,185.38	36,544.33	36,566.11	36,587.90
2	Interest on Loan	13A	15,709.59	14,188.27	11,879.41	8,907.50	5,902.47
3	Return on Equity	1 (I,II)	43,730.59	44,795.50	45,231.71	45,258.70	45,285.69
4	Interest on Working Capital	13B	2,113.55	2,156.49	2,172.74	2,165.51	2,169.06
5	O&M Expenses as per regulation 36(2)		16,313.75	17,168.78	18,069.25	19,017.59	20,016.39
	Sub Total		**1,13,185.82**	**1,14,494.43**	**1,13,897.43**	**1,11,915.41**	**1,09,961.51**
	Total (Annual Fixed Cost)		**1,13,185.82**	**1,14,494.43**	**1,13,897.43**	**1,11,915.41**	**1,09,961.51**

Statement of Capacity and Energy Charges

(₹ Lakhs)

S.No.	Particulars	Unit	2024-25	2025-26	2026-27	2027-28	2028-29
1	2	3	4	5	6	7	8
1	Annual Fixed Cost (AFC)	₹ Lakhs	1,13,185.82	1,14,494.43	1,13,897.43	1,11,915.41	1,09,961.51
2	Capacity Charges (50% of AFC)	₹ Lakhs	56,592.91	57,247.22	56,948.72	55,957.70	54,980.75
3	Energy Charges (50% of AFC)	₹ Lakhs	56,592.91	57,247.22	56,948.72	55,957.70	54,980.75
4	Saleable Design Energy as per Form-1 (IV)	MUs	2,631.09	2,631.09	2,631.09	2,631.09	2,631.09
5	**Energy Charge Rate**	₹/kWh	**2.151**	**2.176**	**2.164**	**2.127**	**2.090**

(Petitioner)

FORM- 1(I)

Summary Sheet

Name of the Petitioner : NTPC Ltd.
Name of the Generating Station : Koldam Hydro Electric Power Project
Station COD : 18.07.2015

Form-1(I) - Statement showing claimed capital cost:(A+B)

(₹ Lakhs)

S. No.	Particulars	2024-25	2025-26	2026-27	2027-28	2028-29
1	2	3	4	5	6	7
1	Opening Capital Cost	718871.63	7,40,313.63	7,54,693.63	7,55,143.63	7,55,593.63
2	Add: Addition during the year/period	21442.00	14380.00	450.00	450.00	450.00
3	Less: Decapitalisation during the year/period	-	-	-	-	-
4	Less: Reversal during the year/period	-	-	-	-	
5	Add: Increase due to discharges during the year/perio	-	-	-	-	-
6	**Closing Capital Cost**	**7,40,313.63**	**7,54,693.63**	**7,55,143.63**	**7,55,593.63**	**7,56,043.63**
7	**Average Capital Cost**	**7,29,592.63**	**7,47,503.63**	**7,54,918.63**	**7,55,368.63**	**7,55,818.63**

Statement showing claimed capital cost eligible for RoE at normal rate (A)

S. No.	Particulars	2024-25	2025-26	2026-27	2027-28	2028-29
1	2	3	4	5	6	7
1	Opening Capital Cost	717048.96	738385.9627	751685.9627	752135.9627	752585.9627
2	Add: Addition during the year / period	21337	13300	450	450	450
3	Less: Decapitalisation during the year / period	0	0	0	0	0
4	Less: Reversal during the year / period	0	0	0	0	0
5	Add: Discharges during the year / period	0	0	0	0	0
6	Closing Capital Cost	738385.9627	751685.9627	752135.9627	752585.9627	753035.9627
7	Average Capital Cost	727717.4627	745035.9627	751910.9627	752360.9627	752810.9627

Statement showing claimed capital cost eligible for RoE at One Year MCLR+350 bps subject to ceiling of 14.00%(B)

Addl. General Manager (Commercial)

S. No.	Particulars	2024-25	2025-26	2026-27	2027-28	2028-29
1	2	3	4	5	6	7
1	Opening Capital Cost	1822.670379	1927.670379	3007.670379	3007.670379	3007.670379
2	Add: Addition during the year / period	105	1080	0	0	0
3	Less: Decapitalisation during the year / period	0	0	0	0	0
4	Less: Reversal during the year / period	0	0	0	0	0
5	Add: Discharges during the year / period	0	0	0	0	0
6	Closing Capital Cost	1927.670379	3007.670379	3007.670379	3007.670379	3007.670379
7	Average Capital Cost	1875.170379	2467.670379	3007.670379	3007.670379	3007.670379

Manish Kumar Verma
Addl. General Manager (Commercial)
NTPC Limited

Name of the Petitioner : NTPC Ltd.
Name of the Generating Station : Koldam Hydro Electric Power Project

PART-II
FORM-1(II)

Statement showing Return on Equity at Normal Rate

(₹ Lakhs)

S. No.	Particulars	2024-25	2025-26	2026-27	2027-28	2028-29
1	2	3	4	5	6	7
1	Gross Opening Equity (Normal)	215114.69				
2	Less: Adjustment in Equity	0				
3	Adjustment during the year	0				
4	Net Opening Equity (Normal)	215114.69	221515.79	225505.79	225640.79	225775.79
5	Add: Increase in equity due to additionduring the year / period	6401.1	3990	135	135	135
6	Less: Decrease due to de-capitalisationduring the year / period	0	0	0	0	0
7	Less: Decrease due to reversal duringthe year / period	0	0	0	0	0
8	Add: Increase due to discharges during the year/ period	0	0	0	0	0
9	Net closing Equity (Normal)	221515.79	225505.79	225640.79	225775.79	225910.79
10	Average Equity (Normal)	218315.24	223510.79	225573.29	225708.29	225843.29
11	Rate of ROE	19.993%	19.993%	19.993%	19.993%	19.993%
12	Total ROE	43647.77	44686.51	45098.87	45125.86	45152.85

Statement showing Return on Equity at One Year MCLR + 350 bps subject to ceiling of 14.00%

S. No.	Particulars	2024-25	2025-26	2026-27	2027-28	2028-29
1	2	3	4	5	6	7
1	Gross Opening Equity (pertaining to Proviso to Regulation 30(2))	546.8011138				
2	Less: Adjustment in Equity	0				
3	Adjustment during the year	0				
4	Net Opening Equity	546.8011138	578.3011138	902.3011138	902.3011138	902.3011138

5	Add: Increase in equity due to additionduring the year / period	31.5	324	0	0	0
6	Less: Decrease due to de-capitalisation during the year / period	0	0	0	0	0
7	Less: Decrease due to reversal duringthe year / period	0	0	0	0	0
8	Add: Increase due to discharges during the year/ period	0	0	0	0	0
9	Net closing Equity (pertaining to Proviso to Regulation 30(2))	578.3011138	902.3011138	902.3011138	902.3011138	902.3011138
10	Average Equity (pertaining to Proviso to Regulation 30(2))	562.5511138	740.3011138	902.3011138	902.3011138	902.3011138
11	Rate of ROE (One-year MCLR+350 bps subject to ceiling of 14.00%)	14.72%	14.72%	14.72%	14.72%	14.72%
12	Total ROE	82.82	108.99	132.84	132.84	132.84

मनीष कुमार वर्मा / Manish Kumar Verma
अपर महाप्रबंधक (वाणिज्यिक)
Addl. General Manager (Commercial)
एनटीपीसी लिमिटेड / NTPC Limited
ECC Annexe Bldg, A-8A, Sector-24, NOIDA-201301 (U.P.)

PART - II
FORM- 1(IV)
Additional Form

Computation of Saleable Design Energy

Name of the Petitioner : **NTPC Ltd.**
Name of the Generating Station : **Koldam Hydro Electric Power Project**
Station COD : **18.07.2015**

(in MUs)

S.No.	Particulars	FY
1	Design Energy	3054.79
2	Less: Auxiliary Consumption (1.0%)	30.55
3	Net Design Energy (1 - 2)	3024.24
4	Less: Free Power to GoHP (12%)	362.91
5	Less: Free Power to GoHP (1%)	30.24
6	**Saleable Design Energy (3-4-5-6)**	**2631.09**

(Petitioner)

Asst. General Manager (Commercial)
On Behalf of Petitioner / NTPC Limited

PART -
FORM -

Details of COD, Type of Hydro Station, Normative Annual Plant Availability Factor (NAPAF) & Other normative parameters considered for tariff calculation

Name of the Petitioner : NTPC Ltd.
Name of the Generating Station : Koldam Hydro Electric Power Project
Station COD : 18.07.2015

S.No.	Description	Year Ending March					
		UM	2024-25	2025-26	2026-27	2027-28	2028-29
1	2	3	5	6	7	8	9
1	Installed Capacity	MW	800	800	800	800	800
2	Free Power to home state	%	13% (12% + 1%)				
3	Date of commercial operation						
	Unit - I		18-07-2015				
	Unit - II		18-07-2015				
	Unit - III		18-07-2015				
	Unit - IV		18-07-2015				
4	Type of Station						
	a) Surface / underground		Surface				
	b) Purely ROR / Pondage / Storage		ROR with Pondage				
	c) Peaking / non-peaking		Peaking				
	d) No. of hours of peaking		3 Hrs				
	e) Overload capacity (MW) & period		80 MW, Continuous				
5	Type of excitation						
	a) Rotating exciters on generator						
	b) Static excitation		Static				
6	Design Energy (Annual)	Gwh	3054.79	3054.79	3054.79	3054.79	3054.79
7	Auxiliary Consumption including Transformation losses	%	1.00%	1.00%	1.00%	1.00%	1.00%
8	Normative Plant Availability Factor (NAPAF)	%	90%	90%	90%	90%	90%
9.1	Maintenance Spares for WC	% of O&M	15%	15%	15%	15%	15%
9.2	Receivables for WC	in Months	2	2	2	2	3
9.3	Base Rate of Return on Equity	%	16.50%	16.50%	16.50%	16.50%	16.50%
9.4	Tax Rate	%					
9.5	Effective Tax Rate	%	17.4720%	17.4720%	17.4720%	17.4720%	17.4720%
9.6	SBI Base Rate as on 01.04.2024	%	8.65%	8.65%	8.65%	8.65%	8.65%
	SBI Base Rate + 325 basis points		11.90%	11.90%	11.90%	11.90%	11.90%
9.7	8- Average Monthly Frequency Response Performance	0-1					

Note:
1. Month wise 10-day Design Energy enclosed at separate Form-15A-I.

(Petitioner

Asst. General Manager (Commercial)
NTPC Limited

PART - II
FORM- 3

Salient Features of Hydroelectric Project

Name of the Petitioner : **NTPC Ltd.**
Name of the Generating Station : **Koldam Hydro Electric Power Project**
Station COD : **18.07.2015**

1. Location	
State/Distt.	Bilaspur, Himachal Pradesh
River	Satluj
2. Diversion Tunnel	
Size, shape	Two Nos, Finished dia 14m, Horse shoe
Length (M)	T-1 = 901m, T-2 = 934m
3. Dam	
Type	Rock and gravel fill with central Clay Core
Maximum dam height (M)	167m
4. Spillway	
Type	Chute Spillway with Ogee Shaped Weir
Crest level of spillway (M)	EL. 625m
5. Reservoir	
Full Reservoir Level (FRL) (M)	EL. 642m
Minimum Draw Down Level (MDDL) (M)	EL. 636m
Live storage (MCM)	88.64 MCM (Initial)
6. De-silting Chamber	
Type	Decanting Chamber
Number and Size	14 bays, 12.50m clear width
Particle size to be removed (mm)	250µm
7. Head Race Tunnel	N.A.
Size and type	
Length (M)	
Design discharge (Cumecs)	
8. Surge Shaft	N.A.
Type	
Diameter (M)	
Height (M)	
9. Penstock/Pressure shafts	
Type	4 Nos. , Circular Steel Lined
Diameter & Length (M)	6.45m
10. Power House	
Installed capacity (No of units x MW)	4 * 200MW
Type of turbine	Vertical Francis
Rated Head (M)	131.2m
Rated Discharge (Cumecs)	186.2 Cumecs per unit at rated head
Head at Full Reservoir Level (M)	140m
Head at Minimum Draw down Level (M)	127m
MW Capability at FRL	800
MW Capability at MDDL	800
11. Tail Race Tunnel/ Channel	
Diameter (M) , shape	Open Channel
Length (M)	100m
Minimum tail water level (M)	503m
12. Switchyard	
Type of Switch gear	AIS
No. of generator bays	4
No. of Bus coupler bays	Koldam being a 1-1/2 breaker scheme, there are 2 tie bays for GT bays and 2 tie bays on line side. One bus reactor bay is also existing in Koldam
No. of line bays	4

Note: Specify limitation on generation during specific time period(s) on account of restrictions on water use due to irrigation, drinking water, industrial, environmental considerations etc.

(Petitioner)

Manish Kumar Verma
Addl. General Manager (Commercial)

Part-I
FORM-3A
ADDITIONAL FORM

Calculation of O&M Expenses

Name of the Company : NTPC Limited

Name of the Power Station : Koldam HEP

Amount in Rs. Lakhs

S.No.	Particulars	2024-25	2025-26	2026-27	2027-28	2028-29
1	2	3	4	5	7	8
1	O&M expenses under Reg.36 (2)					
1a	Normative	13113.75	13830.78	14587.01	15384.58	16225.77
2a	Insurance	1100.00	1133.00	1166.99	1202.00	1236.06
2b	Wage Revision **	-	-	-	-	-
2c	Security expenses	2100.00	2205.00	2315.25	2431.01	2552.56
3	Capital Spares**	-	-	-	-	-
	Total O&M Expenses	**16313.75**	**17168.78**	**18069.25**	**19017.5922**	**20016.3928**

** Shall be provided at the time of truing up

मनीष कुमार वर्मा / Manish Kumar Verma
Petitioner
Addl. General Manager (Commercial)
On behalf of NTPC Limited

PART - II
FORM-5

Abstract of Admitted Capital Cost for the existing Projects

Name of the Petitioner : **NTPC Ltd.**
Name of the Generating Station : **Koldam Hydro Electric Power Project**
Station COD : **18.07.2015**

(₹ Lakhs)

Capital cost as admitted by CERC
(As per CERC Order dated 19.05.2024 in Review Petition No. 1/RP/2024 in Petition. No. 363/GT/2020)

A. Capital cost admitted as on 01.04.2019 as per the above order	**7,04,063.22**
Foreign Component, if any (In Million US $ or the relevant Currency)	
Domestic Component (Rs. Cr.)	
Foreign Exchange rate considered for the admitted cost	
Hedging Cost, if any, considered for the admitted capital cost	
Total Capital cost admitted	**7,04,063.22**

(Petitioner)

Rajesh Kumar Verma
Addl. General Manager
NTPC Limited
EOC Annexe Bldg., A-8A, Sector 24, NOIDA-201301 (U.P.)

Year wise Statement of Additional Capitalisation

Name of the Petitioner : NTPC Ltd.
Name of the Generating Station : Koldam HPS (4x200 MW)
COD : 15.07.2015

Name of the Petitioner : NTPC Ltd
Name of the Generating Station : Koldam Hydro Electric Power Project
Station COD : 15.07.2015
For Financial Year : 2024-29
(₹ Lakhs)

Sl No.	Description of Work/ Equipment	Additional Capital Expenditure Claimed (Projected)						Regulations Under Which Claimed	Justification (Proposed to be submitted to CERC)
		2024-25	2025-26	2026-27	2027-28	2028-29	Total		
	Under Original Scope								
1	Land Acquisition Office Admin Expenses	50.00	50.00	50.00	50.00	50.00	250.00	25(1) (a)	The private land for Koldam project has been acquired under the provisions of the Land Acquisition Act (1894) through the Land Acquisition Office at Bilaspur established by Govt. of HP and the expenses for this office are borne by NTPC as per Clause 2.4 & 2.5 of the agreement signed between Government of HP (GoHP), HPSEB and NTPC Ltd. on 28th Feb 2000.Supporting documents are attached as Annexure-C There are several legal cases being filed on account of the alleged damages due to reservoir impounding to the properties which are being refuted by the Petitioner. Therefore, there is a need of LAC office for the purposes of joint inspection, assessment of damages and valuation (if any) etc In view of the above, the services of the land acquisition staff shall be invariably required further.
2	Land Reference Cases	400.00	400.00	400.00	400.00	400.00	2,000.00	25(1)(a)	NTPC has acquired private land for the construction of Koldam Project under the provisions of the Land Acquisition Act (1894) through the Land Acquisition Officer appointed by the Govt. of HP. Subsequent to the acquisition, the landowners have filed reference cases before the respective Court's seeking enhancement of compensation amount to be paid to them. The Distt. Courts passed judgments in favour of the landowners and enhanced the rate of compensation. NTPC preferred appeals in the Hon'ble High Court of HP wherein NTPC was directed to deposit the enhanced amount of compensation with the registry of the Court on case to case basis.Supporting documents are attached as Annexure-D Further, envisaging the requirement of deposition of enhanced compensation to all such landowners as decided by the respective Courts in future, an estimated amount of Rs.20 Cr has been projected to be incurred during 2024-29 period.
3	R&R Works	1,200.00	300.00	-	-	-	1,500.00	25(1)(a)	These works have been necessitated due to the villages acquired for the construction of Koldam Project and Resettlement Colonies (RCs) were required to be constructed for the affected land owners in consultation with the District Administration. As on date 5 Nos of RCs have been constructed at Sunni, Jitarnthal, Chamiyon, Kasol and Kangoo out of which 4 nos of RCs (Sunni, Jitarnthal, Chamiyon and Kasol) have been handed over to State Administration and 1 No of RC (Kangoo) will be handed over in due course of time. Further, 1 no. of RC (at Muridkar, Distt Solan) is yet to be constructed which got delayed due to reasons beyond the control of the Petitioner (law & order issue). Out of the amount of approx Rs. 15 Cr is projected to be deposited with State Authorities for FY 2024-25 and 25-26 towards RC Jitarnthal, Chamiyon and Kasol.
4	Implementation of Offsite Buildings along with Administrative Building	332.00	550.00				882.00	25(1) with102	Implementation of Offsite Building Package was initially awarded to M/s Supreme in Aug'2012 however, the same could not be completed on time due to abandonment of the work by Contractor because of various defaults on its part including GST cancellation by O/o Joint Commissioner, HP State Taxes and Excise Deptt and other contractual issues along with invocation of Arbitration in respect thereof. Subsequently, having left with no other option, NTPC terminated the said contract due to non performance on part of the Contractor and awarded multiple fresh contracts at risk and cost of the Contractor for completion of the balance works. The said contracts awarded at risk & cost of the previous contractor are under execution and likely to get completed by Mar'26.
5	Permanent Water Supply	460.00					460.00	25(1) with 102	This work could not be awarded initially due to lack of response from the bidders. Subsequently, the work was split in multiple packages thereby including Civil, Mechanical, Electrical & Instrumentation works of Permanent Water Supply and Water Treatment System by way of Erection and commissioning of Clarifloculator etc. The above stated works are nearing completion and shall be capitalized in FY 2024-29.
6	Additional Plunge pool Strengthening along with associated Works	17,595.00	12,000.00				29,595.00	25(1) with 102	Due to operation of spillway Gates in the monsoon , severe soil erosion & damage of concrete cladding in plunge pool area has been observed. For safe and continuous operation of Koldam HPS, various Panel of Experts (PoE) have made recommendations with regard to Plunge pool works, Diversion Tunnel works, Bank protections works, Downstream protection works,Dilatation Joint Filling in Spillway Chute,Cable Anchoring Works & other related strengthening works . Protection works have been identified based on the recommendations from the Panel of Experts as well as Central Water Commission. Plunge pool works which got delayed from the tariff period 2019 – 24 has spilled over to the present tariff period 2024 – 29 due to uncontrollable factors. The work is expected to be completed by FY 2025-26. Reports from Panel of Experts (PoE) and CWC are attached as Annexure-A& B respectively.
7	Plugging of Diversion Tunnel,Hiring of Project Management Consultant for assistance (scheduling, planning, supervision, key issues resolution etc) in successful execution of construction of additional plug in DT-2	845.00					845.00	25(1) with 102	This work has been awarded to facilitate construction of additional plug in Diversion Tunnel-2 which is being executed based on the recommendations from the Panel of Experts as well as Central Water Commission and are expected to be completed by Mar'2025. Reports from Panel of Experts (PoE) and CWC are attached as Annexure-A & B respectively.
8	Upgradation against Obsolescence of HMI of M/s BHEL with cyber security features at NTPC Koldam	400.00					400.00	25(2)(c)	This work is required because of obsolescence of technology and hardware and for better security of plant with latest technology with respect to hardware and software.
9	Construction of a Single Court badminton Hall in NTPC Township, Jai Jyoti Vihar at Koldam	55.00					55.00	25(1) with 102	Award and execution of this work got delayed due to non availability/ non participation of the agencies available in the vicinity for bidding/ execution of the work. This work has been completed in FY 2024-25 and the Badminton Hall has been put to use.
	Sub Total Original Scope	21,337.00	13,300.00	450.00	450.00	450.00	35,987.00		

मनीष कुमार वर्मा / Manish Kumar Verma
अति. महाप्रबंधक (वाणिज्यिक)
Addl. General Manager (Commercial)
एनटीपीसी लिमिटेड / NTPC Limited

Year wise Statement of Additional Capitalisation

Name of the Petitioner	**: NTPC Ltd.**
Name of the Generating Station	**: Koldam HPS (4X200 MW)**
COD	**: 18.07.2015**

Name of the Petitioner : NTPC Ltd
Name of the Generating Station : Koldam Hydro Electric Power Project
Station COD : 18.07.2015
For Financial Year : 2024-29
(₹ Lakhs)

Sl No.	Description of Work/ Equipment	Additional Capital Expenditure Claimed (Projected)						Regulations Under Which Claimed	Justification (Proposed to be submitted to CERC)
		2024-25	2025-26	2026-27	2027-28	2028-29	Total		
	Under Original Scope								
	Work beyond original Scope and excluding Change In Law works								
10	Supply, Erection & Commissioning of 03 Nos. Solar PV Rooftop Plants	105.00					105.00	26(1)(b)	It is submitted that the work of installation of roof top solar PV plant at instant Station was carried out under Policy framework of the Government of India to achieve its ambitious 2022 target of achieving 175GW of RE which includes 100 GW from solar, 60 GW from wind, 10 GW from bio-power and 5 GW from small hydro-power that marks 75 years of our independence. The project is towards compliance of the Govt of India initiative for promoting renewable energy such as rooftop solar PV plant to reduce inhouse power consumption.
11	Real Time Inflow & Flood Forecasting System (RTIFFS) in the catchment of NTPC Koldam 2024		1,000.00				1,000.00	26(1)(b)	This work is required for augmentation of Early Warning System (EWS) as per Dam Safety Act by installing latest technology instruments which involves upgradation of sensors to latest technology, inclusion of Automatic Weather Stations (AWS) and to have communication redundancy. As per Dam safety Act Clause 35 (1) (a) and Clause 4 (3) of subsequent gazette notification dated 20.05.2024 for Surveillance, Inspection and Hydrometeorological Station of Specified Dams Regulation, it is obligatory on part of dam owner to establish well designed hydro-meteorological network and an inflow forecasting system. In this regard detailed Standard Operating Procedures (SOP) for structure of Early Warning System at Hydro Stations has been issued by Central Electricity Authority in June 2024 (Supporting documents are enclosed as Annexure-E). Strengthening of Early warning system is also being discussed in various meetings with NDMA and SDSO-Himachal.
	Sub Total Work beyond original Scope and under Change in Law works	105.00	1,000.00	-	-	-	1,105.00		
	Total	**21,442.00**	**16,280.00**	**400.00**	**400.00**	**400.00**	**37,172.00**		

PETITIONER

मनीष कुमार वर्मा / Manish Kumar Verma
अपर महाप्रबंधक (वाणिज्यिक)
Addl. General Manager (Commercial)
एनटीपीसी लिमिटेड / NTPC Limited
EOC Annexe Bldg., A-8A, Sector-24, NOIDA-201301 (U.P.)

Name of the Petitioner : NTPC Ltd.
Name of the Generating Station : Koldam HPS (4X200 MW)
COD : 18.07.2015
FY 2024-25

Year wise Statement of Additional Capitalisation

(Rs. Lakhs)

Sl No.	Description of Works Equipment	Additional Capital Expenditure Claimed (Projected)				Regulations Under Which Claimed	Justification (Proposed to be submitted to CERC)
		Accrual basis as per IGAAP	Un-discharged Liability included in col. 3	Cash basis	IDC included in col. 3		
1	Land Acquisition Office Admin Expenses	50.00	-	50.00	-	25(1)(a)	The private land for Koldam project has been acquired under the provisions of the Land Acquisition Act (1894) through the Land Acquisition Office at Bilaspur established by Govt. of HP and the expenses for this office are borne by NTPC as per Clause 2.4 & 2.5 of the agreement signed between Government of HP (GoHP), HPSEB and NTPC Ltd. on 26th Feb 2000. Supporting documents are attached as Annexure-C. There are several legal cases being filed on account of the alleged damages due to reservoir impounding to the properties which are being refuted by the Petitioner. Therefore, there is a need of LAO office for the purposes of joint inspection, assessment of damages and valuation (if any) etc. In view of the above, the services of the land acquisition staff shall be inevitably required further.
2	Land Reference Cases	400.00	-	400.00		25(1)(a)	NTPC has acquired private land for the construction of Koldam Project under the provisions of the Land Acquisition Act (1894) through the Land Acquisition Officer appointed by the Govt. of HP. Subsequent to the acquisition, the landowners have filed reference cases before the respective Court's seeking enhancement of compensation amount to be paid to them. The Distt. Courts passed judgments in favour of the landowners and enhanced the rate of compensation. NTPC preferred appeals in the Hon'ble High Court of HP wherein NTPC was directed to deposit the enhanced amount of compensation with the registry of the Court on case to case basis. Supporting documents are attached as Annexure-D. Further, envisaging the requirement of deposition of enhanced compensation to all such landowners as decided by the respective Courts in future, an estimated amount of Rs.20 Cr has been projected to be incurred during 2024-29 period.
3	R&R Works	1,200.00	-	1,200.00		25(1)(a)	These works have been necessitated due to the villages acquired for the construction of Koldam Project and Resettlement Colonies (RC's) were required to be constructed for the affected land owners in consultation with the District Administration. As on date 5 Nos of RC's have been constructed at Suma, Jhanthal, Champon, Kasol and Kangoo out of which 4 nos of RCs (Suma, Jhanthal, Champon and Kasol) have been handed over to State Administration and 1 No of RC (Kangoo) will be handed over in due course of time. Further, 1 no. of RC (at Mundkar, Distt Solan) is yet to be constructed which got delayed due to reasons beyond the control of the Petitioner (law & order issue). Out of the amount of approx Rs. 15 Cr is projected to be deposited with State Authorities for FY 2024-25 and 25-26 towards RC Jhanthal, Champon and Kasol.
4	Implementation of Offsite Buildings along with Administrative Building	312.00	-	312.00		25(1) with 102	Implementation of Offsite Building Package was initially awarded to M/s Supreme in Aug/2012 however, the same could not be completed on time due to abandonment of the work by Contractor because of various defaults on its part including GST cancellation by O/o Joint Commissioner, HP State Taxes and Excise Deptt and other contractual issues along with invocation of Arbitration in respect thereof. Subsequently, having left with no other option NTPC terminated the said contract due to non performance on part of the Contractor and awarded multiple fresh contracts at risk and cost of the Contractor for completion of the balance works. The said contracts awarded at risk & cost of the previous contractor are under execution and likely to get completed by Mar'26.
5	Permanent Water Supply	400.00	-	400.00		25(1) with 102	This work could not be awarded initially due to lack of response from the bidders. Subsequently, the work was split in multiple packages thereby including Civil, Mechanical, Electrical & Instrumentation works of Permanent Water Supply and Water Treatment System by way of Erection and commissioning of Clariflocculator etc. The above stated works are nearing completion and shall be capitalized in FY 2024-25.
6	Additional Plunge pool Strengthening along with associated Works	17,595.00	-	17,595.00		25(1) 102	Due to operation of spillway Gates in the monsoon, severe soil erosion & damage of concrete cladding in plunge pool area has been observed. For safe and continuous operation of Koldam HPS, various Panel of Experts (PoE) have made recommendations with regard to Plunge pool works, Diversion Tunnel works, Bank protections works, Downstream protection works, Dilation Joint Filling in Spillway Chute, Cable Anchoring Works & other related strengthening works. Protection works have been identified based on the recommendations from the Panel of Experts as well as Central Water Commission. Plunge pool works which got delayed from the tariff period 2019 – 24 has spilled over to the present tariff period 2024 – 29 due to uncontrollable factors. The work is expected to be completed by FY 2025-26. Reports from Panel of Experts (PoE) and CWC are attached as Annexure-A& B respectively.
7	Plugging of Diversion Tunnel,Hiring of Project Management Consultant for assistance (scheduling, planning, supervision, key issues resolution etc) in successful execution of construction of additional plug in DT-2	845.00	-	845.00		25(1) with 102	This work has been awarded to facilitate construction of additional plug in Diversion Tunnel-2 which is being executed based on the recommendations from the Panel of Experts as well as Central Water Commission and are expected to be completed by Mar'2025. Reports from Panel of Experts (PoE) and CWC are attached as Annexure-A& B respectively.
8	Upgradation against Obsolescence of HMI of M/s BHEL with cyber security features at NTPC Koldam	400.00	-	400.00		25(2)(c)	This work is required because of obsolescence of technology and hardware and for better security of plant with latest technology with respect to hardware and software.
9	Construction of a Single Court badminton Hall in NTPC Township, Jal Jyoti Vihar at Koldam	55.00	-	55.00		25(1) with 102	Award and execution of this work got delayed due to non availability/ non participation of the agencies available in the vicinity for bidding/ execution of the work. This work has been completed in FY 2024-25 and the Badminton Hall has been put to use.
10	Supply, Erection & Commissioning of 03 Nos. Solar PV Rooftop Plants	105.00	-	105.00		25(1)	It is submitted that the work of installation of roof top solar PV plant at Koldam Station was carried out under Policy framework of the Government of India to achieve its ambitious 2022 target of achieving 175GW of RE which includes 100 GW from solar, 60 GW from wind, 10 GW from bio-power and 5 GW from small hydro power that marks 75 years of our independence. The project is towards compliance of the Govt of India initiative for promoting renewable energy and as rooftop solar PV plant to reduce [illegible]

एनटीपीसी लिमिटेड / NTPC Limited
[illegible]

11	Real Time Inflow & Flood Forecasting System (RTIFFS) in the catchment of NTPC Kishtwar 2024					25(1)(b)	This work is required for augmentation of Early Warning System (EWS) as per Dam Safety Act by installing latest technologie instruments which involves upgradation of sensors to latest technology, inclusion of Automatic Weather Stations (AWS) and to have communication redundancy. As per Dam safety Act Clause 35 (1) (a) and Clause 4 (3) of subsequent gazette notification dated 28.05.2024 for Surveillance, Inspection and Hydrometeorological Station of Specified Dams Regulation, it is obligatory on part of dam owner to establish well designed hydro-metereological network and an inflow forecasting system. In this regard detailed Standard Operating Procedures (SOP) for structure of Early Warning System at Hydro Stations has been issued by Central Electricity Authority in June'2024. (Supporting documents are enclosed as Annexure-E) Strengthening of Early warning system is also being discussed in various meetings with NDMA and SDMA Himachal.
	Total	**31,442.00**	-	**31,442.00**			

PETITIONER

मनीष कुमार वर्मा / Manish Kumar Verma
अपर महाप्रबंधक (वाणिज्यिक)
Addl. General Manager (Commercial)
एनटीपीसी लिमिटेड / NTPC Limited

Year wise Statement of Additional Capitalisation

Name of the Petitioner : NTPC Ltd.
Name of the Generating Station : Koldam HPS (4X200 MW)
COD : 18.07.2015
FY 2025-26

(Rs. Lakhs)

Sl No.	Description of Work/ Equipment	Additional Capital Expenditure Claimed (Projected)				Regulations Under Which Claimed	Justification (Proposed to be submitted to CERC)
		Accrual basis as per IGAAP	Un-discharged Liability included in col. 3	Cash basis	IDC included in col. 1		
1	Land Acquisition Office Admin Expenses	50.00	-	50.00	-	25(1)(a)	The private land for Koldam project has been acquired under the provisions of the Land Acquisition Act (1894) through the Land Acquisition Office at Bilaspur established by Govt. of HP and the expenses for this office are borne by NTPC as per Clause 2.4 & 2.5 of the agreement signed between Government of HP (GoHP), HPSEB and NTPC Ltd. on 26th Feb 2000. Supporting documents are attached as Annexure-C. There are several legal cases being filed on account of the alleged damages due to reservoir impounding to the properties which are being refuted by the Petitioner. Therefore, there is a need of LAC office for the purposes of joint inspection, assessment of damages and valuation of property. In view of the above, the services of the land acquisition staff shall be invariably required further.
2	Land Reference Cases	400.00	-	400.00		25(1)(a)	NTPC has acquired private land for the construction of Koldam Project under the provisions of the Land Acquisition Act (1894) through the Land Acquisition Officer appointed by the Govt. of HP. Subsequent to the acquisition, the landowners have filed reference cases before the respective Courts seeking enhancement of compensation amount to be paid to them. The Distt. Courts passed judgments in favour of the landowners and enhanced the rate of compensation. NTPC preferred appeals in the Hon'ble High Court of HP wherein NTPC was directed to deposit the enhanced amount of compensation with the registry of the Court on case to case basis. Supporting documents are attached as Annexure-D. Further, envisaging the requirement of deposition of enhanced compensation to all such landowners as decided by the respective Courts in future, an estimated amount of Rs 20 Cr has been projected to be incurred during 2024-29 period.
3	R&R Works	300.00	-	300.00		25(1)(d)	These works have been necessitated due to the villages acquired for the construction of Koldam Project and Resettlement Colonies (RC's) were required to be constructed for the affected land owners in consultation with the District Administration. As on date 5 Nos of RCs have been constructed at Suni, Jhamthal, Chamyon, Kasol and Kangoo out of which 4 nos of RCs (Suni, Jhamthal, Chamyon and Kasol) have been handed over to State Administration and 1 No of RC (Kangoo) will be handed over in due course of time. Further, 1 no. of RC (at Mundkar, Distt Solan) is yet to be constructed which got delayed due to reasons beyond the control of the Petitioner (law & order issue). Out of the amount of approx Rs. 15 Cr is projected to be deposited with State Authorities for FY 2024-25 and 25-26 towards RC Jhamthal, Chamyon and Kasol.
4	Implementation of Offsite Buildings along with Administrative Building	550.00	-	550.00		25(1) with 102	Implementation of Offsite Building Package was initially awarded to M/s Supreme in Aug2012 however, the same could not be completed on time due to abandonment of the work by Contractor because of various defaults on its part including GST cancellation by O/o Joint Commissioner, HP State Taxes and Excise Deptt and other contractual issues along with invocation of Arbitration in respect thereof. Subsequently, having left with no other option, NTPC terminated the said contract due to non performance on part of the Contractor and awarded multiple fresh contracts at risk and cost of the Contractor for completion of the balance works. The said contracts awarded at risk & cost of the previous contractor are under execution and likely to get completed by Mar'26.
5	Additional Plunge pool Strengthening along with associated Works	12,000.00	-	12,000.00		25(1) with 102	Due to operation of spillway Gates in the monsoon, severe soil erosion & damage of concrete cladding in plunge pool area has been observed. For safe and continuous operation of Koldam HPS, various Panel of Experts (PoE) have made recommendations with regard to Plunge pool works, Diversion Tunnel works, Bank protections works, Downstream protection works, Diversion Joint Filling in Spillway Chute, Cable Anchoring Works & other related strengthening works. Protection works have been identified based on the recommendations from the Panel of Experts as well as Central Water Commission. Plunge pool works which got delayed from the tariff period 2019 – 24 has spilled over to the present tariff period 2024 – 29 due to uncontrollable factors. The work is expected to be completed by FY 2025-26. Reports from Panel of Experts (PoE) and CWC are attached as Annexure-A& B respectively.
6	Real Time Inflow & Flood Forecasting System (RTIFFS) in the catchment of NTPC Koldam 2024	1,000.00	-	1,000.00		25(1)(b)	This work is required for augmentation of Early Warning System (EWS) as per Dam Safety Act by installing latest technology instruments which involves upgradation of sensors to latest technology, inclusion of Automatic Weather Stations (AWS) and to have communication redundancy. As per Dam safety Act Clause 35 (1) (a) and Clause 4 (3) of subsequent gazette notification dated 29.05.2024 for Surveillance, Inspection and Hydrometeorological Station of Specified Dams Regulation, it is obligatory on part of dam owner to establish well designed hydro-meteorological network and an inflow forecasting system. In this regard detailed Standard Operating Procedures (SOP) for structure of Early Warning System at Hydro Stations has been issued by Central Electricity Authority in June'2024 (Supporting documents are enclosed as Annexure-E). Strengthening of Early warning system is also being discussed in various meetings with NDSA and SDSO Himachal.
	Total	14,300.00	-	14,300.00			

PETITIONER

अनिल कुमार वर्मा / Anil Kumar Verma
अपर महाप्रबंधक (वाणिज्यिक) / Addl. General Manager (Commercial)
एनटीपीसी लिमिटेड / NTPC Limited

Year wise Statement of Additional Capitalisation

Name of the Petitioner : NTPC Ltd.
Name of the Generating Station : Koldam HPS (4X200 MW)
COD : 11.07.2015
FY 2026-27

(Rs. Lakhs)

Sl No.	Description of Work/ Equipment	Additional Capital Expenditure Claimed (Projected)				Regulations Under Which Claimed	Justification (Proposed to be submitted to CERC)
		Accrual basis as per IGAAP	Un-discharged Liability included in col 3	Cash basis	IDC included in col 3		
1	Land Acquisition Office Admin Expenses	50.00	-	50.00	-	25(1)(a)	The private land for Koldam project has been acquired under the provisions of the Land Acquisition Act (1894) through the Land Acquisition Office at Bilaspur established by Govt. of HP and the expenses for this office are borne by NTPC as per Clause 2.4 & 2.5 of the agreement signed between Government of HP (GoHP), HPSEB and NTPC Ltd. on 26th Feb 2000 Supporting documents are attached as Annexure C. There are several legal cases being filed on account of the alleged damages due to reservoir impounding to the properties which are being refuted by the Petitioner. Therefore, there is a need of LAC office for the purposes of joint inspection, assessment of damages and valuation (if any) etc. In view of the above, the services of the land acquisition staff shall be invariably required further.
2	Land Reference Cases	400.00	-	400.00		25(1)(a)	NTPC has acquired private land for the construction of Koldam Project under the provisions of the Land Acquisition Act (1894) through the Land Acquisition Officer appointed by the Govt. of HP. Subsequent to the acquisition, the landowners have filed reference cases before the respective Court's seeking enhancement of compensation amount to be paid to them. The Distt. Courts passed judgments in favour of the landowners and enhanced the rate of compensation. NTPC preferred appeals in the Hon'ble High Court of HP wherein NTPC was directed to deposit the enhanced amount of compensation with the registry of the Court on case to case basis. Supporting documents are attached as Annexure D. Further, envisaging the requirement of deposition of enhanced compensation to all such landowners as decided by the respective Courts in future, an estimated amount of Rs.20 Cr has been projected to be incurred during 2024-29 period.
		450.00	-	450.00			

PETITIONER

Kumar Verma
अपर महाप्रबंधक (वाणिज्यिक)
Addl. General Manager (Commercial)
एन टी पी सी लिमिटेड / NTPC Limited
EOC, Sector-24, NOIDA-201301 (U.P.)

Year wise Statement of Additional Capitalisation

Name of the Petitioner : NTPC Ltd.
Name of the Generating Station : Koldam HPS (49200 MW)
COD : 18.07.2015
FY 2027-28

(Rs. Lakhs)

Sl No.	Description of Work/ Equipment	Additional Capital Expenditure Claimed (Projected)				Regulations Under Which Claimed	Justification (Proposed to be submitted to CERC)
		Actual basis as per IGAAP	Un-discharged Liability included in col. 3	Cash basis	IDC included in col. 3		
1	Land Acquisition Office Admin Expenses	50.00	-	50.00	-	25(1) (a)	The private land for Koldam project has been acquired under the provisions of the Land Acquisition Act (1894) through the Land Acquisition Office at Bilaspur established by Govt. of HP and the expenses for this office are borne by NTPC as per Clause 2.4 & 2.5 of the agreement signed between Government of HP (GoHP), HPSEB and NTPC Ltd. on 26th Feb 2000 Supporting documents are attached as Annexure-C There are several legal cases being filed on account of the alleged damages due to reservoir impounding to the properties which are being refuted by the Petitioner. Therefore, there is a need of LAC office for the purposes of joint inspection, assessment of damages and valuation (if any) etc. In view of the above, the services of the land acquisition staff shall be invariably required further.
2	Land Reference Cases	400.00	-	400.00		25(1)(a)	NTPC has acquired private land for the construction of Koldam Project under the provisions of the Land Acquisition Act (1894) through the Land Acquisition Officer appointed by the Govt. of HP. Subsequent to the acquisition, the landowners have filed reference cases before the respective Court's seeking enhancement of compensation amount to be paid to them. The Distt. Courts passed judgments in favour of the landowners and enhanced the rate of compensation. NTPC preferred appeals in the Hon'ble High Court of HP wherein NTPC was directed to deposit the enhanced amount of compensation with the registry of the Court on case to case basis. Supporting documents are attached as Annexure-D Further, envisaging the requirement of deposition of enhanced compensation to all such landowners as decided by the respective Courts in future, an estimated amount of Rs.20 Cr has been projected to be incurred during 2024-29 period.
	Total	450.00	-	450.00			

PETITIONER

(Ashish Kumar Verma)
Addl. General Manager (Commercial)
NTPC Limited

the Petitioner : NTPC Ltd.
the Generating Station : Kolddam HPS (4X200 MW)
: 18.07.2015

2028-29

(Rs. Lakhs)

Description of Works/ Equipment	Additional Capital Expenditure Claimed (Projected)				Regulations Under Which Claimed	Justification (Proposed to be submitted to CERC)
	Accrual basis as per IGAAP	Un-discharged Liability included in col. 3	Cash basis	IDC included in col. 3		
Land Acquisition Office Admin Expenses	50.00	-	50.00	-	25(1) (a)	The private land for Koldam project has been acquired under the provisions of the Land Acquisition Act (1894) through the Land Acquisition Office at Bilaspur established by Govt. of HP and the expenses for this office are borne by NTPC as per Clause 2.4 & 2.5 of the agreement signed between Government of HP (GoHP), HPSEB and NTPC Ltd on 26th Feb 2000. Supporting documents are attached as Annexure-C There are several legal cases being filed on account of the alleged damages due to reservoir impounding to the properties which are being refuted by the Petitioner. Therefore, there is a need of LAC office for the purposes of joint inspection, assessment of damages and valuation (if any) etc In view of the above, the services of the land acquisition staff shall be invariably required further
Land Reference Cases	400.00	-	400.00		25(1)(a)	NTPC has acquired private land for the construction of Koldam Project under the provisions of the Land Acquisition Act (1894) through the Land Acquisition Officer appointed by the Govt. of HP. Subsequent to the acquisition, the landowners have filed reference cases before the respective Courts seeking enhancement of compensation amount to be paid to them. The Distt. Courts passed judgments in favour of the landowners and enhanced the rate of compensation. NTPC preferred appeals in the Hon'ble High Court of HP wherein NTPC was directed to deposit the enhanced amount of compensation with the registry of the Court on case to case basis. Supporting documents are attached as Annexure-D Further, envisaging the requirement of deposition of enhanced compensation to all such landowners as decided by the respective Courts in future, an estimated amount of Rs.20 Cr has been projected to be incurred during 2024-29 period.
Total	450.00	-	450.00			

PETITIONER

मनीष कुमार वर्मा / Manish Kumar Verma
अपर महाप्रबंधक (वाणिज्यिक)
Addl General Manager (Commercial)
एनटीपीसी लिमिटेड / NTPC Limited

PART-II
Form-9E

Statement of Capital Cost

(To be given for relevant dates and year wise)

Name of the Petitioner : NTPC Ltd.
Name of the Generating Station : Koldam Hydro Electric Power Project
Station COD : 16.07.2015

(₹ Lakhs)

Sl. No.		Particulars	01.04.2024		
			Accrual Basis	Un-discharged Liabilities	Cash Basis
A	a)	Opening Gross Block amount As per books	784427.0441	27574.08195	7,56,852.96
	b)	Amount of Capital liabilities in A(a) above	214866.63		2,14,866.63
	c)	Amount of IDC in A(a) above			-
	d)	Amount of FC in A(a) above	20519.02545		20,519.03
	e)	Amount of FERV in A(a) above			
	f)	Amount of Hedging Cost in A(a) above			
	g)	Amount of IEDC in A(a) above			
B	a)	Addition in Gross Block amount during the period (Direct			
	b)	Amount of Capital liabilities in B(a) above			
	c)	Amount of IDC in B(a) above			
	d)	Amount of FC in B(a) above			
	e)	Amount of FERV in B(a) above			
	f)	Amount of Hedging Cost in B(a) above			
	g)	Amount of IEDC in B(a) above			
C	a)	Addition in Gross Block amount during the period (Transfer from CWIP)			
	b)	Amount of Capital liabilities in C(a) above			
	c)	Amount of IDC in C(a) above			
	d)	Amount of FC in C(a) above			
	e)	Amount of FERV in C(a) above			
	f)	Amount of Hedging Cost in C(a) above			
	g)	Amount of IEDC in C(a) above			Shall be submitted at the time of Truing Up
D	a)	Deletion in Gross Block Amount during the period			
	b)	Amount of Capital liabilities in D(a) above			
	c)	Amount of IDC in D(a) above			
	d)	Amount of FC in D(a) above			
	e)	Amount of FERV in D(a) above			
	f)	Amount of Hedging Cost in D(a) above			
	g)	Amount of IEDC in D(a) above			
E	a)	Closing Gross Block amount As per books			
	b)	Amount of Capital liabilities in E(a) above			
	c)	Amount of IDC in E(a) above			
	d)	Amount of FC in E(a) above			
	e)	Amount of FERV in E(a) above			
	f)	Amount of Hedging Cost in E(a) above			
	g)	Amount of IEDC in E(a) above			

Note:

(Petitioner)

Additional General Manager (Commercial)
NTPC Limited

PART - II
Form-9F

Statement of Capital Woks in Progress

(To be given for the relevant dates and year wise)

Name of the Petitioner : NTPC Ltd.
Name of the Generating Station : Koldam Hydro Electric Power Project
Station COD : 18.07.2015

(₹ Lakhs)

Sl. No.		Particulars	01.04.2024		
			Accrual Basis	Un-discharged Liabilities	Cash Basis
A	a)	Opening CWIP As per books	7947.990385	1091.483166	6,856.51
	b)	Amount of Capital liabilities in A(a) above			
	c)	Amount of IDC in A(a) above			
	d)	Amount of FC in A(a) above			
	e)	Amount of FERV in A(a) above			
	f)	Amount of Hedging Cost in A(a) above			
	g)	Amount of IEDC in A(a) above			
B	a)	Addition in CWIP during the period			
	b)	Amount of Capital liabilities in B(a) above			
	c)	Amount of IDC in B(a) above			
	d)	Amount of FC in B(a) above			
	e)	Amount of FERV in B(a) above			
	f)	Amount of Hedging Cost in B(a) above			
	g)	Amount of IEDC in B(a) above			
C	a)	Transferred to Gross Block Amount during the period			
	b)	Amount of Capital liabilities in C(a) above			
	c)	Amount of IDC in C(a) above			
	d)	Amount of FC in C(a) above			
	e)	Amount of FERV in C(a) above			
	f)	Amount of Hedging Cost in C(a) above			
	g)	Amount of IEDC in C(a) above			Shall be submitted at the time of Truing Up
D	a)	Deletion in CWIP during the period			
	b)	Amount of Capital liabilities in D(a) above			
	c)	Amount of IDC in D(a) above			
	d)	Amount of FC in D(a) above			
	e)	Amount of FERV in D(a) above			
	f)	Amount of Hedging Cost in D(a) above			
	g)	Amount of IEDC in D(a) above			
E	a)	Closing CWIP as per books			
	b)	Amount of Capital liabilities in E(a) above			
	c)	Amount of IDC in E(a) above			
	d)	Amount of FC in E(a) above			
	e)	Amount of FERV in E(a) above			
	f)	Amount of Hedging Cost in E(a) above			
	g)	Amount of IEDC in E(a) above			

Note:

(Petitioner)

मनीष कुमार वर्मा/Manish Kumar Verma
अपर महाप्रबंधक (वाणिज्यिक)
Addl. General Manager (Commercial)
कृते एनटीपीसी लिमिटेड/For NTPC Limited
[illegible]

PART - II
FORM- 10

Financing of Additional Capitalisation

Name of the Petitioner : NTPC Ltd.
Name of the Generating Station : Koldam Hydro Electric Power Project
Station COD : 18.07.2015

(₹ Lakhs)

Financial Year (Starting from COD)	2024-25	2025-26	2026-27	2027-28	2028-29	2024-25	2025-26	2026-27	2027-28	2028-29
	Actual					Admitted				
1	2	3	4	5	6	7	8	9	10	11
Amount capitalised in Work/Equipment										
Financing Details										
Loan-1										
Loan-2										
Loan-3 and so on										
Total Loan[2]										
Equity										
Internal Resources										
Others										
Total										

Add cap is proposed to be funded in Debt:Equity ratio of 70:30

PETITIONER

PART-II
FORM- 11

Calculation of Depreciation

Name of the Petitioner : NTPC Ltd.
Name of the Generating Station : Koldam Hydro Electric Power Project
Station COD : 18.07.2015

(₹ Lakhs)

Sl. no.	Name of the Assets	Gross Block on 31.03.2024	Depreciation Rates as per CERC's Depreciation Rate Schedule	Depreciation Amount on Gross Block as per CERC depreciation rate schedule as on 31.03.2024
1	Freehold Land - other than Land under Reservoir	14727.19	0.00%	0.00
2	Freehold Land - Land under Reservior	63572.92	3.34%	2,123.34
3	Leasehold Land - other than Land under Reservoir	1059.86	3.34%	35.40
4	Leasehold Land - Land under Reservior	42190.68	3.34%	1,409.17
5	Roads, Bridges & Culverts	9705.48	3.34%	324.16
6	Main Plant Buildings	23251.80	3.34%	776.61
7	Other Buildings	12135.55	3.34%	405.33
8	Temporary erection	224.85	100.00%	224.85
9	Water supply, drainage & sewerage	705.03	5.28%	37.23
10	Dam & Spillway	403419.05	5.28%	21,300.53
11	Penstock	24151.24	5.28%	1,275.19
12	Hydromechanical system	17564.84	5.28%	927.42
13	Plant and machinery (includes associated civil works)	163967.06	5.28%	8,657.46
14	Furniture and fixtures	1727.02	6.33%	109.32
15	Vehicles including speedboats	99.67	9.50%	9.47
16	Other Office Equipment	474.20	6.33%	30.02
17	Office Equipments-Air Conditioners	66.53	9.50%	6.32
18	EDP Machines and other IT equipments	338.32	15.00%	50.75
19	Construction equipment	221.45	5.28%	11.69

Add. General Manager (Commercial)

PART-II
FORM- 11

Calculation of Depreciation

Name of the Petitioner : NTPC Ltd.
Name of the Generating Station : Koldam Hydro Electric Power Project
Station COD : 18.07.2015

(₹ Lakhs)

Sl. no.	Name of the Assets	Gross Block on 31.03.2024	Depreciation Rates as per CERC's Depreciation Rate Schedule	Depreciation Amount on Gross Block as per CERC depreciation rate schedule as on 31.03.2024
20	Electrical installations	2400.86	5.28%	126.77
21	Communication equipment-Cables	2211.10	5.28%	116.75
22	Hospital equipment	40.92	5.28%	2.16
23	Capex on assets not owned by company	0.00	5.28%	0.00
24	Software	33.35	15.00%	5.00
25	Laboratory and workshop equipment	268.99	5.28%	14.20
	Total	**784557.96**		**37979.12**
Weighted Average Rate of Depreciation			**4.8408%**	

(Petitioner)

Manish Kumar Verma
Add. General Manager (Commercial)
NTPC Limited

Statement of Depreciation

Name of the Petitioner : NTPC Ltd.
Name of the Generating Station : Koldam Hydro Electric Power Project
Station COD : 18.07.2015

(₹ Lakhs)

Sl. No.	Particulars	2024-25	2025-26	2026-27	2027-28	2028-29
1	2	3	4	5	6	7
	No. of Days	365	365	365	366	365
1	Opening Capital Cost[1]	7,18,871.63	7,40,313.63	7,54,693.63	7,55,143.63	7,55,593.63
2	Closing Capital Cost[1]	7,40,313.63	7,54,693.63	7,55,143.63	7,55,593.63	7,56,043.63
3	**Average Capital Cost**	**7,29,592.63**	**7,47,503.63**	**7,54,918.63**	**7,55,368.63**	**7,55,818.63**
1a	*Cost of IT Equipments & Software included in (1) above ^^	371.67	371.67	371.67	371.67	371.67
2a	Cost of IT Equipments & Software included in (2) above^^	371.67	371.67	371.67	371.67	371.67
3a	Average Cost of IT Equipments & Software	**371.67**	**371.67**	**371.67**	**371.67**	**371.67**
4	Freehold land	14,727.19	14,727.19	14,727.19	14,727.19	14,727.19
5	Rate of Depreciation	4.8408%	4.8408%	4.8408%	4.8408%	4.8408%
6	Depreciable Value	6,43,416.07	6,59,535.97	6,66,209.47	6,66,614.47	6,67,019.47
7	Balance useful life at the beginning of the period	26.29	25.29	24.29	23.29	22.29
8	Remaining depreciable value at beginning of period	3,48,925.07	3,29,726.62	3,00,214.74	2,64,075.41	2,27,914.30
9	**Depreciation (for the period)**	**35,318.3411**	**36,185.38**	**36,544.33**	**36,566.11**	**36,587.90**
10	**Depreciation (annualised)**	**35,318.3411**	**36,185.38**	**36,544.33**	**36,566.11**	**36,587.90**
11	Cumulative depreciation at the end of the period	3,29,809.34	3,65,994.72	4,02,539.05	4,39,105.17	4,75,693.06
12	Less: Cumulative depreciation adjustment on account of un-discharged liabilities deducted as on 01.04.2009/Station COD, whichever is later[1]	-	-	-	-	
13	Less: Cumulative depreciation adjustment on account of de-capitalisation	-	-	-	-	
14	Net Cumulative depreciation at the end of the period	3,29,809.34	3,65,994.72	4,02,539.05	4,39,105.17	4,75,693.06

* Actual value of IT equipments shall be submitted at the time of truing up.

PETITIONER

Calculation of Interest on Actual Loans

Name of the Company
Name of the Power Station

Sl. no.	Particulars	2024-25	2025-26	2026-27	2027-28	2028-29
1	**USD 750 Million Drawl III**					
	Gross loan - Opening	13087.00	13087.00	13087.00	13087.00	13087
	Cumulative repayments of Loans upto previous period	0.00	0.00	0.00	1869.57	3739
	Net loan - Opening	13087.00	13087.00	13087.00	11217.43	9347
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	0
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	0
	Total	13087.00	13087.00	13087.00	11217.43	9347
	Repayments of Loans during the period	0.00	0.00	1869.57	1869.57	1869
	Net loan - Closing	13087.00	13087.00	11217.43	9347.86	7478
	Average Net Loan	13087.00	13087.00	12152.21	10282.64	8413
	Rate of Interest on Loan	7.0500%	7.0500%	7.0500%	7.0500%	7.050
	Interest on Loan Annualised	922.63	922.63	856.73	724.92	593
2	**4.375% Fixed Rate Note Bullet repayment on 26.11.2024**					
	Gross loan - Opening	11089.04	11089.04	11089.04	11089.04	11089
	Cumulative repayments of Loans upto previous period	0.00	11089.04	11089.04	11089.04	11089
	Net loan - Opening	11089.04	0.00	0.00	0.00	0
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	0
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	0
	Total	11089.04	0.00	0.00	0.00	0
	Repayments of Loans during the period	11089.04	0.00	0.00	0.00	0
	Net loan - Closing	0.00	0.00	0.00	0.00	0
	Average Net Loan	5544.52	0.00	0.00	0.00	0
	Rate of Interest on Loan	4.6277%	0.0000%	0.0000%	0.0000%	0.000
	Interest on Loan Annualised	256.58	0.00	0.00	0.00	0
3	**BONDS-L VII Bullet repayment from 15.12.2025**					
	Gross loan - Opening	3700.00	3700.00	3700.00	3700.00	3700
	Cumulative repayments of Loans upto previous period	0.00	0.00	3700.00	3700.00	3700
	Net loan - Opening	3700.00	3700.00	0.00	0.00	0
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	0
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	0
	Total	3700.00	3700.00	0.00	0.00	0
	Repayments of Loans during the period	0.00	3700.00	0.00	0.00	0
	Net loan - Closing	3700.00	3700.00	0.00	0.00	0
	Average Net Loan	3700.00	3700.00	0.00	0.00	0
	Rate of Interest on Loan	8.2200%	8.2200%	0.0000%	0.0000%	0.000
	Interest on Loan Annualised	304.14	304.14	0.00	0.00	0
4	**BONDS-LX VI Bullet repayment from 14.12.2031**					
	Gross loan - Opening	900.00	900.00	900.00	900.00	900
	Cumulative repayments of Loans upto previous period	0.00	0.00	0.00	0.00	0
	Net loan - Opening	900.00	900.00	900.00	900.00	900
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	0
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	0
	Total	900.00	900.00	900.00	900.00	900
	Repayments of Loans during the period	0.00	0.00	0.00	0.00	0
	Net loan - Closing	900.00	900.00	900.00	900.00	900
	Average Net Loan	900.00	900.00	900.00	900.00	900
	Rate of Interest on Loan	7.4000%	7.4000%	7.4000%	7.4000%	7.400
	Interest on Loan Annualised	66.60	66.60	66.60	66.60	66
5	**BONDS-LX VII Bullet repayment from 15.01.2029**					
	Gross loan - Opening	8598.21	8598.21	8598.21	8598.21	8598
	Cumulative repayments of Loans upto previous period	0.00	0.00	0.00	0.00	0
	Net loan - Opening	8598.21	8598.21	8598.21	8598.21	8598
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	0
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	0
	Total	8598.21	8598.21	8598.21	8598.21	8598
	Repayments of Loans during the period	0.00	0.00	0.00	0.00	8598
	Net loan - Closing	8598.21	8598.21	8598.21	8598.21	0
	Average Net Loan	8598.21	8598.21	8598.21	8598.21	4299
	Rate of Interest on Loan	8.4300%	8.4300%	8.4300%	8.4300%	8.430
	Interest on Loan Annualised	724.83	724.83	724.83	724.83	362

Add. General Manager (Commercial)

Calculation of Interest on Actual Loans

Name of the Company
Name of the Power Station

Sl. no.	Particulars	2024-25	2025-26	2026-27	2027-28	2028-29
6	**BONDS-XXXII Repayment from 25.03.2016**					
	Gross loan - Opening	7000.00	7000.00	7000.00	7000.00	700
	Cumulative repayments of Loans upto previous period	4200.00	4666.67	5133.33	5600.00	606
	Net loan - Opening	2800.00	2333.33	1866.67	1400.00	93
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	
	Total	2800.00	2333.33	1866.67	1400.00	93
	Repayments of Loans during the period	466.67	466.67	466.67	466.67	46
	Net loan - Closing	2333.33	1866.67	1400.00	933.33	46
	Average Net Loan	2566.67	2100.00	1633.33	1166.67	70
	Rate of Interest on Loan	8.8800%	8.8800%	8.8800%	8.8800%	8.880
	Interest on Loan Annualised	227.92	186.48	145.04	103.60	62
7	**BONDS-XXXIV Repayment from 10.06.2016**					
	Gross loan - Opening	3900.00	3900.00	3900.00	3900.00	390
	Cumulative repayments of Loans upto previous period	2080.00	2340.00	2600.00	2860.00	312
	Net loan - Opening	1820.00	1560.00	1300.00	1040.00	78
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	
	Total	1820.00	1560.00	1300.00	1040.00	78
	Repayments of Loans during the period	260.00	260.00	260.00	260.00	26
	Net loan - Closing	1560.00	1300.00	1040.00	780.00	52
	Average Net Loan	1690.00	1430.00	1170.00	910.00	65
	Rate of Interest on Loan	8.7400%	8.7400%	8.7400%	8.7400%	8.740
	Interest on Loan Annualised	147.71	124.98	102.26	79.53	56
8	**BONDS-XXXVIII repayment from 22.03.2017**					
	Gross loan - Opening	700.00	700.00	700.00	700.00	70
	Cumulative repayments of Loans upto previous period	373.33	420.00	466.67	513.33	56
	Net loan - Opening	326.67	280.00	233.33	186.67	14
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	
	Total	326.67	280.00	233.33	186.67	14
	Repayments of Loans during the period	46.67	46.67	46.67	46.67	4
	Net loan - Closing	280.00	233.33	186.67	140.00	9
	Average Net Loan	303.33	256.67	210.00	163.33	11
	Rate of Interest on Loan	9.2000%	9.2000%	9.2000%	9.2000%	9.200
	Interest on Loan Annualised	27.91	23.61	19.32	15.03	1
9	**BONDS-XXXIX repayment from 09.06.2017**					
	Gross loan - Opening	3100.00	3100.00	3100.00	3100.00	310
	Cumulative repayments of Loans upto previous period	1446.67	1653.33	1860.00	2066.67	227
	Net loan - Opening	1653.33	1446.67	1240.00	1033.33	82
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	
	Total	1653.33	1446.67	1240.00	1033.33	82
	Repayments of Loans during the period	206.67	206.67	206.67	206.67	20
	Net loan - Closing	1446.67	1240.00	1033.33	826.67	62
	Average Net Loan	1550.00	1343.33	1136.67	930.00	72
	Rate of Interest on Loan	9.4200%	9.4200%	9.4200%	9.4200%	9.420
	Interest on Loan Annualised	146.01	126.54	107.07	87.61	68
10	**BONDS-XLI repayment from 23.12.2017**					
	Gross loan - Opening	3000.00	3000.00	3000.00	3000.00	300
	Cumulative repayments of Loans upto previous period	1400.00	1600.00	1800.00	2000.00	220
	Net loan - Opening	1600.00	1400.00	1200.00	1000.00	80
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	
	Total	1600.00	1400.00	1200.00	1000.00	80
	Repayments of Loans during the period	200.00	200.00	200.00	200.00	20
	Net loan - Closing	1400.00	1200.00	1000.00	800.00	60
	Average Net Loan	1500.00	1300.00	1100.00	900.00	70
	Rate of Interest on Loan	9.7013%	9.7013%	9.7013%	9.7013%	9.701

Manish Kumar Verma
Joint General Manager (Commercial)

Calculation of Interest on Actual Loans

Name of the Company
Name of the Power Station

Sl. no.	Particulars	2024-25	2025-26	2026-27	2027-28	2028-29
	Interest on Loan Annualised	145.52	126.12	106.71	87.31	6
11	**BONDS-XLII repayment from 25.01.2023**					
	Gross loan - Opening	7500.00	7500.00	7500.00	7500.00	750
	Cumulative repayments of Loans upto previous period	3000.00	4500.00	6000.00	7500.00	750
	Net loan - Opening	4500.00	3000.00	1500.00	0.00	
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	
	Total	4500.00	3000.00	1500.00	0.00	
	Repayments of Loans during the period	1500.00	1500.00	1500.00	0.00	
	Net loan - Closing	3000.00	1500.00	0.00	0.00	
	Average Net Loan	3750.00	2250.00	750.00	0.00	
	Rate of Interest on Loan	9.0300%	9.0300%	9.0300%	0.0000%	0.000
	Interest on Loan Annualised	338.63	203.18	67.73	0.00	
12	**BONDS-L 2A Bullet repayment 16.12.2028**					
	Gross loan - Opening	3085.05	3085.05	3085.05	3085.05	3085
	Cumulative repayments of Loans upto previous period	0.00	0.00	0.00	0.00	0
	Net loan - Opening	3085.05	3085.05	3085.05	3085.05	3085
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	0
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	0
	Total	3085.05	3085.05	3085.05	3085.05	3085
	Repayments of Loans during the period	0.00	0.00	0.00	0.00	3085
	Net loan - Closing	3085.05	3085.05	3085.05	3085.05	0
	Average Net Loan	3085.05	3085.05	3085.05	3085.05	1542
	Rate of Interest on Loan	8.5100%	8.5100%	8.5100%	8.5100%	8.510
	Interest on Loan Annualised	262.54	262.54	262.54	262.54	131
13	**BONDS-L 3A Bullet repayment 16.12.2033**					
	Gross loan - Opening	3851.31	3851.31	3851.31	3851.31	3851
	Cumulative repayments of Loans upto previous period	0.00	0.00	0.00	0.00	0
	Net loan - Opening	3851.31	3851.31	3851.31	3851.31	3851
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	0
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	0
	Total	3851.31	3851.31	3851.31	3851.31	3851
	Repayments of Loans during the period	0.00	0.00	0.00	0.00	0
	Net loan - Closing	3851.31	3851.31	3851.31	3851.31	3851
	Average Net Loan	3851.31	3851.31	3851.31	3851.31	3851
	Rate of Interest on Loan	8.6900%	8.6900%	8.6900%	8.6900%	8.690
	Interest on Loan Annualised	334.68	334.68	334.68	334.68	334
14	**BONDS-L 2B Bullet repayment 16.12.2028**					
	Gross loan - Opening	1128.05	1128.05	1128.05	1128.05	1128
	Cumulative repayments of Loans upto previous period	0.00	0.00	0.00	0.00	0
	Net loan - Opening	1128.05	1128.05	1128.05	1128.05	1128
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	0
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	0
	Total	1128.05	1128.05	1128.05	1128.05	1128
	Repayments of Loans during the period	0.00	0.00	0.00	0.00	1128
	Net loan - Closing	1128.05	1128.05	1128.05	1128.05	0
	Average Net Loan	1128.05	1128.05	1128.05	1128.05	564
	Rate of Interest on Loan	8.7600%	8.7600%	8.7600%	8.7600%	8.760
	Interest on Loan Annualised	98.82	98.82	98.82	98.82	49
15	**BONDS-L 3B Bullet repayment 16.12.2033**					
	Gross loan - Opening	4936.75	4936.75	4936.75	4936.75	4936
	Cumulative repayments of Loans upto previous period	0.00	0.00	0.00	0.00	0
	Net loan - Opening	4936.75	4936.75	4936.75	4936.75	4936
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	0
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	0
	Total	4936.75	4936.75	4936.75	4936.75	4936
	Repayments of Loans during the period	0.00	0.00	0.00	0.00	0
	Net loan - Closing	4936.75	4936.75	4936.75	4936.75	4936
	Average Net Loan	4936.75	4936.75	4936.75	4936.75	4936

Additional General Manager (Commercial)
For and on behalf of NHPC Limited

Calculation of Interest on Actual Loans

Name of the Company
Name of the Power Station

Sl. no.	Particulars	2024-25	2025-26	2026-27	2027-28	2028-29
	Rate of Interest on Loan	8.9400%	8.9400%	8.9400%	8.9400%	8.94
	Interest on Loan Annualised	441.35	441.35	441.35	441.35	44
16	**BONDS-LI B Bullet repayment from 04.03.2029**					
	Gross loan - Opening	4200.00	4200.00	4200.00	4200.00	420
	Cumulative repayments of Loans upto previous period	0.00	0.00	0.00	0.00	
	Net loan - Opening	4200.00	4200.00	4200.00	4200.00	420
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	
	Total	4200.00	4200.00	4200.00	4200.00	420
	Repayments of Loans during the period	0.00	0.00	0.00	0.00	420
	Net loan - Closing	4200.00	4200.00	4200.00	4200.00	
	Average Net Loan	4200.00	4200.00	4200.00	4200.00	210
	Rate of Interest on Loan	8.6600%	8.6600%	8.6600%	8.6600%	8.660
	Interest on Loan Annualised	363.72	363.72	363.72	363.72	181
17	**BONDS-L III Bullet repayment from 22.09.2024**					
	Gross loan - Opening	6500.00	6500.00	6500.00	6500.00	650
	Cumulative repayments of Loans upto previous period	0.00	6500.00	6500.00	6500.00	650
	Net loan - Opening	6500.00	0.00	0.00	0.00	
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	
	Total	6500.00	0.00	0.00	0.00	
	Repayments of Loans during the period	6500.00	0.00	0.00	0.00	
	Net loan - Closing	0.00	0.00	0.00	0.00	
	Average Net Loan	3250.00	0.00	0.00	0.00	
	Rate of Interest on Loan	9.2000%	9.2000%	9.2000%	9.2000%	9.200
	Interest on Loan Annualised	299.00	0.00	0.00	0.00	
18	**BONDS-L IV (In Instalments from 8th yr. i.e. 25.03.23)**					
	Gross loan - Opening	25100.00	25100.00	25100.00	25100.00	2510
	Cumulative repayments of Loans upto previous period	15060.00	25100.00	25100.00	25100.00	2510
	Net loan - Opening	10040.00	0.00	0.00	0.00	
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	
	Total	10040.00	0.00	0.00	0.00	
	Repayments of Loans during the period	10040.00	0.00	0.00	0.00	
	Net loan - Closing	0.00	0.00	0.00	0.00	
	Average Net Loan	5020.00	0.00	0.00	0.00	
	Rate of Interest on Loan	8.5200%	0.0000%	0.0000%	0.0000%	0.000
	Interest on Loan Annualised	427.70	0.00	0.00	0.00	
19	**BOND-72 (Bullet repayment on 15.10.2025) (Refiance PFC V)**					
	Gross loan - Opening	5800.00	5800.00	5800.00	5800.00	5800
	Cumulative repayments of Loans upto previous period	0.00	0.00	5800.00	5800.00	5800
	Net loan - Opening	5800.00	5800.00	0.00	0.00	
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	
	Total	5800.00	5800.00	0.00	0.00	
	Repayments of Loans during the period	0.00	5800.00	0.00	0.00	
	Net loan - Closing	5800.00	0.00	0.00	0.00	
	Average Net Loan	5800.00	2900.00	0.00	0.00	
	Rate of Interest on Loan	6.4750%	6.4750%	0.0000%	0.0000%	0.000
	Interest on Loan Annualised	375.55	187.78	0.00	0.00	
20	**BOND-72 (Bullet repayment on 15.10.2025) (Refiance PFC V)**					
	Gross loan - Opening	9700.00	9700.00	9700.00	9700.00	9700
	Cumulative repayments of Loans upto previous period	0.00	0.00	9700.00	9700.00	9700
	Net loan - Opening	9700.00	9700.00	0.00	0.00	
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	
	Total	9700.00	9700.00	0.00	0.00	
	Repayments of Loans during the period	0.00	9700.00	0.00	0.00	
	Net loan - Closing	9700.00	0.00	0.00	0.00	

Executive (Finance)
Asst. General Manager (Commercial)
Rihand / NTPC Limited
Dist. Sonebhadra (U.P.)

Calculation of Interest on Actual Loans

Name of the Company
Name of the Power Station

Sl. no.	Particulars	2024-25	2025-26	2026-27	2027-28	2028-29
	Average Net Loan	9700.00	4850.00	0.00	0.00	
	Rate of Interest on Loan	6.5950%	6.5950%	0.0000%	0.0000%	0.000
	Interest on Loan Annualised	639.72	319.86	0.00	0.00	
21	**BOND-72 (Bullet repayment on 15.10.2025) (Refiance PFC V)**					
	Gross loan - Opening	3300.00	3300.00	3300.00	3300.00	330
	Cumulative repayments of Loans upto previous period	0.00	0.00	3300.00	3300.00	330
	Net loan - Opening	3300.00	3300.00	0.00	0.00	
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	
	Total	3300.00	3300.00	0.00	0.00	
	Repayments of Loans during the period	0.00	3300.00	0.00	0.00	
	Net loan - Closing	3300.00	0.00	0.00	0.00	
	Average Net Loan	3300.00	1650.00	0.00	0.00	
	Rate of Interest on Loan	6.8400%	6.8400%	0.0000%	0.0000%	0.000
	Interest on Loan Annualised	225.72	112.86	0.00	0.00	
22	**UNION BANK OF INDIA-II-repayment on 01.02.2017**					
	Gross loan - Opening	20000.00	20000.00	20000.00	20000.00	20000
	Cumulative repayments of Loans upto previous period	15000.00	17000.00	19000.00	20000.00	20000
	Net loan - Opening	5000.00	3000.00	1000.00	0.00	
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	
	Total	5000.00	3000.00	1000.00	0.00	
	Repayments of Loans during the period	2000.00	2000.00	1000.00	0.00	
	Net loan - Closing	3000.00	1000.00	0.00	0.00	
	Average Net Loan	4000.00	2000.00	500.00	0.00	
	Rate of Interest on Loan	8.1000%	8.1000%	8.1000%	0.0000%	0.000
	Interest on Loan Annualised	324.00	162.00	40.50	0.00	
23	**Corporation Bank-IV D1 repayment from 11.01.2023**					
	Gross loan - Opening	27151.79	27151.79	27151.79	27151.79	27151
	Cumulative repayments of Loans upto previous period	6033.73	9050.60	12067.46	15084.33	18101
	Net loan - Opening	21118.06	18101.19	15084.33	12067.46	9050
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	
	Total	21118.06	18101.19	15084.33	12067.46	9050
	Repayments of Loans during the period	3016.87	3016.87	3016.87	3016.87	3016
	Net loan - Closing	18101.19	15084.33	12067.46	9050.60	6033
	Average Net Loan	19609.62	16592.76	13575.89	10559.03	7542
	Rate of Interest on Loan	8.2333%	8.2333%	8.2333%	8.2333%	8.233
	Interest on Loan Annualised	1614.53	1366.14	1117.75	869.36	620
24	**Punjab National Bank-III D1 repayment from 01.02.2022**					
	Gross loan - Opening	643.00	643.00	643.00	643.00	643
	Cumulative repayments of Loans upto previous period	142.89	214.33	285.78	357.22	428
	Net loan - Opening	500.11	428.67	357.22	285.78	214
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	
	Total	500.11	428.67	357.22	285.78	214
	Repayments of Loans during the period	71.44	71.44	71.44	71.44	71
	Net loan - Closing	428.67	357.22	285.78	214.33	142
	Average Net Loan	464.39	392.94	321.50	250.06	178
	Rate of Interest on Loan	7.9000%	7.9000%	7.9000%	7.9000%	7.900
	Interest on Loan Annualised	36.69	31.04	25.40	19.75	14
25	**Jammu & Kashmir Bank-IV D2 repayment from 31.03.2021**					
	Gross loan - Opening	3800.00	3800.00	3800.00	3800.00	3800
	Cumulative repayments of Loans upto previous period	1266.67	1688.89	2111.11	2533.33	2955
	Net loan - Opening	2533.33	2111.11	1688.89	1266.67	844
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	
	Total	2533.33	2111.11	1688.89	1266.67	844
	Repayments of Loans during the period	422.22	422.22	422.22	422.22	422

Addl. General Manager (Commercial)
Dadri Power Station / NTPC Limited

Calculation of Interest on Actual Loans

Name of the Company

Name of the Power Station

Sl. no.	Particulars	2024-25	2025-26	2026-27	2027-28	2028-29
	Net loan - Closing	2111.11	1688.89	1266.67	844.44	42
	Average Net Loan	2322.22	1900.00	1477.78	1055.56	63
	Rate of Interest on Loan	7.9800%	7.9800%	7.9800%	7.9800%	7.98
	Interest on Loan Annualised	185.31	151.62	117.93	84.23	5
26	**SBI-VIII D4 repayment from 31.01.2022**					
	Gross loan - Opening	2900.00	2900.00	2900.00	2900.00	290
	Cumulative repayments of Loans upto previous period	966.67	1288.89	1611.11	1933.33	225
	Net loan - Opening	1933.33	1611.11	1288.89	966.67	64
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	0
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	0
	Total	1933.33	1611.11	1288.89	966.67	644
	Repayments of Loans during the period	322.22	322.22	322.22	322.22	322
	Net loan - Closing	1611.11	1288.89	966.67	644.44	322
	Average Net Loan	1772.22	1450.00	1127.78	805.56	483
	Rate of Interest on Loan	8.2000%	8.2000%	8.2000%	8.2000%	8.200
	Interest on Loan Annualised	145.32	118.90	92.48	66.06	39
27	**SBI-VIII D7 repayment from 31.01.2022**					
	Gross loan - Opening	1000.00	1000.00	1000.00	1000.00	1000
	Cumulative repayments of Loans upto previous period	333.33	444.44	555.56	666.67	777
	Net loan - Opening	666.67	555.56	444.44	333.33	222
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	0
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	0
	Total	666.67	555.56	444.44	333.33	222
	Repayments of Loans during the period	111.11	111.11	111.11	111.11	111
	Net loan - Closing	555.56	444.44	333.33	222.22	111
	Average Net Loan	611.11	500.00	388.89	277.78	166
	Rate of Interest on Loan	8.2000%	8.2000%	8.2000%	8.2000%	8.200
	Interest on Loan Annualised	50.11	41.00	31.89	22.78	13
28	**SBI-VIII D21 repayment from 31.01.2022**					
	Gross loan - Opening	1800.00	1800.00	1800.00	1800.00	1800
	Cumulative repayments of Loans upto previous period	600.00	800.00	1000.00	1200.00	1400
	Net loan - Opening	1200.00	1000.00	800.00	600.00	400
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	0
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	0
	Total	1200.00	1000.00	800.00	600.00	400
	Repayments of Loans during the period	200.00	200.00	200.00	200.00	200
	Net loan - Closing	1000.00	800.00	600.00	400.00	200
	Average Net Loan	1100.00	900.00	700.00	500.00	300
	Rate of Interest on Loan	8.2000%	8.2000%	8.2000%	8.2000%	8.200
	Interest on Loan Annualised	90.20	73.80	57.40	41.00	24
29	**SBI-VIII D24 repayment from 31.01.2022**					
	Gross loan - Opening	9285.71	9285.71	9285.71	9285.71	9285
	Cumulative repayments of Loans upto previous period	3095.24	4126.98	5158.73	6190.47	7222
	Net loan - Opening	6190.47	5158.73	4126.98	3095.24	2063
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	0
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	0
	Total	6190.47	5158.73	4126.98	3095.24	2063
	Repayments of Loans during the period	1031.75	1031.75	1031.75	1031.75	1031
	Net loan - Closing	5158.73	4126.98	3095.24	2063.49	1031
	Average Net Loan	5674.60	4642.86	3611.11	2579.36	1547
	Rate of Interest on Loan	8.2000%	8.2000%	8.2000%	8.2000%	8.200
	Interest on Loan Annualised	465.32	380.71	296.11	211.51	126
30	**SBI-IX D2 repayment from 31.03.2021**					
	Gross loan - Opening	1000.00	1000.00	1000.00	1000.00	1000
	Cumulative repayments of Loans upto previous period	333.33	555.56	666.67	777.78	888
	Net loan - Opening	666.67	444.44	333.33	222.22	111
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	0
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	0
	Total	666.67	444.44	333.33	222.22	111

Asst. General Manager (Commercial)
NTPC Limited

Calculation of Interest on Actual Loans

Name of the Company

Name of the Power Station

Sl. no.	Particulars	2024-25	2025-26	2026-27	2027-28	2028-29
	Repayments of Loans during the period	222.22	111.11	111.11	111.11	11
	Net loan - Closing	444.44	333.33	222.22	111.11	
	Average Net Loan	555.56	388.89	277.78	166.67	5
	Rate of Interest on Loan	8.2000%	8.2000%	8.2000%	8.2000%	8.20
	Interest on Loan Annualised	45.56	31.89	22.78	13.67	
31	**SBI-IX D5 repayment from 31.03.2021**					
	Gross loan - Opening	500.00	500.00	500.00	500.00	50
	Cumulative repayments of Loans upto previous period	166.67	277.78	333.33	388.89	44
	Net loan - Opening	333.33	222.22	166.67	111.11	55
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	(
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	(
	Total	333.33	222.22	166.67	111.11	55
	Repayments of Loans during the period	111.11	55.56	55.56	55.56	55
	Net loan - Closing	222.22	166.67	111.11	55.56	0
	Average Net Loan	277.78	194.44	138.89	83.33	27
	Rate of Interest on Loan	8.2000%	8.2000%	8.2000%	8.2000%	8.200
	Interest on Loan Annualised	22.78	15.94	11.39	6.83	2
32	**SBI-X D2 repayment from 01.10.2024**					
	Gross loan - Opening	2000.00	2000.00	2000.00	2000.00	2000
	Cumulative repayments of Loans upto previous period	0.00	222.22	444.44	666.67	888
	Net loan - Opening	2000.00	1777.78	1555.56	1333.33	1111
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	0
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	0
	Total	2000.00	1777.78	1555.56	1333.33	1111
	Repayments of Loans during the period	222.22	222.22	222.22	222.22	222
	Net loan - Closing	1777.78	1555.56	1333.33	1111.11	888
	Average Net Loan	1888.89	1666.67	1444.44	1222.22	1000
	Rate of Interest on Loan	8.2000%	8.2000%	8.2000%	8.2000%	8.200
	Interest on Loan Annualised	154.89	136.67	118.44	100.22	82
33	**HDFC-IX (Repayment Start 30.06.2024)**					
	Gross loan - Opening	454.00	454.00	454.00	454.00	454
	Cumulative repayments of Loans upto previous period	0.00	37.83	75.67	113.50	151
	Net loan - Opening	454.00	416.17	378.33	340.50	302
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	0
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	0
	Total	454.00	416.17	378.33	340.50	302
	Repayments of Loans during the period	37.83	37.83	37.83	37.83	37
	Net loan - Closing	416.17	378.33	340.50	302.67	264
	Average Net Loan	435.08	397.25	359.42	321.58	283
	Rate of Interest on Loan	8.4250%	8.4250%	8.4250%	8.4250%	8.425
	Interest on Loan Annualised	36.66	33.47	30.28	27.09	23
34	**Bank of India-IV**					
	Gross loan - Opening	8000.00	8000.00	8000.00	8000.00	8000
	Cumulative repayments of Loans upto previous period	0.00	666.67	1333.33	2000.00	2666
	Net loan - Opening	8000.00	7333.33	6666.67	6000.00	5333
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	0
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	0
	Total	8000.00	7333.33	6666.67	6000.00	5333
	Repayments of Loans during the period	666.67	666.67	666.67	666.67	666
	Net loan - Closing	7333.33	6666.67	6000.00	5333.33	4666
	Average Net Loan	7666.67	7000.00	6333.33	5666.67	5000
	Rate of Interest on Loan	8.3500%	8.3500%	8.3500%	8.3500%	8.350
	Interest on Loan Annualised	640.17	584.50	528.83	473.17	417

Addl. General Manager (Commercial)

NTPC Limited

Calculation of Interest on Actual Loans

Name of the Company

Name of the Power Station

Sl. no.	Particulars	2024-25	2025-26	2026-27	2027-28	2028
	TOTAL LOAN					
	Gross loan - Opening	317478.11	317478.11	317478.11	317478.11	317
	Cumulative repayments of Loans upto previous period	164266.73	203011.44	236460.44	248279.01	257
	Net loan - Opening	153211.38	114466.67	81017.67	69199.10	59
	Increase/ Decrease due to FERV	0.00	0.00	0.00	0.00	
	Increase/ Decrease due to ACE/Drawl during the period	0.00	0.00	0.00	0.00	
	Total	153211.38	114466.67	81017.67	69199.10	59
	Repayments of Loans during the period	38744.71	33449.00	11818.57	9318.57	263
	Net loan - Closing	**114466.67**	**84717.67**	**69199.10**	**59880.53**	**335**
	Average Net Loan	133839.03	99592.17	75108.39	64539.82	467
	Rate of Interest on Loan	7.9116%	8.0914%	8.2395%	8.2526%	8.2
	Interest on Loan Annualised	10588.78	8058.38	6188.56	5326.20	38

मनोज कुमार वर्मा / Manoj Kumar Verma

अपर महाप्रबंधक (वाणिज्यिक)

Addl. General Manager (Commercial)

एनटीपीसी लिमिटेड / NTPC Limited

PART - II
FORM - 13A

Calculation of Interest on Normative Loan

Name of the Petitioner : NTPC Ltd.

Name of the Generating Station : Koldam Hydro Electric Power Project

Station COD : 18.07.2015

(₹ Lakhs)

Sl. No.	Particulars	2024-25	2025-26	2026-27	2027-28	2028-29
1	2	3	4	5	6	7
	No. of Days	365	365	365	366	365
1	Opening Capital Cost					
2	Gross Normative loan - Opening	7,18,871.63	7,40,313.63	7,54,693.63	7,55,143.63	7,55,593.63
3	Cumulative repayment of Normative Loan upto previous year	5,03,210.14	5,18,219.54	5,28,285.54	5,28,600.54	5,28,915.54
4	**Net Normative loan - Opening**	294491.0	329809.3411	365994.7234	402539.0532	439105.1668
5	Normative repayment of loan During the year	**2,08,719.15**	**1,88,410.20**	**1,62,290.82**	**1,26,061.49**	**89,810.38**
6	Add: Increase due to addition during the year / period	35,318.34	36,185.38	36,544.33	36,566.11	36,587.90
7	Less: Decrease due to de-capitalisation during the year / period	15,009.40	10,066.00	315.00	315.00	315.00
8	Less: Decrease due to reversal during the year / period	-	-	-	-	
9	Add: Increase due to discharges during the year / period	-	-	-	-	
10	**Net Normative loan - Closing**	-	-	-	-	
11	**Average Normative loan**	**1,88,410.21**	**1,62,290.82**	**1,26,061.49**	**89,810.38**	**53,537.48**
12	Weighted average Rate of Interest	**1,98,564.68**	**1,75,350.51**	**1,44,176.15**	**1,07,935.93**	**71,673.93**
13	**Interest on loan**	7.9116%	8.0914%	8.2395%	8.2526%	8.2352%
		15,709.59	**14,188.27**	**11,879.41**	**8,907.50**	**5,902.47**

(Petitioner)

PART - II
FORM - 13B

Calculation of Interest on Working Capital

Name of the Petitioner : NTPC Ltd.
Name of the Generating Station : Koldam Hydro Electric Power Project
Station COD : 18.07.2015

(₹ Lakhs)

Sl. No.	Particulars	2024-25	2025-26	2026-27	2027-28	2028-29
1	2	3	4	5	6	7
	No. of Days	365	365	365	366	365
1	**O&M expenses**	**16,313.75**	**17,168.78**	**18,069.25**	**19,017.59**	**20,016.39**
1a	O&M expenses (for one month)	1,359.48	1,430.73	1,505.77	1,584.80	1,668.03
2	Maintenance Spares @ 15%	2,447.06	2,575.32	2,710.39	2,852.64	3,002.46
3	Receivables (45 Days)	13,954.42	14,115.75	14,042.15	13,760.09	13,556.90
4	**Total Working Capital**	**17,760.96**	**18,121.80**	**18,258.31**	**18,197.53**	**18,227.39**
5	Rate of Interest	11.90%	11.90%	11.90%	11.90%	11.90%
6	**Interest on Working Capital**	**2113.55**	**2156.49**	**2172.74**	**2165.51**	**2169.06**

(Petitioner)

Addl. General Manager (Commercial)

Part - II
Form - 15A

Design Energy and peaking capability (month wise) - ROR with Pondage / Storage type new stations

Name of the Petitioner : NTPC Ltd.
Name of the Generating Station : Koldam Hydro Electric Power Project
Station COD : 18.07.2015

Month		Design Energy (Mus)	Designed Peaking Capability (MW)
April	I	59.21	
	II	57.80	
	III	89.80	
May	I	103.87	
	II	186.01	
	III	206.82	
June	I	64.92	
	II	171.32	
	III	118.63	
July	I	155.60	
	II	192.00	
	III	211.20	
August	I	192.00	
	II	192.00	
	III	211.20	
September	I	129.86	
	II	93.03	
	III	71.50	
October	I	46.88	Designed peaking capacity is 800 x 1.10 (i.e. 110% of deemed rated capacity on continuous basis) = 880 MW
	II	44.33	
	III	41.29	
November	I	30.49	
	II	27.94	
	III	25.39	
December	I	24.48	
	II	24.48	
	III	26.93	
January	I	24.48	
	II	24.48	
	III	26.93	
February	I	24.48	
	II	24.48	
	III	19.58	
March	I	24.48	
	II	39.39	
	III	47.51	
Total		3054.79	

PETITIONER

Add. General Manager (Commercial)
NTPC Limited

		PART II
		FORM 19
		Summary of issue involved in the petition
1. Petitioner:		NTPC Ltd
2. Subject:		Tariff Petition 2024-29
3. Prayer:		
	i.	Approve tariff of Koldam Hydro Electric Project (4 X 200 MW) for the tariff period 01.04.2024 to 31.03.2029;
	ii.	Allow the recovery of filing fees as & when paid to the Hon'ble Commission and publication expenses from the beneficiaries;
	iii.	Allow the recovery of pay/wage revision as additional O&M over and above the normative O&M.
	iv	Pass any other order as it may deem fit in the circumstances mentioned above.
4 Respondents		
		Name of Respondents:
	a.	UPPCL
	b.	RUVNL
	c.	HPPC
	d	PSPCL
	e	PDD J&K
	f	HPSEBL
	g	UPCL
	h	ED UT Chanigad
5. Project Scope		
IC	MW	800
DE	MU	3054.79
FEHS	MU	393.15
AUX	%	1
NAPAF	%	90
Cost		
Sanction Cost	Cr	
Latest RCE	Cr	
Commissioning		
Unit/Station COD		15.07.2015
Claim		
AFC	Cr	1131.858/1144.944/1138.974/1119.154/1099.615
Capital cost	Cr	7295.926/7475.036/7549.186/7553.686/7558.186
Initial spare	Cr	
NAPAF	%	90
Design Energy	Mu	3054.79
Any Specific		

Addl. General Manager (Commercial)

Annexure – A

NTPC Ltd Kol Dam HEP
Report of the Thirteenth Meeting of Panel of Experts (NTPC Hydro)

Preamble

The thirteenth meeting of the Panel of Experts took place at Koldam site between 23rd to 27th September 2015.

Programme

23 Sept.	Arrival at Koldam site by PoE members
24 Sept	Site Visit and discussions in the field : visit Plunge Pool damages, Dam and Appurtenances
25 Sept.	Presentation by NTPC on Videography of Plunge pool , Bathymetric Survey Results and Discussions on proposed remedial Measures Invitation to EDF for subsequent joint technical discussions reviewing the rehab and remedial measures in consideration Discussions and drafting PoE Report
26 Sept	Joint Review of Proposals after the visit of Director (Projects) with EDF, PoE and NTPC site and Engineering Finalisation of PoE and signing of the Report
27 Sept.	Departure from Koldam site to Chandigarh and to respective base stations

The following PoE members were present:

Er. M. Gopalakrishnan
Er. Brijendra Sharma
Er. M. K. V Sharma

Apology:
Dr. R.S. Varshney

The team of officers from NTPC who were available are given in Annexure- I. EDF expert team who also joined the discussions on 25th Sept., is also seen therein.

Agenda Item 1:

Erosion of Plunge Pool at both banks

The Preformed Plunge Pool which had suffered some damages in the downstream cladding with concrete and slope damages in the left bank was visited on 24th September 2015 along with NTPC Engineers at site. During the last site visit in July, POE had observed these damages and had opined that erosion damage, consequent to further operation of spillway in the remaining monsoon period should be observed and that no immediate remedial measures need be taken up till the end of monsoon.

There has been discharges over the spillway after POE's last visit. Consultants M/S EDF had, taking note of damages in the plunge pool area, sought a bathymetric survey of the plunge pool with suggested

117

specifications for the work to be undertaken in order to facilitate their recommendations regarding the remedial measures to be implemented after the monsoon.

In addition, with the information already requested in the referenced letters (inspection and monitoring of flip bucket, as-built drawings of the plunge pool) the necessary input data include :

- **Bathymetric survey of the plunge pool**

The bathymetry was desired to cover the whole surface of the plunge pool, from the cladding wall to the junction with the Satluj River, for their detailed assessment of the erosion damage and had informed NTPC that the extent of damages would then determine the necessity/desirability of remedial measures. Besides, EDF had desired an underwater inspection of the cladding wall using divers so that the condition of the whole cladding wall below the water level, and the condition of its foundation could be assessed and cracks on the concrete surface identified to the extent possible. It was advised by EDF that the bottom part of the cladding wall in order to identify scouring below the wall should also be investigated.

NTPC had accomplished the suggested tasks and had presented the outcome to EDF which was also given to the POE as a part of Agenda notes. The works had been undertaken and completed through M/s Geosense Surveys, Andhra Pradesh. NTPC made a video presentation of the conditions of the damages along select lines suggested by EDF on the slopes of the cladding wall. A detailed Report of the Observations with contours of the plunge pool made out of bathymetry data was made available, with select pictures.

From the Report of Geosense Survey, PoE observe the following results:

- *Results of the Bathymetric surveys yielding contours of erosion pattern at bed & sides*

- Bathymetric surveys show an interesting erosion pattern.
- Deepest erosion has gone down to El. 492m, for the observed flows spilled over as per the gate operation adopted in the beginning of this monsoon season.
- The shape of the hole is parallel to the right bank slope.
- The length of the hole is almost 125m and the width varies from a max. of 45m to less than 10m at d/s end.
- The right wall of the hole more or less coincides with the right bank cladding slope and follows the eroded right bank rock slope d/s of the cladding.
- The shape of the deepest scour hole indicates that the spillway gate operation, both during reservoir filling above El. 622m as well as subsequently, could have been asymmetrical (*till about May 15 end*) and not as per any set guidelines; when EDF visited site and had recommended symmetrical operation of the spillway gates.
- This mode of operation in the earlier part of this monsoon could have apparently resulted in the major backflow condition on the left side of the spillway with resultant erosion, near the d/s end of the concrete cladding, and substantial erosion of the rock slopes on this side. The poor rock (phyllite) could also be an additional factor.

- *Interpretations possible from the Videography of cladding (d/s of spillway bucket)*

- The videography records were shown to POE and these were along the joints in concrete cladding.

- The visibility through water has been somewhat hazy; it is not possible to detect any opening of the joints or damage to concrete from what was obtained by the videographic record of the Claddings.

- *Observed Damages*

- Erosion of rock (beyond concrete cladding) on both left as well as right side.
- Erosion (above water level) extends upto bench at El. 527m on both sides.
- Erosion behind the cladding (near end) on both sides seen above water level upto EL 515m.
- Extent of erosion (width) varies from about 1.5m to 4m.
- Erosion is somewhat less on right side probably due to extension of '*basic rock*' dyke, instead of phyllites seen on left side.
- Erosion below water level (El. 510m) is not visible; but this might have taken place and cannot be possibly ruled out.
- Some more erosion and some damage to extension part of concrete cladding not observed during the last PoE site visit must have occurred sometime during the latter half of July; about half length of extension has fallen down and the remaining portion is hanging on the slope and the joint with originally designed portion also opening up (max at top & less at water level); this could be due to dragging and part rotation of this portion towards d/s. This has probably happened due to loss of continuity with the fallen portion.
- No distress seen in the cladding upto originally designed length. Perhaps, this is an indicator to reasonably presume that erosion behind concrete cladding is restricted at most upto start of extension of cladding.
- No distress in concrete in right bank cladding; this also indicates that erosion of rock does not extend much (5-8m) towards the u/s and deeper below water level.

Global Review on performance of EDA with ski-jump for the spillway & plunge pools

PoE took note of the fact that the plunge pool provision as Energy Dissipating Arrangements for Projects do take on board a natural erosion process. This could be varied depending upon the flows and the pattern of operation of gates and the way the flood flows get evacuated. This has been covered in PoE's Report after site visit in July, last.

A recent academic review of the performance of Wivenhoe dam[1] provide a fair insight of the complicated phenomenon that obtains when skijump with plunge pools operate. In the case reported in respect of Wivenhoe Dam, near Brisbane, one finds that during the severe 2011 floods when all gates were opened the erosion even in competent argillaceous massive sandstone bed was alarming. It is reported that the flood evacuation by operation with all gates open that was necessitated, dislodged a 'bus size' solid block, weighing nearly 1200 tonnes, which after its detachment, got transported downstream for nearly over 40 m. The spillway in comparison to Koldam spillway is much smaller {(Ogee crest at El. 57.00 and the lip of the flip bucket at El. 45.00 (*with a full supply level or FRL @ El. 67.00 m*)}. The fact sheet on geology indicate that the sandstone at site displayed joint sets but notwithstanding, the whole mass was extensive and homogeneous tight jointed with hardly any variability in the entire plunge pool extent.

The conclusion of the findings in the instant case of Wivenhoe runs as follows: *(quote)*

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[1] Plunge Pool Rock Scour Analysis Techniques: Wivenhoe Dam spillway, Australia by C.E. Bradford, T.K.R. Ballard and E.J. [illegible], ty refer https://www.academia.edu/[illegible]/Plunge_pool_rock_scour_analysis_techniques_Wivenhoe_Dam_Spillway_Australia

"The Wivenhoe experience provides a valuable alert and shows that we cannot sell short of the ability of high velocity flows to cause extensive scour even in what may be considered hard rock."

To quote further,

"One reason is that the flow from a ski-jump bucket for example is not simply unidirectional flow along the jet trajectory but a violent interaction of turbulent shear flows with the entrainment of large quantities of air which are partly released explosively, and is pressurized at depth and partly involved in the mechanism of pressure penetration and amplification in fissured rock." (unquote)

It is therefore reasonable to presume that the causative factor for the damages suffered in the first operation of ski-jump and consequent damages noticed in Koldam case could be also due to turbulent swirling flows with air entrainment in the process. That the rocks encountered at the plunge pool location especially phyllites were prone to suffer damages with dynamic flows is well known. The initially formed plunge pool was expected to attain a natural stabilization with the passage of floods and this could ask for a larger re-sized plunge pool of a dimension that would be dictated by the natural processes. The quick rush to tame the turbulent flow expecting results that might avoid or mitigate the damages to flanks or abutments is a tall expectation, even with engineering measures and interventions.

- ***Discussions with NTPC's Engineering Consultants M/s EDF:***

NTPC facilitated a joint review meeting with the Expert team of EDF who were having their mission coinciding with POE meeting on 28th September at GM's committee room at Bamuara.

EDF explained their findings from the further data made available through Bathymetry surveys and their preliminary approach to suggest further remedial measures as indicated in their CAS Sheet 0743 (forming part of POE's Agenda Notes on the Item). This was further amplified by the EDF expert team opening up the proposals for a review and discussions before finalization.

EDF has come up with remedial measure proposals, yet to firmed up as indicated. This apparently would include certain measures essentially aimed at preventing further damages that could progressively reach the flip bucket toe by scouring, due to back flows in the subsequent monsoon(s) when flip bucket is brought in to handle flood discharges of the spillway.

EDF's sketch proposals envisage *(subject to further internal review by EDF Paris before firming up)*:

i. Drilling through the cladding wall & for the top berm some 30-40 m long piles *(or micro-piles alternatively should the large piles pose difficulties, recognizing that the work has to be organized and executed in a time bound manner before the onset of the next monsoon)*. This is expected to create an anti scouring barrier, as per EDF and would help counter the back flow erosion and resultant damages that could get nearer to flip bucket toe region in foundation.

ii. Proposed options for the execution of the works:
   - From a floating platform (made with modular jointed elements) located inside the plunge pool.
   - Another option of backfilling the upstream side of the plunge pool, above the cladding wall, to obtain a working platform at El. 515 m, which could be used to install some machines to drill piles.

iii. An additional suggestion indicates providing precast concrete blocks, at the toe and placing the precast elements with a tower crane positioned on banks. It was explained that the provision might help even in dislodged position during floods, some resistance to turbulent flows and associated scour / damages. It was however apprehended that this might itself start with swirling

417

actions, unknown consequences but it was felt that this could be useful to control damages following subsequent attacks when dealing with evacuating floods in the monsoon seasons in future.

iv. The suggestion from EDF also includes, as an alternative to precast blocks, gabions of suitable dimensions, stacked one above the other to obtain the desired thicknesses with protection of a layer of concrete.

In a frank and free discussion with PoE the proposals for remedification of the plunge pool damaged cladding was discussed. The aspects touched upon included, inter-alia,

i. Need for these works right now and as to why not they could wait to allow more time for the natural erosion process to take place, given the principles inherent in plunge pool option as an Energy Dissipation Arrangement (EDA) in such cases
ii. Would these works, once executed would themselves be stable with the onslaught of subsequent monsoon's flood evacuation, depending upon the flows to be routed based on floods that might occur (higher or lower, with more or less frequency)
iii. The limited time availability for executing massive work of piles and precast elements for placement of cladding at the bottom of the plunge pool over the sediment deposits
iv. The uncertain behavior of flow conditions with the new measures, and the apprehension as to whether they themselves could be the causative factor for accentuating damages in future floods
v. Whether these measures at a substantial cost could become infructuous, as one cannot rule out possible damages even with these new measures

The discussions brought out pros and cons of the action suggested to be undertaken as immediate yet temporary, remedial measures as envisaged. Deferring them for future also form part of the exchange in ideas and the possible consequences.

The damages suffered, it came up, could have also been due to the operation of gates to deal with evacuation flood flows and the need for envisaging a threshold level such as >1000 cumecs so that the impinging jet is as far away as possible in all cases. This could be by operating the reservoir at lower level with additional pondage so as to obtain the necessary condition.

- **Conclusion**

In conclusion, PoE firmly believe that the process of erosion will continue to take place in the plunge pool area for a few years to come. Till a fairly stable regimen is attained with the passage of several floods of varying magnitude any interventions or structural measures introduced as per the new studies could also suffer damages to varying extent. The need to go for an elaborate rectification measures for the damages occurred to the cladding walls etc right now, is a decision that could wait. The possibility of works spilling over to next season in case of non-completion is also something that will govern the decision to undertake them.

PoE feel that the minor damages that can be quickly rectified in this working season can be taken up.

While EDF recommendations are also falling in this category, it is quite elaborate and commissioning a experienced and resourceful contractor to undertake and complete the job prior to the onset of 2016 monsoon is a big question. The risk of half complete or incomplete works still remains a possibility and this partially completed works themselves could also bring in unforeseeable damages in June 2016.

5/7

Obviously, the hollow behind concrete cladding in the right bank and the disturbed claddings in right bank need rehabilitation. This could certainly minimise the damages in the same zone in the next monsoon season (let us acknowledge that it is not practicable to avoid damages altogether).

The suggested measure as an absolute minimum remedial measure envisage measures to pack the cavities behind the left side cladding by infilling with concrete. Local turbulence resulting from backflows, aerated and entrained sediment laden water and its impact in cavities could be minimised by filling the cavities.

It is suggested that the following works would help tackling the immediate minimum remedial measures that could be undertaken and completed in time before next monsoon.

i) Constructing an approach road on left bank of plunge pool up to El. 505.0 m ±, to carry men, materials and construction equipment.

ii) Isolating the plunge pool by constructing a bund upto El 505 m (assuming that the water level in the river will be around El 503m during non monsoon period) at the junction of the plunge pool and the river (the level of the ledge at the junction may be around El 500m) .

iii) Dewater the plunge pool, as required, to facilitate concrete infilling of the cavities in dry condition to the maximum possible extent. Back fill the cavities behind the cladding walls on both sides with concrete / boulders.

Agenda Item 2:

Review of Grouting done in Gallery #12 vis a vis Gallery Seepage

The results presented after undertaking the additional grouting work in a limited reach in Gallery # 12 has shown considerable reduction in seepage. This is encouraging. Proper drains so as to capture the seepage water entirely within them and making gallery floor free of seepage mud and water should be undertaken immediately.

Agenda Item 3:

Monitoring Data

Reviewing the behavior of instrumentation, in general, POE observed that most of the Dam instruments are stabilised, after reaching FRL i.e. EL 642m on 09.06.2015.

The abnormal behavior observed earlier in respect of few instrument in Sec-CC & EE is no longer noticed.

47

Acknowledgement

PoE thank Sh. Choudhary, GM (Koldam) and his team for the excellent arrangements made for their visit and also acknowledge the efforts to arrange a meeting with EDF expert team facilitating a free exchange of ideas.

PoE also acknowledge the efforts of all concerned to organize various presentations.

PoE thank for the invitation extended to them for joining the discussions chaired by Shri. S. C. Pandey, Director (Projects) NTPC, Shri. K. K. Singh RED - Hydro (NTPC) on 26th Sept., at NTPC Koldam committee meeting room, when EDF expert team made their presentations (points of which were covered in the earlier parts).

They also thank the EDF team for sharing their proposals on envisaged remedial works besides receiving PoE comments. The opportunity provided by NTPC for sharing the case history reported in literature with all concerned on 26th Sept., (Wivenhoe Spillway and plunge pool with 2011 floods) is gratefully acknowledged.

Er. M. Gopalakrishnan

Er. Brijendra Sharma

Er. M.K.V. Sharma

NTPC LIMITED KOLDAM HEP

Report of the Fourteenth Meeting of Panel of Experts (NTPC Hydro)

The fourteenth meeting of the Panel of Experts took place at Koldam site between 18th to 21st April 2016.

Programme

18th April.	Arrival at Koldam site by PoE members. Perusal of agenda items & inspection schedule.
19th April	Site visit and discussions in the field ; visit to Plunge Pool damages, DT 1 leakage near plugs and remedial steps undertaken etc.,
	Visit to PH and inspect leakages from scroll case concrete of turbines
	Presentation of Agenda Notes in the GM's office & discussions
20th April	Drafting of Report
	Joint review of draft PoE Report & finalization
21st April,	Signing of the Report
	Departure from Koldam site to Chandigarh and to respective base stations by air/road

Shri. Jitendra Chaubey has joined the Panel. The members present for the mission were:

Dr. R.S. Varshney
Er. M. Gopalakrishnan
Er. Brijendra Sharma
Shri Jitendra Chaubey (Engineering Geology)

Apology:
Er. M. K. V Sharma

The team of officers from NTPC who were available are listed in Annexure- I.

AGENDA ITEM 1:

Erosion of Plunge Pool at both Banks

PoE had dealt with the agenda item in their last meeting in September 2015 when the problem surfaced.

The preformed plunge pool which has suffered some damages in the concrete cladding on the left bank slope and erosion of rock behind the cladding on both bank side slopes due to spillway operation during reservoir filling and afterwards were observed during the last visit of PoE in Sep 2015. Since then there has been no further damage, as spillway was not required to be operated in the intervening period.

PoE inspected the rectification works on both the left and right sides. In-filling of the cavities by M 20 concrete had been carried out with pumped concrete. This concreting has been done in lifts of about 800mm thickness. Sand bags have been used as shuttering. The balance works to

be completed are minimal. The advice of PoE in its 13th meeting has thus been complied with and stands implemented satisfactorily.

PoE had advised deferring several other major structural interventions proposed by EDF for reasons explained elaborately therein.

PoE had advised, observing the performance of Energy Dissipation Arrangement (EDA) for a few more monsoon seasons with regulated spillway discharges before evaluating EDA's effectiveness and sufficiency. The need for any rectification / remedial measures was suggested to be undertaken thereafter.

This was due to the reason that the need for remedial works without allowing sufficient time for the natural erosion process to take place, is not quite advisable as the inherent plunge pool design principles account for such erosions to take place naturally.

PoE firmly believe that the process of erosion will continue to take place in the plunge pool area for a few years to come, till a fairly stable regime is attained with the passage of several floods of varying magnitude.

PoE however would like to advise that the operation of the spillway gates for evacuation of floods should be done in strict accordance with the suggested procedures as per model studies.(Reference: Study on Hydraulic Scale model of the Koldam Project (India) : Model of the Spillway and global Model: Institut du Genie Civil, Chemin des Chevreuils 1 BELGIUM . This report is available with NTPC). If the set procedures suggested in the Hydraulic Model Studies are followed, one can avoid problems of erosion of the type seen during the initial operation of spillway in 2015.

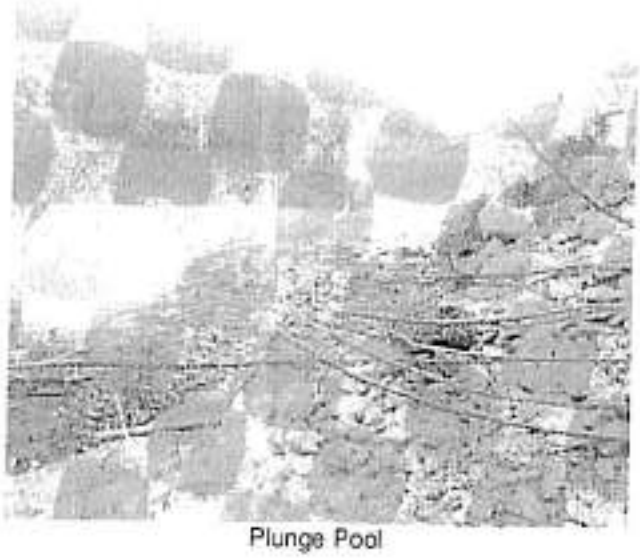
The suggestions for bringing into operation for floods above the threshold level of 1000 cumec as per PoE's report (13th meeting) may also be kept in view while bringing the spillway into operation which can result in minimum possible erosion damages in the plunge pool and its vicinity.

As it obtains, the project has already undertaken additional remedial measures recently. These are based on EDF's advice. The work has been awarded a fortnight back and the job is slotted to be completed prior to monsoon.

PoE are thus in a position only to take note of the EDF's advice and project's efforts to implement them with all rapidity. The measures which are not in line with PoE's recommendations as per their 13th mission visit in September 2015 cannot be endorsed at this stage. The behavior of the EDA in the plunge pool area has to be watched during the 2016 monsoon with the micro piles in place (to the extent it could be completed).

PoE's earlier recommendations (13th Visit in September) reiterated the need to allow a natural erosion process to take place with varying discharge intensities during one or two monsoons before planning any additional permanent / long term measures. PoE stand by their earlier recommendation, even now.

As suggested by EDF, 3 drill holes using triple tube core barrel in the Plunge pool area have already been carried out and the drill hole logs were shown to the PoE. The purpose of these investigative drilling must have been to confirm that no scouring under horizontal apron has taken place. As per the log except for a 35cm zone where no core was recovered in one bore hole, nothing unusual was observed.



Plunge Pool

Plunge Pool

The Plunge Pool is mainly occupied by carbonaceous phyllite which is a very weak rock. Some remnants of the basic dyke could be observed at higher level on left bank in the downstream end of the plunge pool. Rock ledges protruding into the plunge pool were observed. PoE is of the opinion that this protrusion would be eroded in due course of time naturally; it does not require to be blasted with special efforts.

Plunge Pool

AGENDA ITEM 2:

Concreting in Gallery of DT-1

Project has recently undertaken concreting of the gallery provided in the concrete plug of DT-1 for enabling grouting the rock mass and the concrete-rock contact around the plug. Before starting this concreting work, seepage under pressure was observed in the niche left in the gallery for accommodating BF valves of the three drain pipes provided near the bottom of the plug, for enabling concrete placement for plug in near dry conditions.

Project informed that major component of seepage was noticed through pipe used for scaffolding during concreting of the gallery roof (left inadvertently in place after concreting). Pressure in the pipe was so high that jet of seepage water was striking on the gallery roof, spreading throughout and making it difficult to undertake any work. Project, however, managed to control the situation by placing a metal box of size 2' x 2' weighing about 400 kg. This metal box was successfully placed manually using chain pulley indicating that pressure of this seepage to be less than 5kg enabling spread of water on the floor only. This water is being taken away from the gallery by two pipes provided with BF valves at the ends.

Concreting of major portion of gallery has already been completed and only 6m length at the downstream end of gallery remains to be concreted. Seepage water is being directed downstream of the plug through only one pipe now as the other pipe along with its BF valve has already been embedded in concrete.

PoE during its visit to DT-1 could only observe the plug from some distance as heavy seepage flows from roof of tunnel mainly through pipe used for roof concreting did not permit sufficient visibility to assess the condition in the downstream portion of the gallery still to be concreted.

Project proposes to close the remaining BF valve of the seepage pipe and embedded finally in concrete. PoE feels that the seepage water, under some pressure, presently getting into the niche would find some other flow path and ultimately come out at the end of the plug uncontrolled if the BF valve is closed and embedded in concrete.

It would be better to allow this seepage to flow through the drainage pipe with BF valve open in a defined path. PoE recommends that the BF valve need not be closed now. The flow through this pipe should, however, be monitored regularly during non monsoon months when backwaters from Bhakra reservoir recede and enable to access the DT-1 plug area.

Any substantial increase in the seepage through the pipe or presence of sediments in the seepage water (which is now very clear) would require attention and remedial measures if any.

Heavy seepage from DT crown just downstream of the DT plug was noted and PoE advise that this seepage should be channelized by placing a pipe of suitable diameter or diverted along the walls of the tunnel.

AGENDA ITEM 3:

Lowering **of River Bed**

The project informed that the rock ledge just downstream of TRC outlet has now been lowered to the design level of 501m all along its length. Beyond the lowered rock ledge the river bed is however higher at some locations towards the right side of TRC. Project proposes to excavate river bed material in those areas down to elevation 501m to regain the head fall. It was indicated that high river bed near TRC would reduce design head and consequently could lower energy production.

It is perhaps preferable to watch the silting tendency under the site conditions prior to operations specifically aimed at lowering the bed.

Huge material has been dumped in this season in the plunge pool for making roads for rectification works in the area. Much of this dumped material would be transported to the river and for one or two years the river in this reach may experience aggradation.

It was indicated that an innovative solution of digging a smaller channel in the river bed cutting the elevated ledge of rock had enabled the lowering of water levels substantially and the operation yielded an enhanced power generation of 2-3 MW on 20 April. Such measures are laudable and valuable solution. Similar cuttings at appropriate locations during the coming months as per exigencies at site is welcome.

The problem can be discussed again after a study of the river conditions, to be undertaken by the project.

AGENDA ITEM 4:

INSTRUMENTATION & MONITORING REPORT

I. Monitoring **Report**

The behavior of instrumentation was presented in detail by the Project Engineers. PoE observe that most of the dam instruments providing an insight about

1. Pore Pressure distribution in dam foundation along different Sections (AA to GG)
2. Pore Pressure distribution in the clay core of the dam body (& shell portion)
3. Settlement of embankment dam at various observation locations along the sections.

confirm a stage of stabilized behavior which is quite acceptable and are in predictable lines.

4. The seepage in galleries is seen to indicate a general trend of decrease through VW Piezometers and this is satisfactory. However, it is necessary to confirm this by correlating the data of these instruments with the data of Stand Pipe Piezometers.
5. The deflection measurements show acceptable values.
6. The micro seismic instrumentation results, the post earthquake inspection of dam and other structures after recent earthquakes in the vicinity indicate nothing of serious concern.

Project Authorities were advised to bring an annual memoir on instrumentation, just like Bhakra Beas Management Board's practice in respect of their dams (Bhakra Nangal, Beas and BSL projects etc)

II. **Deformation:-** It will be desirable to prepare deformation information in three directions as below:

a) *Deformation upstream and downstream along flow direction i.e. normal to dam axis.*

On a vertical line plot, maximum upstream(minus) and downstream (plus) deformation in mm at elevations where instruments are installed from river bed to crest level.

Two verticals, one for upstream face and another for downstream face would be required.

The plot should be in different colours or with assigned symbols). This information may cover the following period:

(i) Just after construction, before filling.
(ii) After filling of reservoir upto full reservoir level.
(iii) Maximum observed values, positive and negative, during the year.

b) *The deformations along the abutments in the direction of dam axis:*

Same as above along two verticals or along curved abutment profiles Plus sign towards rock and minus towards centre of Dam.

c) *Settlements:*

Only on the centre of the dam with respect to the elevation of the constructed dam as the base level. The following should be included:

(i) At the end of construction
(ii) Just before first filling.
(iii) After first filling.
(iv) Maximum during the year (as % of dam height)

This information should be included in every annual report.

d) *Pore Pressures:*

Project is advised to plot contours of pore pressures as below:

(i) Construction pore pressures.
(ii) Measured and computed pore pressures.
(iii) Contours of pore pressures during the year.

e) Seismicity:

It was informed that seismicity records of the area before construction was available with NTPC. This should form the base for comparison for monitoring any possible RIS.

f) Chart of Visual Inspection :

Against many items tick mark has been made. This does not give any specific information. For example the word 'Erosion' has been ticked. It is not clear it was due to water or air. Also the locations are not given.

AGENDA ITEM 5 :

Seepage observed in the Turbine Pit vicinity:

The seepage locations and quantum of seepage were inspected.
PoE observes that the present situation is not of an alarming nature. Further observations could continue and reported.

Acknowledgement

PoE thank Sh. Vinod Choudhary, GM (Koldam), his team and Engg. Department (HRHQ) for the excellent arrangements made for their visit.

Dr. R. S. Varshney Er. M. Gopalakrishnan Er. Brijendra Sharma Sh. Jitendra Chaubey

Kol Dam, Dated 21 April 2016

Annexure-1

Team of NTPC Officers are as below:

1. Sh. Vinod Choudhary GM (KOldam)
2. Sh. V. K. Pradhan GM (Projects)
3. Sh. S. M. Choudhary GM (O&M)
4. Sh. S. K. Shukla AGM (Engg.) HRHQ
5. Sh. P.K.Yadav, AGM (FES/FQA/P&S/)
6. Sh. Madhukar Aggarwal AGM (FES)
7. Sh. K.S.Dogra, AGM (Civil)
8. Sh. B. Prasad DGM (Hydro Engg.) EOC

NTPC Ltd Kol Dam HEP

Report of the Fifteenth Meeting of Panel of Experts (NTPC Hydro)

The fifteenth meeting of the Panel of Experts took place at Koldam site from 30th January to 2nd February 2017.

Programme

30th January	Arrival at Koldam site by PoE members. Perusal of agenda items & inspection schedule
31st January	Site visit and discussions in the field; visit Plunge Pool area, Right bank, Dam Gallery No. 14, Presentation of Agenda Notes and presentation on Instrumentation data and discussions.
1st February	Inspection of Right bank and plunge pool areas in the forenoon followed by discussions with Group General Manager and drafting PoE Report, & finalization
2nd February	Signing of the Report. Departure from Koldam site to Chandigarh and to respective base stations by air/road

The members present for the mission were:

Dr. R.S. Varshney
Sh. M. Gopalakrishnan
Sh. Brijendra Sharma
Sh. Jitendra Chaubey

The team of officers from NTPC who were available is listed in Annexure- I.

Slope Protection & Other works for Plunge Pool

The 14th PoE meeting was held during April 2016. The 15th meeting of PoE is being held after the 2016 monsoon season. The Agenda brings out the issues to be addressed and PoE paid site visits to appreciate them and the records showing the behaviour of instruments for dam monitoring and physical damages to right bank slopes of the river in front of the ski-jump bucket and associated cladding walls.

A review of the spillway operation was done to appreciate the flow passed over the ski-jump and the consequential effect in the plunge pool area, taking into account some of the completed works undertaken based on the CAS of EDF Consultants and suggestions from the earlier PoE Reports.

The Chute spillway had been handling discharges between 2nd July and 29th August 2016. The monsoon flows in 2016 have been below average flows anticipated for the period. Spilling varied between 36 cumec on 2nd July to about 2400 cumec (highest value of the season) on 6th August. The ski jump has handled a maximum of 2400 cumec only in 2016 floods.

Photograph showing the passage of floods over the ski jump

The flow pattern after the impingement of ski jump jet on the downstream has been complex, and the near 90° turn of river to the left creates swirling action on either side. This has eroded the right bank and hill slope damages, taking away some slope wash material.

Observed damages

- Minor slides on right bank in upper reaches
- A slide on right bank of river in front of spillway along access road to power house (slide in overburden only)
- No additional damage on left bank
- Some Micro piles which were not cut sufficiently, bent by force of water /sediment
- Possible damage below El. ± 501m (water level)

Recommendations

- Cavity formed behind concrete cladding (essentially on right bank) to be back filled with concrete. It will be desirable to fill this cavity by first dumping boulders starting in the upstream end of the cavity and then filling the voids between the boulders with sand – cement slurry or pumped concrete (A-20). This process has to start from water level by dumping under water and then building it up to 1.0m above El. ±501m, then concrete with low water cement ratio be pumped into dumped boulder layer. Subsequently the work could be continued in layers of 1-1.5m thickness.

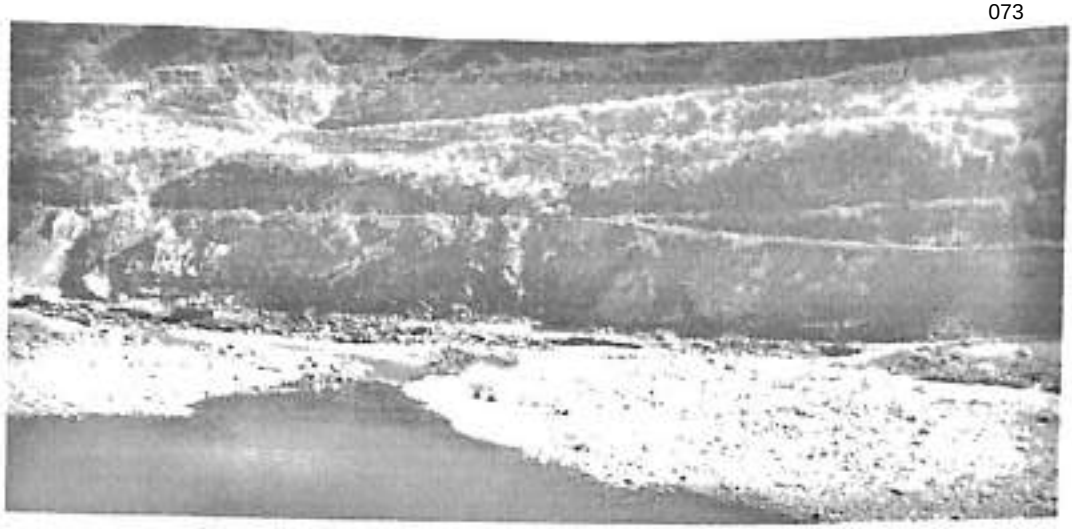
Photograph showing cavities below cladding on the right bank

This process does not require any equipment to be brought up to the cavity location and an ordinary manual path 1.5-2.0m width only need to be made for access. The work could thus start within a week of availability of contractor at site. Enough boulders are available in the plunge pool bed and thus no material is to be transported to site.

- Nothing needs to be done on the left bank of the plunge pool.

- Another area requiring protection works is the right bank of the river in front of the spillway where there could still be significant energy in the spillway water for erosion damage. This is also important as a public road and another access road to power house are located at different elevations in the vicinity. PoE recommend different protection works to this bank in two portion of the river bank

    - For the portion where rock is exposed from river bed up to road level (± 527m) and above, the protection should consist of 1-1-5m thick concrete cladding, anchored to rock surface by 25mm dia bars (untensioned), 5-6m long at 2.0m c/c spacing (staggered). The anchors should be fully grouted using sand - cement or cement slurry (NO CAPSULES). This cladding need not have a regular profile / alignment. It should be provided hugging the existing rock slope and would follow the profile of the rock. At the bottom, the cladding could continue as a horizontal apron about 1.5m thick and 2.0m wide. This apron should also be anchored to the foundation rock.



Right bank opposite to the Spillway (Rock portion)

- The treatment in the other portion (slope in overburden) would consist of 2-3m high gabion toe wall and boulder / stone pitching above. The back slope would however has to be dressed to a regular slope before pitching. A suitable filter layer must be placed behind the pitching. It would be desirable to provide launching apron at the end of gabion wall to be designed for water depth for 2400 m^3/sec.

Right bank slopes in overburden

PoE do not favour provision of rigid protection work (Concrete slab) to this portion of the slope as a flexible protection is likely to allow some movement / deformation and ease of repair after monsoon, if required.

- PoE do not feel the necessity for any protection on the left bank of the river downstream of the Tail Race Channel

Maitri Bridge

One of the significant control section of the river in the downstream is observed to be the Maitri bridge location. The river flows through a narrower section. Because of some civil works undertaken on the right bank, besides the intermediate pier foundation interference of the flow is possible. This also could constrain the flow behaviour affecting the hydraulics downstream of ski jump energy dissipator.

Necessity of Hydraulic Model Studies

PoE strongly recommend that a comprehensive hydraulic model study may be got conducted to study the behavior of Ski jump bucket and its effect on the downstream river conditions. This would help in defining layout and provision of remedial measures for proper flow downstream of ski jump bucket and in river.

Review of Instrumentation Results

A Detailed power point presentation was made to PoE explaining the section wise behaviourial trend of various instruments installed in the dam

Pore pressure distribution in Foundation	Two seasons of impoundment in the reservoir have passed by after its first filling in trials prior to 2015. It is observed that the pore pressures have stabilized. The effects of curtain grouting and reduction in pore pressures downstream of grout curtain confirm the effectiveness of grout curtain in controlling seepage through foundation
Pore Pressure in Dam body	Review was undertaken, section-wise from Section C-C to F-F.

Commencing with reservoir level at El. 642 in 2015, the records of observations through the monsoon as well as non monsoon seasons confirm, in general, that :

- Correspondence with rise and fall of reservoir levels
- Decrease downstream of clay core and sand filter.
- Values obtained show nothing abnormal.

Settlement in Dam

The maximum settlement is seen at the deepest section EE and is about 0.42 m which is acceptable.

The settlements are well within the design limit.

Spillway

- Joint meters
- Pore Pressure Cells

The observation results confirm that no abnormalities are discernible.

Widening of Joint between Guide Wall no. 26 & Flip Bucket

PoE note that there is some widening of joint between right guide wall number 26 and Flip bucket. PoE advise further monitoring at regular intervals.

Seepage through this crack below the right guide wall was seen. It was reported that in December, dripping through this crack was first observed which has now increased to a visible flow. This seepage is apparently coming from the gallery below the right guide wall. The crack appears to be along the joint in the right guide wall. It was further reported that the guide wall in this reach had to be founded about 4-5m below the normal level because of the poor quality of rock. To ascertain the cause for this seepage, inspection of the gallery from inside, is necessary. It is essential that facilities to enable inspection are created urgently.

PoE observe that overflow pipes from the Fire Protection water tank for the Power house are discharging on the spillway chute. To ascertain the integrity of the joint from the spillway chute side, it is necessary that water from overflow pipes are diverted away from the spillway chute. Rectification measures, if required could be decided only after the above inspections.

Seepage through Galleries

PoE could visit Gallery-14 up to drainage ring where copious seepage was observed. PoE was informed that drainage holes in the ring are 12-50m depth. It was reported that the water from the drainage holes did not carry any sediments. The total seepage from this gallery was also reported to be 2650 lpm. The measurement station at the end of this gallery generally shows a uniform seepage pattern between 2500 and 3000 lpm. However, for a brief period of about 20 days during monsoon, a sudden jump in the seepage to more than 5000 lpm is reported. The cause of this increase for a limited period needs to be examined in detail. Remedial measures if required can only be suggested thereafter.

The gallery under the right guide wall of the spillway carries the seepage from Gallery under spillway and Gallery-2 in the left abutment. Further, seepage under the spillway chute floor

(through porous concrete) is also guided through this gallery. Seepage in the gallery shows an increase during August and September. During monsoon the seepage in this gallery increased from about 1300 lpm to almost 4000 lpm and then dropped to ±3000 lpm. Increase in seepage during December and January is also reported.

It is recommended that the observations from galleries contributing seepage to this gallery should be presented separately. This would help in analyzing the reasons for anomalies observed in the seepage data, this monsoon.

Bathymetry

PoE in its 12th meeting had recommended for the establishment of sections both in Plunge pool and Reservoir. The same needs to be established on ground through Pillars on both banks so that the bathymetric survey could be conducted at the same locations every year. It is emphasized that this is done urgently before the onset of monsoon.

Acknowledgement

PoE thank Sh. Sanjeev Kishore, GGM (Koldam), Sh. V.K. Pradhan, GM (Project), Sh. S.M. Chowdhury, GM (O&M) and the project team for the excellent arrangements made for their visit and also facilitating a free exchange of ideas.

Dr. R. S. Varshney Sh. M. Gopalakrishnan Sh. Brijendra Sharma Sh. Jitendra Chaubey

Koldam, Dated 2nd February 2017

Report of the Sixteenth Meeting of Panel of Experts (NTPC Ltd.)

The Sixteenth meeting of the Panel of Experts took place at Koldam site in September 2017.

Programme

Date	Details	Remarks
11 Sept	Arrival at Chandigarh by air/ road by the team and proceed by road to reach Koldam site	
12 Sept Forenoon	Site Inspection of Plunge pool area and the vicinity, Power House, Dam and Reservoir	
12th Sept afternoon	Presentation of Agenda by NTPC and detailed review discussions, with the participation of NTPC officials	GGM (Koldam and GMs at site, joined the discussions after presentation)
13th Sept Forenoon	Preparation of inputs by members for the draft PoE Report	
Sept 13th afternoon, till night	Internal Discussions amongst PoE members, finalisation and signing of the Final Report	
14th Sept	Departure from Koldam site to Chandigarh and to respective base stations by air/road	

Welcome

PoE welcomed the new additional Member, Dr. Y.P Sharda amongst the Panel Members to look into Engineering Geology aspects.

Members Present

The members present for the mission were:

- ✓ Dr. R.S. Varshney
- ✓ Sh. M. Gopalakrishnan
- ✓ Sh. Brijendra Sharma
- ✓ Sh.M.K.V. Sharma
- ✓ Sh. Y.P. Sharda

The team of officers from NTPC who were available is listed in Annexure- I.

Agenda Item 1 – Performance of Plunge Pool / Protection & Other Related Works

This is the 3rd monsoon that the chute spillway is in operation to handle the spill flows over the reservoir capacity and floods.

The plunge pool with concrete cladding both on left as well as right side of flip bucket from El ±528m to El 485m., was called into operation ahead of the monsoon in the year 2015, when the initial filling in of reservoir was completed.

Observations Immediately After the Plunge pool Commissioning while Spillway Operation in 2015 Monsoon

The initial reservoir Impounding in the year 2015 from March to June (The reservoir touched FRL (El 642m) in June 2015) obliged some spilling over the chute spillway even prior to the monsoon, when the gates were operated as it suited, not necessarily following certain guidelines available based on model studies, which was made available to NTPC by M/s EDF consultants. The spillway was also called upon thereafter during 2015 monsoon to discharge surplus inflow.

During its first operation, some damages were observed in the Plunge Pool both on Left as well as Right side. Some part of cladding on Left side of plunge pool was damaged with some panels getting dislodged or disturbed. Cavity formation behind Left and Right cladding wall also took place, due to scooping out of the base material behind the cladding concrete. This was attributable to the swirling flows on either side after the impinging jet plunge in the pool; the consequent scouring action, varying nature and extent for different discharge levels, based on the sequence of operation of gates was discernible.

Consultants M/s EDF soon thereafter had come up with their own engineering review and remedial measures, which were brought before PoE for information and opinion. PoE had reservations to endorse the Consultants suggestions that included micro piles and secant piles to strengthen the entire rock mass where the plunge pool was planned and executed.

EDF had, as Consultants, suggested to NTPC the following measures to be implemented to enhance the performance of energy dissipater designed by them avoiding or reducing damages. These works were proposed by NTPC, to spread over two working seasons:

For 2015-16

- Filling of cavity with concrete behind right and left bank cladding walls.
- Core drilling for investigation.
- Micropiling 200mm dia cased.
- Spillway discharge to be kept at 2000 cumec minimum, to ensure that the impinging jet does not plunge close to bucket lip cladding.

For 2016-17

- Bathymetry survey.
- Coffer dam downstream of cladding wall and dewatering
- Secant concrete piles of 900 mm dia.

During their PoE meeting in Sept. 2015 at site, the Consultants' suggestions were reviewed by PoE, at the instance of NTPC. The PoE felt that the damages during the energy dissipation with Ski Jump are not any uncommon phenomenon, in almost all projects. It was clarified that normally it takes a few years for a 'post project' regime to get in place.

PoE felt that the EDF solutions were not quite necessary as per the elaborate plans indicated. PoE however had no hesitation to agree on the necessity to backfilling of the cavity behind cladding of plunge pool in a systematic manner. PoE advised that the sequence of the operation of gates should be in strict accordance as per model studies, and the spillway should be operated at a threshold level of 1000 cumec(min) and beyond to ensure that jet impinges the plunge pool sufficiently away from bucket lip line.

AS per NTPC, however, following works were commissioned already after monsoon in 2015, with a schedule to complete them by May 2016:

- Backfill of the cavities behind right and left cladding walls of plunge pool
- Micropiling below EL ±503m up to EL ±485m on both Left and Right cladding walls.

Spillway Operation in 2016 & Plunge Pool behaviour, as Observed

The records indicate that the spillway was operated during its second year of operations during monsoons such as to go by the stipulation of minimum 1000 cumec in order to ensure that the jet impinges sufficiently away from the lip of the flip bucket at the extreme.

The flow pattern in the plunge pool has been complex, and the near 90° turn of flow the plunge pool to the river downstream creating back flows on the right side of pool (observed at site). The discharge from tail race may also be contributing to the complexity of the flow. The pattern of flow after it emerges out of the flip in the sky and falls downstream had again demonstrated a swirling motion in the pool, clockwise in the right half and anti-clockwise in the left half of the

plunge pool. This phenomenon had led to sufficient erosion on right side of the hill slopes, even for a discharge level around 1000 cumec, set earlier by PoE as a threshold value to commence the spillway operation. While the flow pattern after impinging of the jet in the plunge pool was okay in respect of left side, it wasn't as expected in the right side, which caused damages again. The damages behind right cladding wall included a cavity formation between El 528 and El 503 m. This was due to scooping of the rock beneath; the backfill concrete M20 (done in 2016 dry season below EL 503m was, however intact.

Works which were completed prior to 2017 monsoon were reported as (i) the filling in the cavity with concrete behind Right Bank cladding wall, (ii) micro-piling from bench at EL 528 m (EDF recommendation), (iii) the removal of the protrusion along Left Bank of Plunge Pool besides (iv) bathymetry survey of the plunge pool area. It was indicated that EDF recommendation to execute the micro piling work from the inclined surface could not be undertaken. Even in the cavity below EL ±503 m i.e. below the backfilled concrete, which was exposed, though big boulders and concrete bags were placed, the total cavity could not be backfilled in time as the water level started rising in June 2017, forcing the stoppage of works at the stage of its accomplishment till then.

In their last visit to site and the meeting in February 2017, PoE had reviewed the situation at site and had reiterated their observations on the matter since the issue was posed before them in the first instance in 2015; it would be difficult to anticipate 'no damages' in the plunge pool area until a normal 'stabilisation in flow behavoiur obtains and PoE had observed that this might definitely take a few more years of operation with different discharges. A new morphology of the river channel downstream with all the new interventions in place would then be available, with nature playing its own significant role. While it is difficult to predict the type of changes in store as it depends on many probable, what best could be done as of now can be given some consideration. It is in this regard that fresh comprehensive 3-D hydraulic model study of ski jump bucket was advised to be commissioned immediately. The model results, essentially the hydraulic aspects relating to downstream river conditions would be useful and any long term measures can be planned and executed. This can be undertaken through a leading hydraulic laboratory.

PoE was appraised of, by NTPC, that they are about to commission these studies through IRI Roorkee. It is however advisable to involve CWPRS also in any suitable manner.

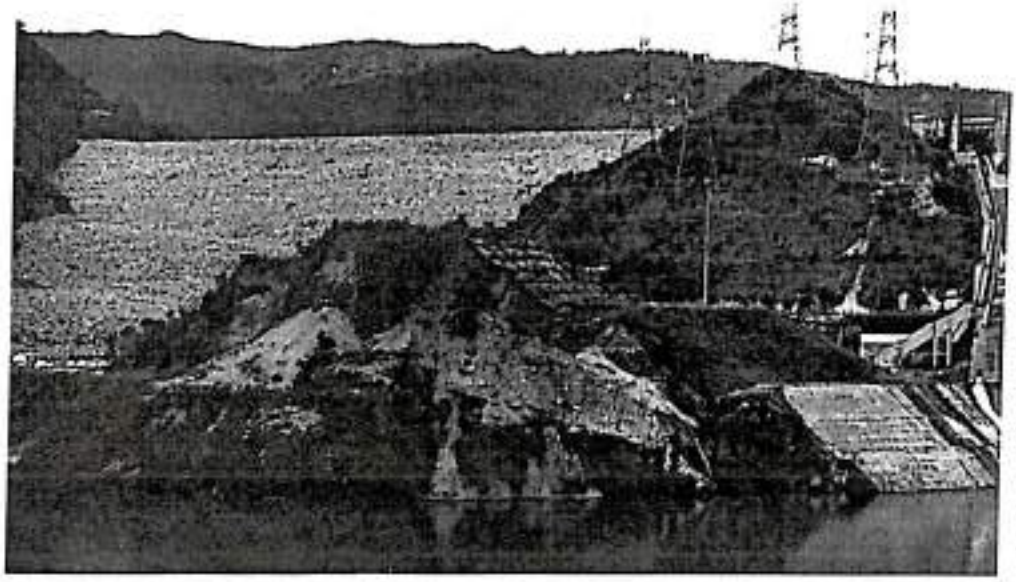
Post Monsoon 2017 (till date) – A Review for Undertaking Remedial Works to Control Possible Future Damages

The chute spillway has been handling discharges over 1000 cumec on many days during the 2017 monsoon and the details given in the Agenda Notes show the highest value passed over chute as 1520 cumec on 1st August. On seventeen days, discharge had exceeded 1000 cumec as per record made available till 18th August. The monsoon 2017 may perhaps be one of the

'normal' ones to be visualised in respect of Sutlej river at Kol. The ski-jump had handled 1520 cumec and plunge pool operation correspondingly is now available.

Some views on the damages correlating to geological aspects

Recapitulating the overall geology at site, one observes that the spillway area located on left bank of Satluj river exposes a sequence of dolomite, phyllite, carbonaceous phyllite with basic dykes emplaced. Phyllites and carbonaceous phyllites are weak and susceptible to erosion and basic dykes are altered to some extent. The rocks strike across the spillway alignment and dip steeply towards upstream. The river Satluj in the area flows almost along the strike and limestone/dolomite limestones are exposed on right bank of Satluj on moderately steep bank right from riverbed level.



The spillway is seen to be aligned in such a way that it debouches into river at right angle. The Plunge Pool area exposes phyllites and carbonaceous phyllites that are quite weak and susceptible to erosion. Since discharge from spillway joins the river perpendicularly, it hits right bank directly and results in formation of eddies in the plunge pool area. This leads to intense erosion on both sides of spillway. However, the intensity of erosion is more on right flank where the protection works comprising cladding wall has been damaged resulting in formation of a large cavity behind the cladding wall. The intensity of erosion increases when power house is in operation. This has been observed during subsequent floods even when the concrete filled behind the cladding wall was also eroded resulting in wide cracks in the cladding.

Some views of damages (RF)

During the current monsoon in 2017, the spillway operation had resulted in certain damages again, on right side of plunge pool. Taking stock of the situation after inspection at site, PoE observe that the backfilled concrete placed in cavity behind the right cladding wall (including the backfilling done in 2016) has been scooped out and washed away. Some related works advised by EDF and completed by NTPC, in respect of micro-piling had also failed to serve its intended purpose. PoE was informed that all the works related to backfilling of the cavity could not be completed; some gap at the bottom has remained open to water access.

A new observation of concern relates to the widening of the expansion joint in right cladding wall.

Given the above, PoE advice that the works for downstream protection in various pockets may have to wait their review of the hydraulic model studies yet to be commissioned.

However, essential works to avoid extension of damages are quite necessary and these could include the following works:

a. Cavity from behind concrete cladding on the right side to be backfilled with concrete. It will be desirable to fill the cavity by first dumping boulders starting in the upstream end of the cavity and then filling the voids between the boulders with sand-cement slurry or concrete. This process has to start from water level by dumping under water and building it up to 1m above water level. Concrete with low cement water ratio can then be placed into dumped boulder layers.

b. Subsequently the concreting work could continue in layers of 1-1.5m thickness up to 2m above the maximum water level in the pool.

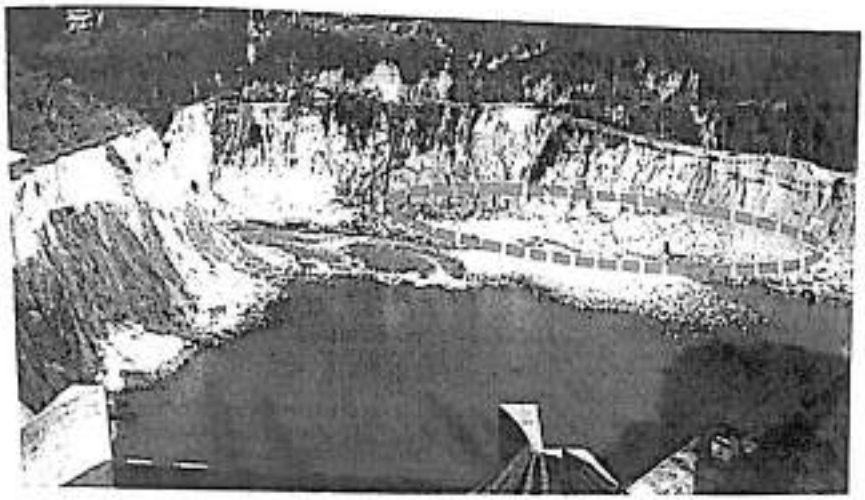
PROPOSED PROTECTION WORKS

c. PoE advise that placement of concrete bags dumped behind the cladding is not resorted to as suggested by project during discussions on 12.09.2017). After filling the cavity with concrete the exposed face at the end of cladding shall be covered by placement of boulders upto El. 512 m i.e., max possible water level, encountered corresponding to say 1500 cumec discharge and keeping in view backwater effects due to Bhakra reservoir. The boulders (unrounded / blasted that can interlock) may be placed in a manner to provide a gradual transition from end of concrete cladding (including backfilled concrete) to the exposed rock slope downstream so that the space for backflow on right side gradually decreased. Alternatively the use of tetrapods or tripods of individual weights of one tonne minimum weight, laid in multiple layers, (duly interlocked) can be explored and adopted.

d. Protection to the remaining length of the right side rock face up to the confluence with river (near the bend towards upstream) may also be provided by extending the boulder layer beyond the transition or placement of boulder wire crates.

e. Removal of the rock nose on the left side near the confluence be continued down to water level in the plunge pool. POE do not endorse rest of protection works additionally, proposed by the project in their Agenda Note.

Agenda 2 - River Protection Works Downstream of TRC



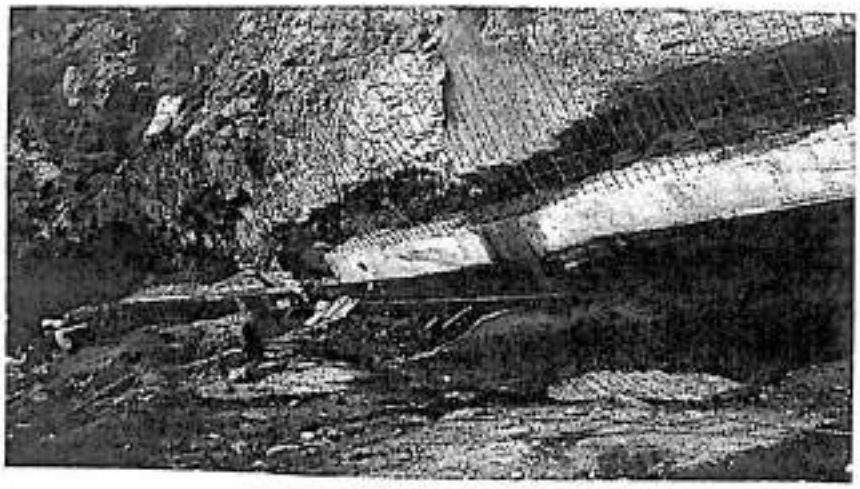
A concrete cladding wall in front of Plunge Pool (on right bank of river) along with rock anchors in a reach of 200m in front of Plunge Pool had been undertaken by NTPC to prevent erosion noticed on the right side of the river.

In their recommendations in the last PoE meeting certain proposals were made in this regard, which was agreed to.

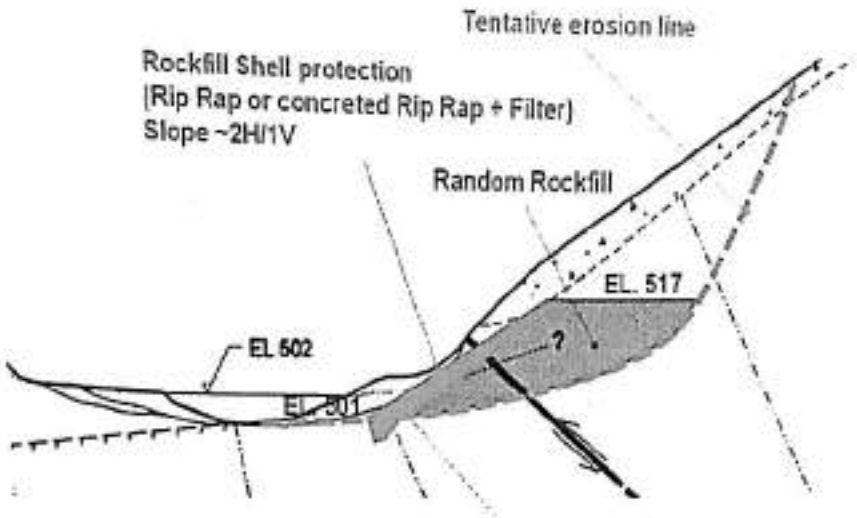
The concreting from foundation at El + 500m to a height of 5 m above has been partially completed in about 60m length. The balance works are to continue. (including the dredging works that have been undertaken already).

It has been proposed to build a flexible guiding structure (made of rip-rap) along the right bank of the Sutlej River. between the end of the tail race channel and the exit of the plunge pool. The structure is to follow the same alignment as the previous concrete wall (remains are visible on site) in the right bank of the river. POE advice had been solicited.

PoE endorse the proposals.



Planned Erosion Protection works (Right Bank- Main River Portion)



Review of Instrumentation Data

PoE was presented behavioural data of different instruments embedded in the dam and foundation. These included (i) Pore Pressure distribution in Dam foundation, (ii) Pore pressure distribution in dam body including upstream and downstream shell and core and (iii) Dam settlement and deformation. It was seen that barring a few instruments which have become defunct, the readings of pressure and deformation have been steady and values are within safe design limits.

However, it would be desirable to present the picture of pore pressures and deformation in a self-explanatory system schematically. For example, (i) for any calendar year, maximum/steady value be chosen for every piezometer and put on a section of dam. Pore pressure contours can be drawn for shell and core. Such illustrative figures are drawn for dam in general and give immediate idea of the behaviour of dam, (ii) Similarly, maximum section of dam be chosen and deformation (Maximum in a calendar year) be plotted and (iii) Dam settlement plot along dam axis for upstream/downstream elevation of dam.

Seepage in Galleries

PoE was presented the seepage data from the network of galleries provided in the dam and abutment. It is seen that the seepage had established a steady trend and is well within the anticipated / possible values as given by Consultants M/s EDF.

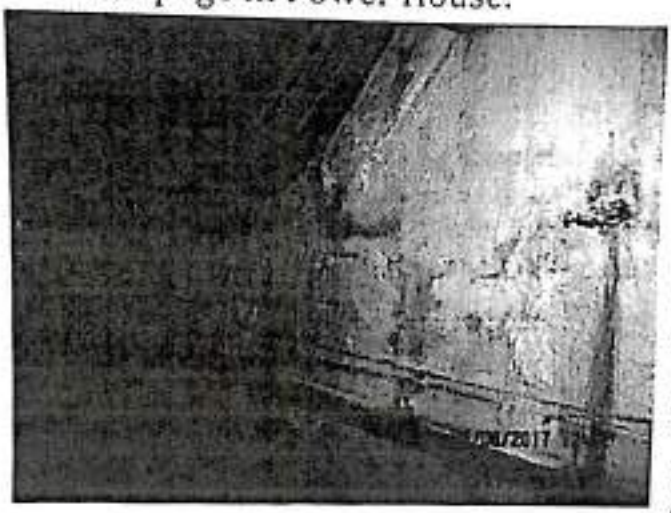
Bathymetry Survey

Survey indicated silting in the delta region of the reservoir, which is quite normal. Silt deposition is also observed near dam axis.

The sedimentation profile in the reservoir with top-set and front-set would take some more years. Therefore bathymetry survey be continued yearly and sediment deposition assessed.

Agenda item 5 Miscellaneous

- Seepage in Power House:



It was informed by the project that to arrest the seepage on upstream wall of power house chemical grouting has been done and found to be very effective and practically 90% of the seepage has been arrested. Still some seepage is continuing in the upstream wall of power house near MIV of all units. Project desired to know whether chemical grouting should be continued further to arrest the present seepage.

During the site visit, PoE observe that the seepage is at acceptable levels. PoE however advise that a few drain holes (size 80 or 100mm dia, 5m long inclined upwards by 10 to 15 deg) may be drilled to channelise the seepage water. This may be tried at one location to finalise the spacing and number of holes and adopt the same at other locations.

- Hydro Mechanical Equipment:

  i) From the information given in Annexure 8, it is seen that no problem is faced in operation of Hydro Mechanical Equipment and regular maintenance is being attended to.

  ii) Spillway Gate No 2 : It is mentioned that during operation of the gate, the side seal is getting compressed more , beyond 2.5 m opening , though there is no problem in raising the gate fully.

Since no problem in operation of gate is reported, no adjustment/modification is required in the sealing arrangement at present. PoE advise that, if the compression of the side seal increases further, the skin plate or seal clamp may obstruct the movement of the gate in future. This can

be monitored and in such an eventuality, modification of seal clamp plate or slight cutting of skin plate may be explored.

iii) Bottom outlet gate:

During the PP presentation, it was pointed out that the bottom outlet gates have not been operated after the initial filling of the reservoir (April 2015). In fact, it was reported that the conditions obtained at the location do not enable any regular maintenance of these gates. Earlier, EDF consultant had reportedly advised NTPC that these gates can be plugged permanently, as they have served their purpose in regulation of reservoir level during initial filling and that they are not required in future for any functional role.

While bottom outlet gates will be useful in depletion of reservoir in case of dams in distress, when there are no openings in the dam at lower level a careful review needs to be done in the instant situation. PoE advise that a comprehensive memo may be put up in the next PoE meeting for consideration and advice by PoE on this issue.

Bathymetry Survey:

The results of the survey recently completed indicate that there is a deposition of silt at the end of the reservoir of the order of about 5m. Further deposition has been reported near Dam Axis by about 3-4m in the upstream 1000m reach. The pattern of sediment deposition in the reservoir needs continuous data collection which may continue.

- Others

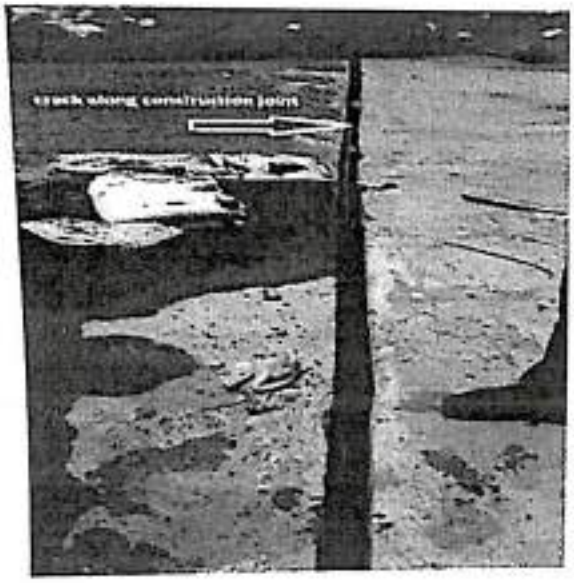
NTPC informed that during 2017 flood season also the reservoir level maintained around El 639m in order to avoid flooding of Chaba power house at the upstream of reservoir. PoE advice to take up the matter with Chaba authorities to expedite the installing vertical gates in their TRC so that NTPC can maximise water head.

Widening of Joint between Guide wall 26 and Flip Bucket

There has been a discernible widening in the chute training wall on the left where the contraction Joint is located between Guidewall and Flip Bucket. The observation can continue. If possible, the crack extension if any on the floor may also be detected though difficulty is reported due to water in the bucket all the times.

A decision to grout the gap will be considered based on the results of further observation.

The root cause for various cracks like those in the cladding wall , inclined and horizontal floor , possible linkage in due consideration to sub surface geological features need a careful analysis of data based on further observation.



The basic dyke's integrity should be protected by all possible means; and to that extent, prevention of washing out of the material by scooping beneath claddings in the left, extended damage in the hill slopes in left flank etc shall be carefully monitored and if required, remedial measures evolved in due course.

Obituary

PoE received the news about the sad demise of Dr. Jitendra Chaubey, Member (Engineering Geology aspects) who had been quite active since his induction in the Panel, especially during its 14th and 15th meetings. His contributions were praiseworthy. PoE record its condolence with prayers for his Soul to rest in peace.

Acknowledgement

PoE thank profusely all concerned in NTPC (Hydro) for organising the meeting post monsoon and arranging all logistics. Thanks are particularly due to Mr. Jagadish Roy GGM (Koldam), Shri V K Pradhan GM Project, Shri V.M. Chowdhury GM (O&M) and Sh P.K. Yadav GM (Engg-Hydro Region Hqrs) and other senior Officers from Corporate Office and site.

Signed and delivered to NTPC by PoE at Koldam site on 14th Sept 2017

Dr. Y.P. Sharda | Er. M.K.V. Sharma | Er. Brijendra Sharma

Er. M. Gopalakrishnan FNAE | Dr. R.S. Varshney FNAE, Chairman PoE

Report of the 17th Meeting of Panel of Experts (NTPC Hydro)

The 17th meeting of the Panel of Experts took place at Koldam site between 7th and 9th February 2018.

Programme

Date	Details	Remarks
7th February	Arrival at Chandigarh by air/ road by the team, proceed by road to Koldam site	
8th February	Inspection of right and left training wall and the observed cracking, walk through drainage gallery beneath the sloping beneath the sky-jump, downstream wing cladding walls etc Presentation of Agenda and Discussions	
9th February	Leave Koldam GH @ 8 am, by road to Chandigarh and by air to Delhi (Spice Jet @ 3.15 p.m	
10th February	Discussions with NTPC Hydro wing @ NOIDA ; Finalise draft PoE Report Departure by air / road for respective stations	

Welcome

PoE welcomed the new Member PoE, Shri A.K. Sood in the Panel Members to look into Engineering Geology aspects.

Members Present

The members present for the mission were:

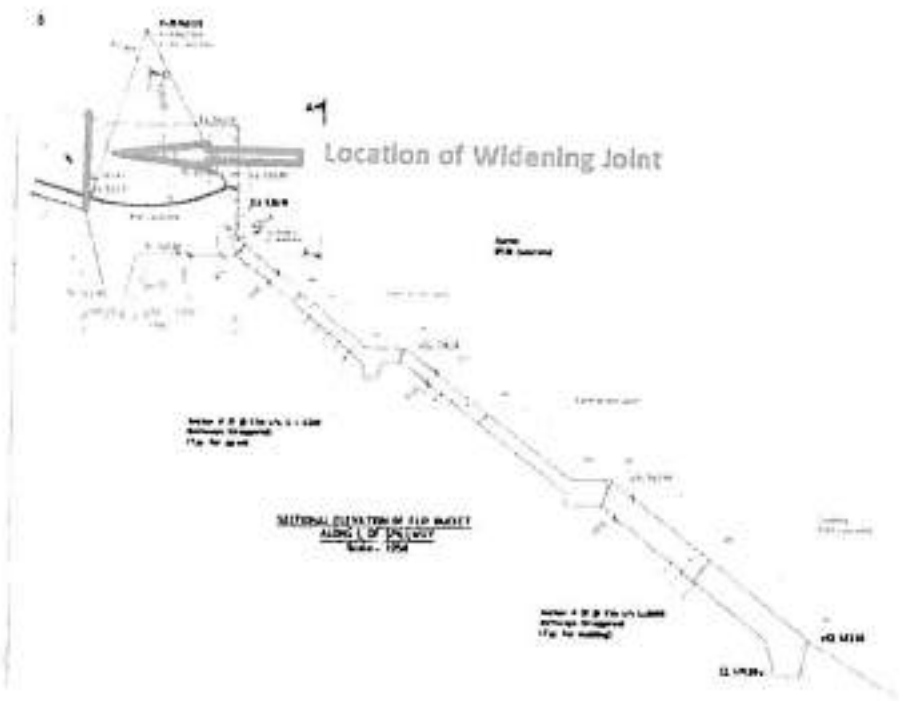
- ✓ Dr. R.S. Varshney
- ✓ Sh. M. Gopalakrishnan
- ✓ Sh. Brijendra Sharma
- ✓ Sh. A.K. Sood

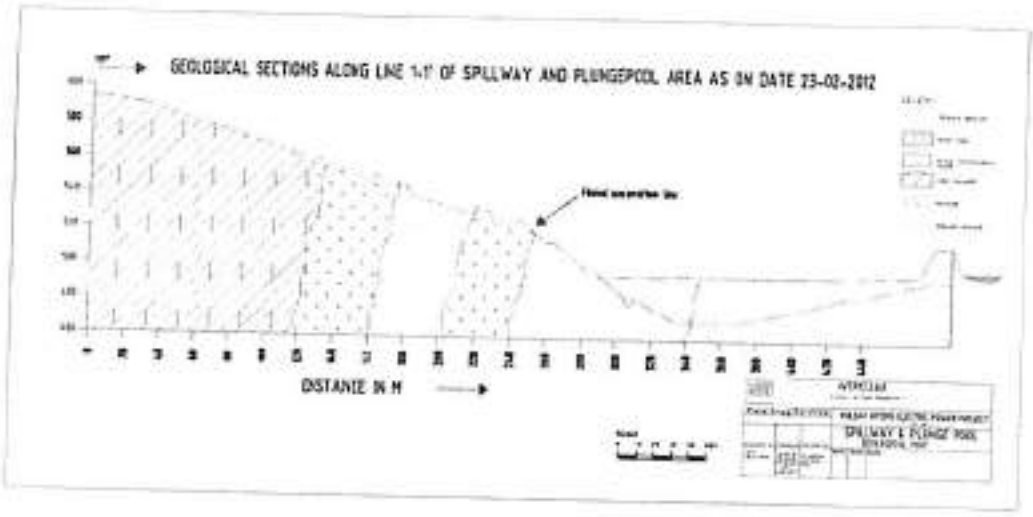
The team of officers from NTPC who were available is listed in Annexure- I.

Agenda Item 1 – Review of Flip Bucket joint widening

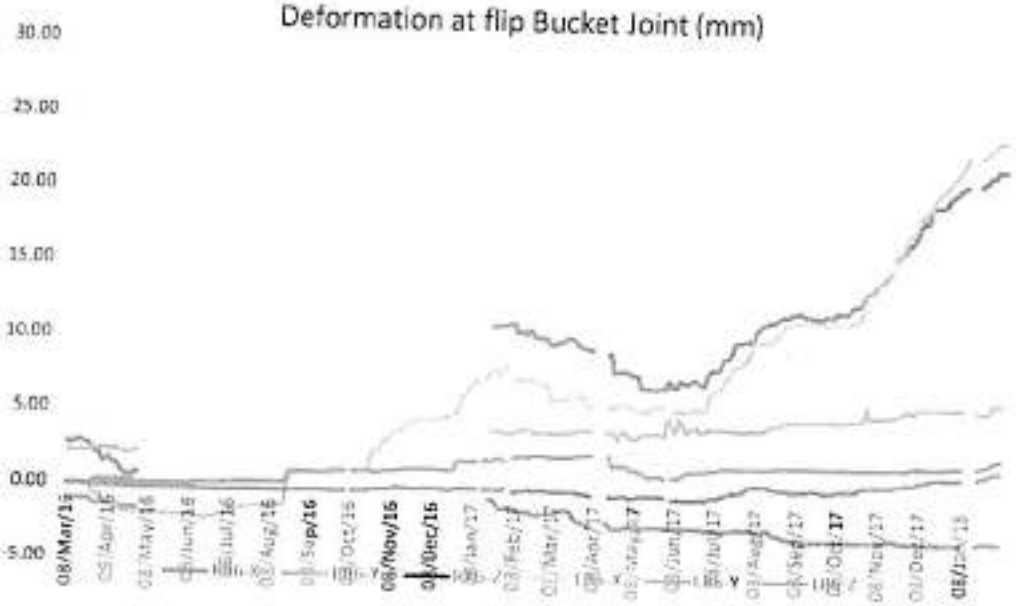
It was brought out that monitoring of the tendency of suspected opening of joint between end block and training wall near flip bucket in both right and left side indicate an increase during the months following last monsoon, which was higher in comparison to previous observed values. Till Jan. 2018, the displacement observed was reported as 24 mm & 21 mm on left and right wall, respectively.

The agenda notes reflect the widening of joints at locations seen in the sections indicated beneath, both in the right and left raining wall. It is suspected that it runs all across along the contraction joint on the floor of the chute spillway. (Figures below show sections).

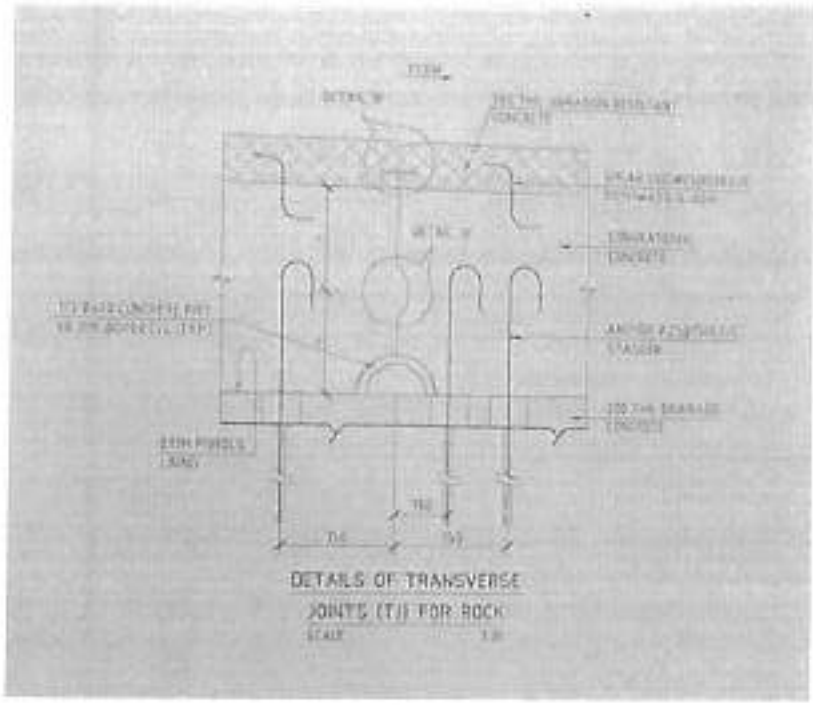

Location of Widening Joint



It is seen that the flip bucket and its guide walls are founded on competent basic dyke, as per the geological section.



PoE note that where the suspected widening of floor joints of chute spillway had taken place, construction drawings as made available during the meeting indicate certain special provisions like shear lugs and a single water stop, anchors to ensure bonding with the competent base dyke foundation.



It is also seen that the transverse joint has also the provision of chamfer at the joint location which can help air supply in case of any development of negative pressure or cavitation.

More investigations are warranted to apprise the phenomenon and confirm or otherwise the widening of joints, especially on the floor.

For data regarding suspected widening of the floor joints, at least a manual access to visually examine the joint all along, from left to right guide wall, is to be ensured urgently. Additional measurement points need also to be established from top to bottom of the guide wall. Data regarding ambient temperature may also be incorporated in the report. It is likely that the water pressure on guide walls and floor in the bucket portion are subjected to very high pressure as compared to chute.

Agenda 2 – Right Bank River Protection Works Downstream of TRC

POE was presented the status and details of protection works proposed for the right bank river slope in front of the Plunge Pool in the 16th Meeting in Sep 2017. The works included concrete cladding of the portion of river bank slope in rock as well as rockfill shell protection covered by concrete or rock riprap in portion, where rock is not available. POE had endorsed the above, earlier.

Some work of the concrete cladding has recently been started. The Project now inform that it is not possible to arrange for boulders of sizes 600mm to 900mm. In view of this, it is now proposed to place Gabions (Boulder wire crates), in place of rip rap. POE observe during site visit that dredging in the river bed downstream of TRC towards plunge pool right bank is being carried out. A considerable amount of river borne material has deposited in the middle portion of the river channel, thus creating a raised island, which obstructs the flow during operation of the power house.

Since the treatment of right bank river slope is to be taken up now, it is important to keep the river channel as far away from this bank, as possible. POE, therefore, recommend that the material from the island be removed and a deeper river channel created in the middle for carrying daily discharges from the tail race channel. This should be done on priority, to enable faster construction of right bank protection works.

It was also observed during site visit that a limited amount of large size boulders is lying in the river itself. These could be used for protection of the boulder filling on slope in the whole length (about 150 m).

POE would further like to emphasise the necessity of expediting the works of right bank river protection works in the whole length even if it results in completion of works only up to the expected water level (El 505 – 509 m).

Agenda 3 – Protection and other works for Plunge Pool

In last PoE visit, it was advised to undertake all essential works to avoid any extension of the damages that had taken place and these included:

a. Cavity from behind concrete cladding on the right side to be backfilled with concrete.

b. After filling the cavity with concrete, the exposed face at the end of cladding shall be covered by placement of boulders upto El. 512.

c. Protection to the remaining length of the right-side rock face up to the confluence with river (near the bend towards upstream) may also be provided by extending the boulder layer beyond the transition.

Project proposes to take up these works in two phases – Phase A and Phase B.

Phase A works include boulder filling in the cavity behind cladding upto El 502m-503m followed by concreting of the cavity upto top of cladding. Boulder filling has already been taken up at site. Concreting is also in progress.

Phase B works include extension of protection works on the rock slope beyond cladding. Project has now proposed the rockface protection by tetrapods (or equivalent). POE support this alternative and recommend that expeditious

action should be taken. Preparation for casting tetrapods in a yard at suitable location can start immediately.

Acknowledgement

PoE thank profusely all concerned in NTPC (Hydro) for arranging all logistics.

Thanks are due to all Officers from Corporate Office and site.

Sh. A.K. Sood | Er. Brijendra Sharma | Er. M. Gopalakrishnan

Dr. R.S. Varshney,

Chairman PoE

Annexure-1

A. List of participants from NTPC on 08.02.2018 (Site visit at Koldam)

1. Sh. S.M.Chaudhary, GM(O&M), Koldam Project.
2. Sh. Madhukar Agarwal, AGM(FES/P&S/FQA), Koldam
3. Sh. U.K.Chaddha, AGM(Civil), Koldam
4. Sh. Kulveer Singh, AGM(Engg.), HRHQ
5. Sh. S.K.Srivastava, DGM(Engg.), HRHQ
6. Sh. S.K.Garg, DGM(P&S),Koldam
7. Sh. Prashant N. Gaur, Sr. Manager, Engg.
8. Sh. Rakesh Bhakar, Sr.Manager(Civil), Koldam
9. Sh. Bhagirath Chaudhary, Manager, HRHQ

B. List of participants from NTPC on 10.02.2018 (at EOC, Noida)

1. Sh. K.K.Singh, RED(Hydro & DBF)
2. Sh. Jagdish Roy, ED(Koldam)
3. Sh. G.L.Hurla, GM(Hydro Engg.), EOC, Noida
4. Sh. Madhukar Aggarwal, AGM(FES/P&S/FQA), Koldam
5. Sh. U.K.Chaddha, AGM(Civil), Koldam
6. Sh. Kulveer Singh, AGM(Engg.), HRHQ
7. Sh. S.K.Srivastava, DGM(Engg.), HRHQ
8. Smt. Vibhu Kaushal, DGM(Geology),EOC
9. Sh. Bhuvnesh Kumar,DGM (Geology),EOC
10. Sh. Rakesh Rathee, Sr.Manager(FES), Koldam
11. Sh. P. N. Gaur, Sr. Manager (Engg.),EOC
12. Sh. Abhishek Singh, Manager, HRHQ
13. Sh. Bhagirath Chaudhary, Manager, HRHQ

Report of the 18th Meeting of Panel of Experts (NTPC Hydro)

1.0 Preamble

The 18th meeting of the Panel of Experts took place at Koldam site between 18th and 21st June 2018.

Members Present

- ✓ Dr. R.S. Varshney
- ✓ Dr Y P Sharda
- ✓ Sh. M K V Sharma

Sh. M Gopalakrishnan and Sh. Brijendra Sharma could not attend the meeting due to preoccupation/health issues.

Dr R S Varshney, Sh. M K V Sharma and Dr Y P Sharda assembelled at Chandigarh on 18.06.2018 and drove to Koldam site in the evening.

NTPC presented Agenda notes to POE containing issues which required attention of the members. Main issues are as below:

1. Review of flip bucket joint widening
2. Plugging of bottom outlet
3. Protection and other works for plunge pool.

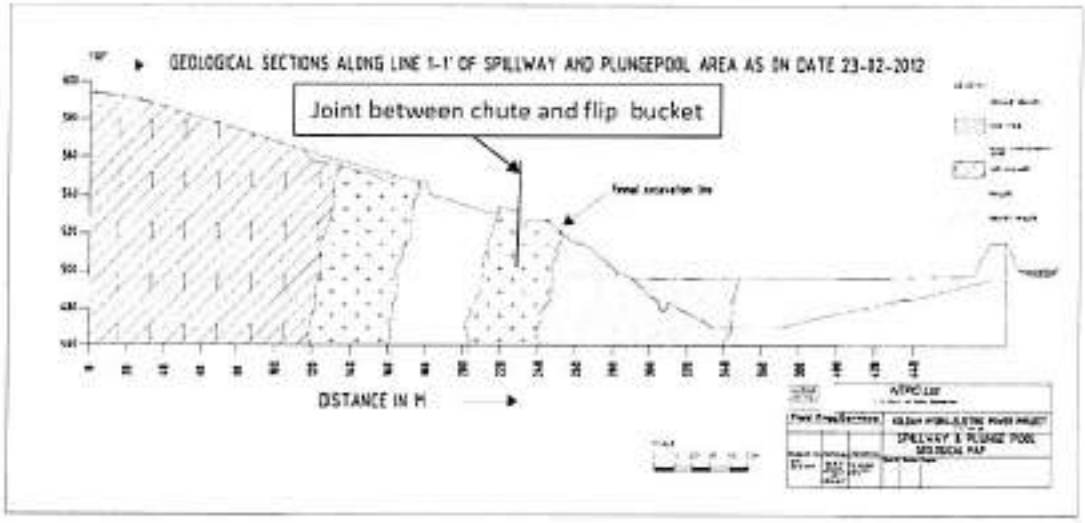
Members visited the site on 19.06.2018 and inspected Diversion Tunnel (DT-2), Right bank protection works and Flip bucket Joint of Spillway.

NTPC officers made a presentation of the problems and instrumentation data on the evening of 19th June 2018. Discussions included the remedial measures for the three agenda note items as well as allied subjects like instrumentations etc.

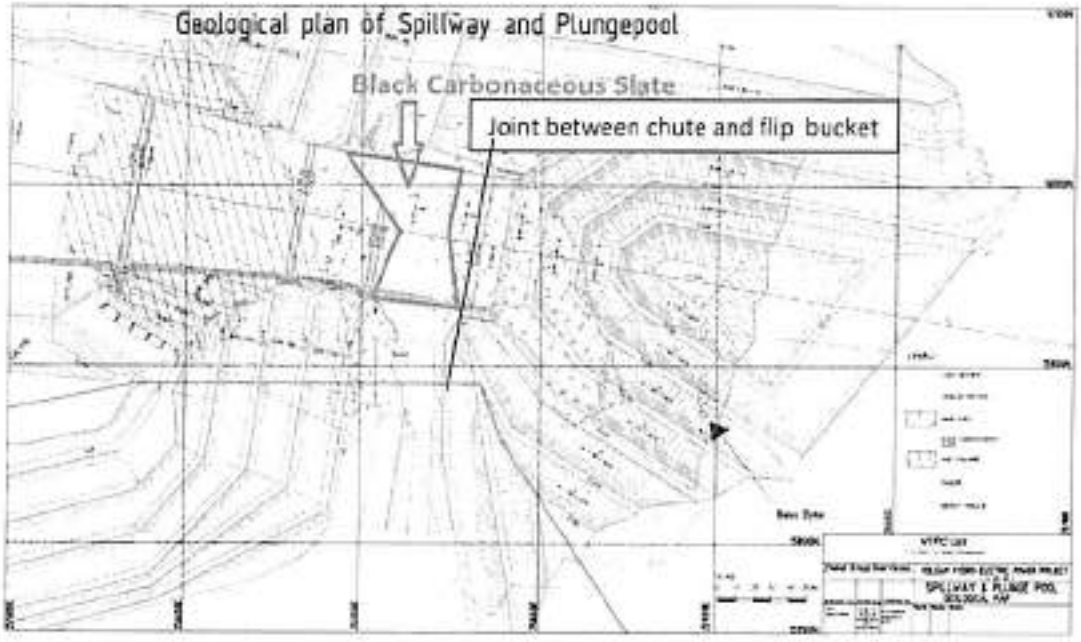
POE compiled the report on 20th and in the morning of 21st June and there after the members departed to their respective base stations.

2.0 Agenda Item 1 – Review of Flip Bucket Joint Widening

The available drawings indicate that spillway is founded on grey dolomites, carbonaceous slates/ phyllites and phyllites with emplacement of basic dykes. It is observed that grey dolomites, basic dykes and carbonaceous slates are exposed in the foundation of glacis and flip bucket is founded on basic dyke whereas sheared slates/ phyllites form the foundation of plunge pool.



It is observed that the construction joint (Contraction/Expansion) has been provided at the junction of end of chute and start of flip bucket. The problem of widening of this joint was brought to notice of POE during the meeting of Sep 2017. The problem was reviewed in details during 17th meeting of POE held in Feb 2018. The dilation was being observed in the two vertical training walls by vinchon apparatus located at approximately centre of the walls. In Jan 2018 the horizontal dilation reached 25mm, the limit of the instrument. Therefore, the instruments were readjusted to original setting. In addition as desired by POE two additional vinchons were installed , one above & one below the already installed vinchon on left training wall. One additional vinchon was also installed on right side training wall, below the existing vinchon.



The observations of the five vinchons were demonstrated to POE . The actual absolute values as on 18 Jun 2018 were 19.75mm, -1.75mm & 0.52mm (in X, Y and Z directions of Right bank ;RB6 instrument) and 20.67mm,3.39mm & 2.03 mm (X,Y and Z directions of Left bank; LB6 instrument). The readings indicate practically the same position of the joint after construction. While pouring concerete for chute and flip bucket blocks and installation of water seal there would be no gap in Y & Z directions and there might have been a gap of around 10 – 15 mm in X direction due to installation of seal. An absolute value of 20mm in x direction proves only slight opening of the joint. The values in Z & Y directions are 2mm each which are negligible. This can be due to some contraction and expansion of the concrete due to temperature difference. The readings show there is no settlement of foundation and no adverse effect of change of hydraulic pressure from low pressure on chute portion and high pressure on flip bucket side. The present trend of behaviour of joint indicates that the dilation and contraction of the joint may not be related to foundation settlement.

The monitoring indicates slight stabilising trend in the dilation between February 2018 and June 2018. However, the period may be too short and therefore, it is recommended that the monitoring may be continued for at least one more year.

3.0 Agenda Item 2 Bottom outlet Plugging :

3.1 Background

In support of the proposal of plugging of the bottom outlet gates, the following points were brought out in the memo:

(a) Seepage is observed from the gates for the last 3 years, after initial filling of the reservoir (April 2015).

(b) Conditions at the location of these gates do not permit any regular maintenance of gates.

(c) Consultant EDF had earlier, reportedly advised NTPC that these gates can be plugged permanently, as they have served their purpose in regulation of reservoir level during initial filling and these gates are not required in future for any functional role.

(d) The following points are also mentioned in the detailed note in Annexure-4 of agenda note:

(i) Pressure balancing pipes which are provided for balance operation of the upstream Emergency gates, are constantly exposed to the moist conditions and high pressure (127 m head). If there is a failure of these pipes or valves, there will be outburst of water and it would be very difficult to close/rectify the same.

(ii) Hydraulic system provided for operation of gates is not in working condition.

(iii) There is a risk of gates lifting up which are presently in the closed position, if there is failure/leakage of oil from the piston seals.

(iv) The leakage of the high velocity silt laden water through the gates and periphery of the tunnel, may damage the liners, sill beam and gates in the long run.

(v) Similarly, the hoist support structure and steel ribs supporting the tunnel may also get damaged in the long run.

Hence in view of the above, NTPC sought POE opinion for suitable measures with regard to safety of Bottom Outlet Gates and its supporting structures.

3.2 Site visit by POE:

(a) POE along with project officers visited the bottom Outlet Gates on 19.06.2018. It is observed that there is profuse leakage through the radial gates under high velocity indicating total damage to the seals of both radial gates and upstream emergency gates, which are also in closed position.

(b) The hoist chamber is full of leakage water from the top of upstream concrete plug. The power packs (i.e. Hydraulic hoist, control panels and pumps etc) are fully wet and in moist condition and hence may not be in working condition.

3.3 Observations of POE:

(i) Originally it was planned to operate these gates till the sediment reaches 30m height in front of the bottom Outlet Gates. Accordingly a 30m shaft above the river bed level was constructed to pass the water through these gates. But during construction stage, diversion tunnel (DT-2) gates at the inlet could not be opened and to pass the water through the bottom outlet gates, openings at a height of 10 m were made in the diversion tunnel gates. This would cause accumulation of silt in front of the bottom outlet gates. When the silt level in the reservoir would reach 10 m in front of the diversion tunnel intakes, it will not be possible to operate the gates.

(ii) It is very likely that the silt level might have already reached to 8-10 m in front of the diversion tunnel or is likely to reach in a year or two, and then the gates will become in-operative.

(iii) These gates, in any case have not been designed and cannot be used for emptying the reservoir if the rock fill dam is in distress.

(iv) The points raised in para 3.1 d (i) to (v) of page 4 above will not have any bearing regarding plugging of bottom outlet gates.

(v) There is no provision in this project for emptying the reservoir in case of any emergency.

3.4 Recommendation:

With the existing conditions at site, it is not practicable to make these gates operational.There is no utility of these gates any further, as these gates have served the intended purpose as envisaged. Hence POE recommends to plug these gates permanently.

3.5 Suggested Plugging Operations:

(i) It is suggested that the entire gate/hoisting chambers may be filled with concrete.

(ii) As the present plug is not very effective in arresting the seepage from upstream, it is suggested that a new concrete plug of about 1.5D length with suitable keys may be made on the downstream of the gate chamber. Grouting around this new plug must connect the grout curtain of the main dam.

(iii) To avoid any leakage of water through the connecting tunnel between DT-1 and DT-2, concrete plug may also be provided in this connecting tunnel.

(iv) Final proposal for plugging of the Bottom Outlet gates may be put up to POE for their review.

4.0 Agenda Item 3 :- Protection Works for Plunge Pool Area Including Left and Right Banks.

4.1 Plunge Pool Cavity Filling

It was informed that 2129 m^3 of boulders have been filled in the cavity. 3688 m^3 concreting has been filled in the cavity over boulders. Entire cavity should be filled with concrete.

4.2 Protection of Right Bank of Plunge Pool beyond Cladding

The treatment comprising gabion wall and placement of large size boulders/tetrapods has not yet been started. It is recommended that same may be completed as soon as possible.

To avoid under cutting of toe of the slope, boulders/ tetrapods may be dumped. As the rock is exposed the slope may protected by providing shotcrete with wire mesh. Further, weep holes at suitable intervals may be provided.

4.3 Protection of Left bank of Plunge Pool beyond Cladding

In case of left bank of plunge pool, as recommended, the rock ledge protruding into water way has been removed in order to smoothen the flow downstream of plunge pool.

During the visit, it was reported that the slopes at higher elevation comprising of terrace deposits are failing at certain locations. The left bank exposes phyllites and sheared phyllites up to elevation ranging between 530m and 540m. The bedrock is overlain by thick pile fluvial terrace deposits above that. The slopes in the terrace deposits have been dressed. It is possible that water spray generated due to spillway operation saturates the unconsolidated terrace deposits inducing instability in them.

The follwing steps may be followed :

i) Provide a toe wall, properly designed, resting on the rock.

ii) Make up the slopes in scooped areas by back filling and compacting.

iii) It is recommended that a 3-4m wide bench may be developed on the top of bedrock at its contact with terrace deposits and a toe wall with a surface drain with the provision of directing surface flow away from the slopes be provided. Provide 3-4 m wide berms dovetailing with berms already provided along the left bank cladding wall.

iv) Provide a cunette/drain along the slope face at the toe of the next higher slope and sloped to pass the rain water in to the river. If NTPC desires to provide a pitching on the slopes, banded type pitching is desirable.

v) It is also recommended that the bedrock exposed at lower elevations be covered with shotcrete with wiremesh in case signs of erosion are noticed.

4.4 Concrete Cladding Wall on Right bank of River in front of Plunge Pool

It was observed during the site visit, the treatment suggested to protect the right wall against erosion is in progress. The top of the cladding may be raised as per site conditions. The work may be completed at the earliest.

5.0 Instrumentation

NTPC informed that they are preparing the quaterly report giving date wise observations of different instruments embedded in the Dam & Galleries. Such data was also demonstrated on 19th June. POE advises NTPC to prepare annual analytical report which would be useful.

The annual report may contain the following:

a) A map showing dam sections indicating different materials and their basic propoerties such as density, Liquid Limit (LL), Plastic Limit (PL) etc.
b) A map showing location of instruments, their type and reference numbers.
c) Pore Pressure contours in the dam section.
d) The information about instruments which have become defective or are showing abnormal values along with their reasons be presented.
e) Table showing maximum values of settlement /deformation, pore pressures, seepage along with recommended values and actual values.
f) Principal stress contours.

6.0 Model Study of Plunge Pool

It was informed to POE that model study of plunge pool as recommended by POE has been taken up. The study has been awarded to IRI, Roorkee and model has been prepared and trial run has been conducted.

7.0 Acknowledgment

POE acknowlegdes with gratitude and appreciation Sh. Rajesh Jain, AGM (O&M) and the project staff for nice arrangements and courtesy extended to POE during their visit.

The list of officers who accompanied POE is attached at Annexure-1.

Dr Y P Sharda **Sh M K V Sharma**

Dr R S Varshney
Chairman POE

Inspection Report by Sh. P.L.Narula Ex DDG, GSI and Dr. R.S Varshney, FNAE on the Problem of seepage through Weep Hole at Elevation 531m at Junction 1 (between gallery 3 & 5).

On 13th Aug 2018, NTPC informed Dr. R.S.Varshney over phone about disturbing observations of sediment loaded seepage flow through weep hole at elevation 531m at Junction 1 (between gallery 3 & 5).

At the instance of NTPC Hydro Region to solve this issue, basically a hydro-geological problem, Dr. R S Varshney accompanied by Sh. P.L.Narula reached Koldam Site on 17th Aug' 2018. They inspected the problem site on 18th Aug 2018 in forenoon and had detailed discussions with GM (Koldam) Sh. S.M.Chowdhury and his team after site visit to evaluate the problem of seepage in the gallery no.14 and junction1 of gallery no. 3 & 5 along the dam axis which have been made for providing grout curtain for the earth and rock fill dam (Refer Annexure-1). At the junction of these galleries, heavy water seepage was recorded on the 10th of Aug' 2018. This water seepage was accompanied by carriage of particles. The seepage from this location which is just upstream of the grout curtain is being recorded since long but the carriage of particle was recorded only during heavy rainfall on 10th and 11th Aug when the rainfall was of the order 192 mm in a period of 48 hrs (Refer Annexure-2). The occurrence of muddy water was recorded for a limited period of 4 to 5 days. This seepage water at the time of inspection was quite clear.

In order to assess the reason for emergence of muddy water the data on the grouting efforts, pattern of water seepage, general drainage arrangement and the data obtained from the piezometer records in the vicinity of these galleries was reviewed and following observations are made

1. The cumulative discharge from the gallery no.14, gallery no.3 and gallery no.15 have been of the order of 1750 lpm. After excessive rains on 10th and 11th Aug, the discharge increased to 2200 lpm indicating abutment surcharge for a limited period of time (Refer Annexure-3). The muddy water was recorded only from one hole at the right side wall crown contact. The silt in the seepage water varied from 8000 to 10000 ppm.

   This location is just upstream of the two rows of grout curtain provided through gallery no 3 & 5 on the left abutement of the dam. The junction of the gallery 3 & 5 and gallery 14 is at an elevation of +- 530 m.

   The grouting and drainage arrangement is illustrated in the drawing attached (Refer Annexure-4).The drainage arrangement of the abutment is in the form of radial holes in a circular fashion to a maximum depth of 50m in all the directions. Drainage holes in the downstream of the grout curtain have not been provided in the design and hence not made (Refer Annexure-5).

2. The material carried by seepage water has been collected and sent for chemical analysis by the project authorities. This material is grey in colour and is very fine fraction (clayey). The colour of this material is different from that of the clay core material.
3. A review of limited data of grouting, showed that the permeability of the rock mass generally is of the order of 10 Lugeon and after grouting it was supposed to have been reduced to 3 lugeon or below. The grout intake was very low i.e. of the order of 17 to 31 kg/m (Refer Annexure-6). The seepage which carried muddy water is located upstream of the curtain.
4. During site inspection, the pressure of water was measured which was of the order of 4 kg/ sqcm which when converted, corresponds to 575 m elevation. The pressure during the increase in discharge was not recorded. It is possible that pressure might have been more when muddy water emerged.
5. It was given to understand that in 2015, heavy seepage was recorded when impounding was being carried out. The water jet was fouling with the electrical installations and grouting in the vicinity was carried out to check the inflow which got reduced after grouting.
6. The piezometeric pressures in the piezometers transects B & C, both foundation and embankment type, were reviewed which have given consistent results and the piezometer levels are falling in the downstream directions as expected and no abnormal behaviour was observed (Refer Annexure-7).

The observations made indicate no possibility of connection of the emergence of muddy water with the clay core because of the variation in the colour of the materials. Emergence of this only during heavy rain and its becoming clear after the excessive rains shows no abnormality with the piezometer pressures. The piezometeric heads are constant and the trend corresponds to the reservoir level. This phenomenon cannot be related to piping of the clay core.

However emergence of clay fraction material of grey colour for a limited period of heavy rain, the source of the material is difficult to comprehend. It is suggested that the muddy material collected may be chemically analysed and compared with the chemistry of cement so that relation if any with cement washings from the grouting done in this hole is established.

Dr R S Varshney

Sh. P L Narula

SECOND INSPECTION REPORT BY SH. P.L.NARULA, FORMER D.G.GSI AND DR. R.S.VARSHNEY, F.N.A.E ON HYDRO-GEOLOGICAL PROBLEM OF KOLDAM ON RIVER SUTLEJ, H.P. FROM OCTOBER 2ND TO OCTOBER 5TH, 2018

1. PREAMBLE

Dr R S Varshney and Sh. P L Narula inspected the Koldam site and examined the reservoir rim by boat for an approximate length of 20 km. The spillway bucket area and the distress in the plunge pool area was also examined. Discussions were also held with NTPC Engineers for evaluating possible sources of the muddy water which emerged through a weep hole at Junction 1 of Gallery no. 3 and Gallery no. 5. The observations and suggestions made are briefly given below.

2. SAFETY CONCERNS OF THE DAM

At the top berm of the rock fill dam some cracks are observed on either side of the road in central portion of the dam. The detailed examination of rip rap on either side slopes indicates that the rip-rap big blocks have dislodged and are in the process of adjusting in some stretches. These adjustments in the slope fill material have cracked in the portion which has been cemented at the road sides under the drag of rip-rap adjustments.

This effect is more pronounced on the downstream side because of larger slope heights between top berm and the next berm. In some sections of this slope bulging has also been noticed. (Refer Photographs (1 &2). These adjustments appear to be superficial and are not deep seated. As such there is no stability concern for the dam. It is, however, suggested that the disturbed rip-rap should be properly repacked/packed and the slopes are restored so that adjustment of rip-rap does not take place.

The toe area of the rock fill dam was also inspected. It is seen that the water from the drainage galleries on either abutment is being discharged near the toe with in the body of the Dam. It is suggested that the same may be diverted further downstream clear of the body of the dam. The area where this water is being discharged now should be cleared of bushes and the slopes should be properly dressed and maintained. The dam toe should be cleared and made visible.

The instrumentation data was casually examined and it has been suggested that the same may be plotted on the pattern suggested for detailed assessment.

It is reported that the maximum settlement of the dam of 454 mm was recorded in Beam no. 30 before impoundment while after impoundment it has increased by nearly 13mm. This total settlement is well within the limit of 1% of dam height and as such there is no concern.

The piezometers are also showing a regular and consistent pattern of progressively reducing head in the downstream direction which is as expected.

Photograph 1

The left abutment drainage is generally much more than the right abutment which is 6982 lpm and 4235 lpm respectively. The pattern of seepage has not changed much .

Primafacie the instrumental data and physical examinations of the dam site and vicinity indicates that there was no serious impact of heavy rainfall in the month of September 2018.

3. SLIDES ALONG RIM OF RESERVOIR

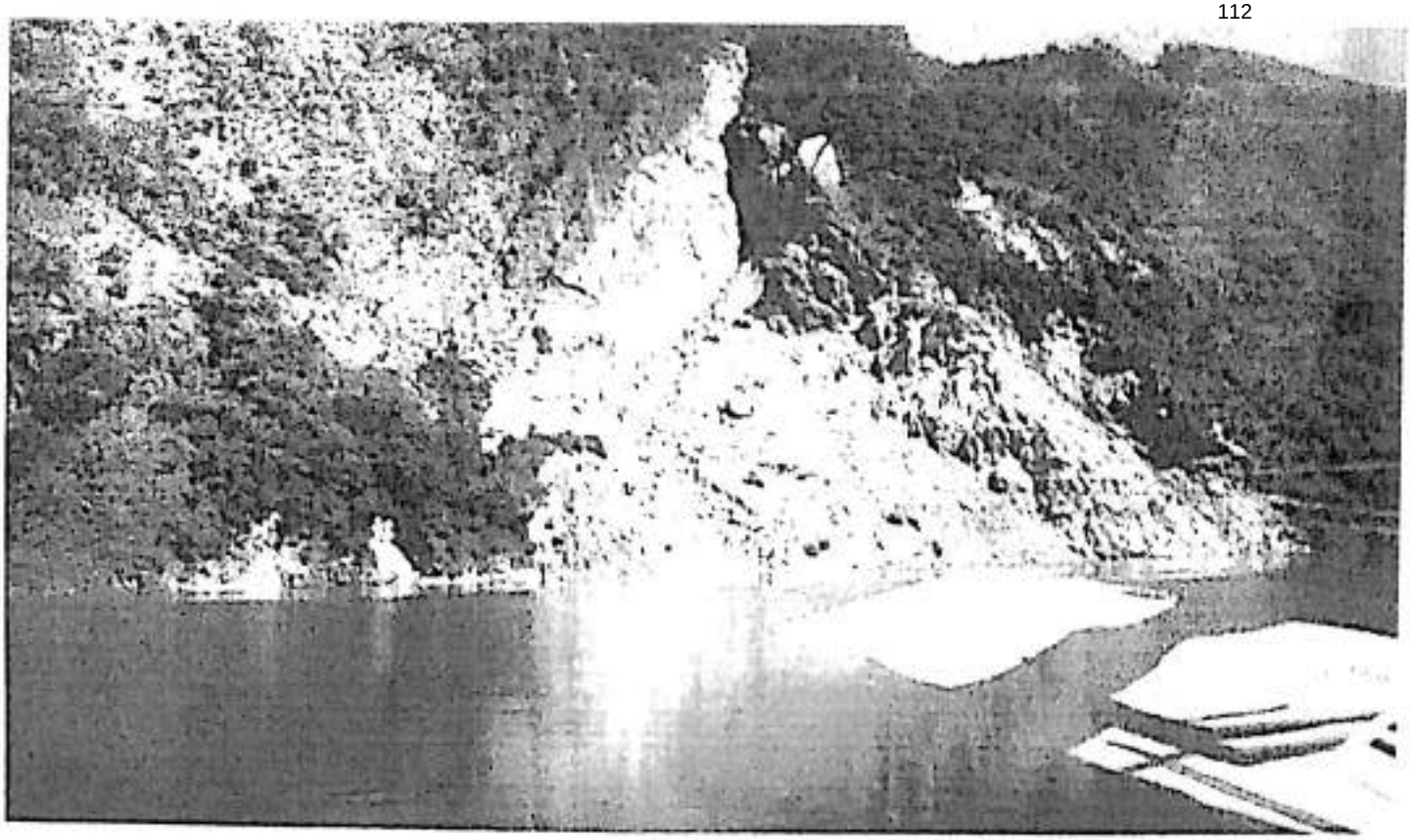
The reservoir rim has been examined for a distance of about 20 km. It is seen that on the left bank side the slopes are quite stable except at one or two locations where minor slides have developed in locations where over burden material was present on steep slopes. Whether these slides were pre-existing or not cannot be ascertained. The right bank slopes are generally stable but dotted with some slides which are primarily related to formation cutting for the road under development. **The PWD may be asked not to dump the excavated material into the reservoir.** It is noted that the villages located on the upslope side near the vicinity of the reservoir are not showing any signs of distress.

A landslide has been seen on the right bank extending up to the reservoir which has developed along a major shear zone (Refer Photograph 3). This location is about 15 km upstream and the Kanthi village is located on the upslope side of this slide at considerable distance and at considerable height (Refer Photograph 4). This landslide is localized and can not affect some houses located on a terrace just upstream of this slide. Generally rock outcrops are seen near the reservoir rim. The distress in the form of slope failures and development of cracks in Kanthi Village could be related to overburden material which might have been initiated by toe cutting along a small nala during heavy precipitation.

It is understood that GSI have investigated this area who have apprehended that the whole slope from reservoir to Kanthi village is under distress because of the reservoir. It is suggested that an independent detailed assessment of the problem may be entrusted to some accredited agency to give their expert opinion whether or not the reservoir water is responsible for the distress in Kanthi village. We feel that there is no connection between the distress in Kanthi village and the reservoir.

4. PLUNGE POOL AREA DOWNSTREAM OF THE FLIP BUCKET

After operation of spillway, damages to the plunge pool area have been reported. The left side concrete cladding placed over the crushed and sheared carbonaceous shales has collapsed and part of the carbonaceous shale is getting eroded. On the right side cladding at the lower levels between levels 494.5 m and 527 m has under cut and swirling currents have created 15 -20m long cavity towards flipbucket and the crushed and sheared rock mass has been washed out. (Refer Annexure 1 & 2) This has resulted in toe erosion of the hill mass on the back slopes. This toe erosion has caused initiation of a slide. The till date evidences of the same were seen in the form of wide cracks along the joints and the perceptible outward movement of the concrete cladding. These cracks have continued in the hill mass behind in the form of peripheral cracks. These cracks have been physically traced upto elevation ± 540m. At this level the cracks become quite wide with slumping evidences.



Photograph 3

The cavities formed below, which had undercut even the hill mass, are being backfilled with mass concrete. This mass concreting has been done upto a level of 517m and another ± 10m has yet to done. Hopefully this mass concrete would provide adequate toe support to the hill mass.
It is suggested that the stability of hill mass in the reach and its vicinity may be checked to establish the adequacy of the toe restraint being provided. Suggestions about other measures have already been given by POE.

It will not be out of place to mention that any retrogression on the back of spillway in front of flip bucket may distress the bucket also. Precautions for the same should be taken.

5. MUDDY WATER SEEPAGE THROUGH THE WEEP HOLE AT JUNCTION 1 OF GALLERY NO. 3 AND GALLERY NO. 5

The pattern of water seepage through the weep hole has not changed significantly. During rains in the month of September 2018 the maximum seepage discharge was of the order of 35 lpm while in August 2018 it was 28 lpm and corresponding maximum rainfall was 58mm & 62mm respectively. Though the discharge through this hole has marginally increased, there is no carriage of particles and clear water is coming.

The material when tested with Hydro Chloric Acid (HCL) has given profuse efflorescence indicating considerable amount of $CaCO_3$. Primafacie the material could be partly from cement grout leaching and or the crushed material along some shear zone in the bed rock.

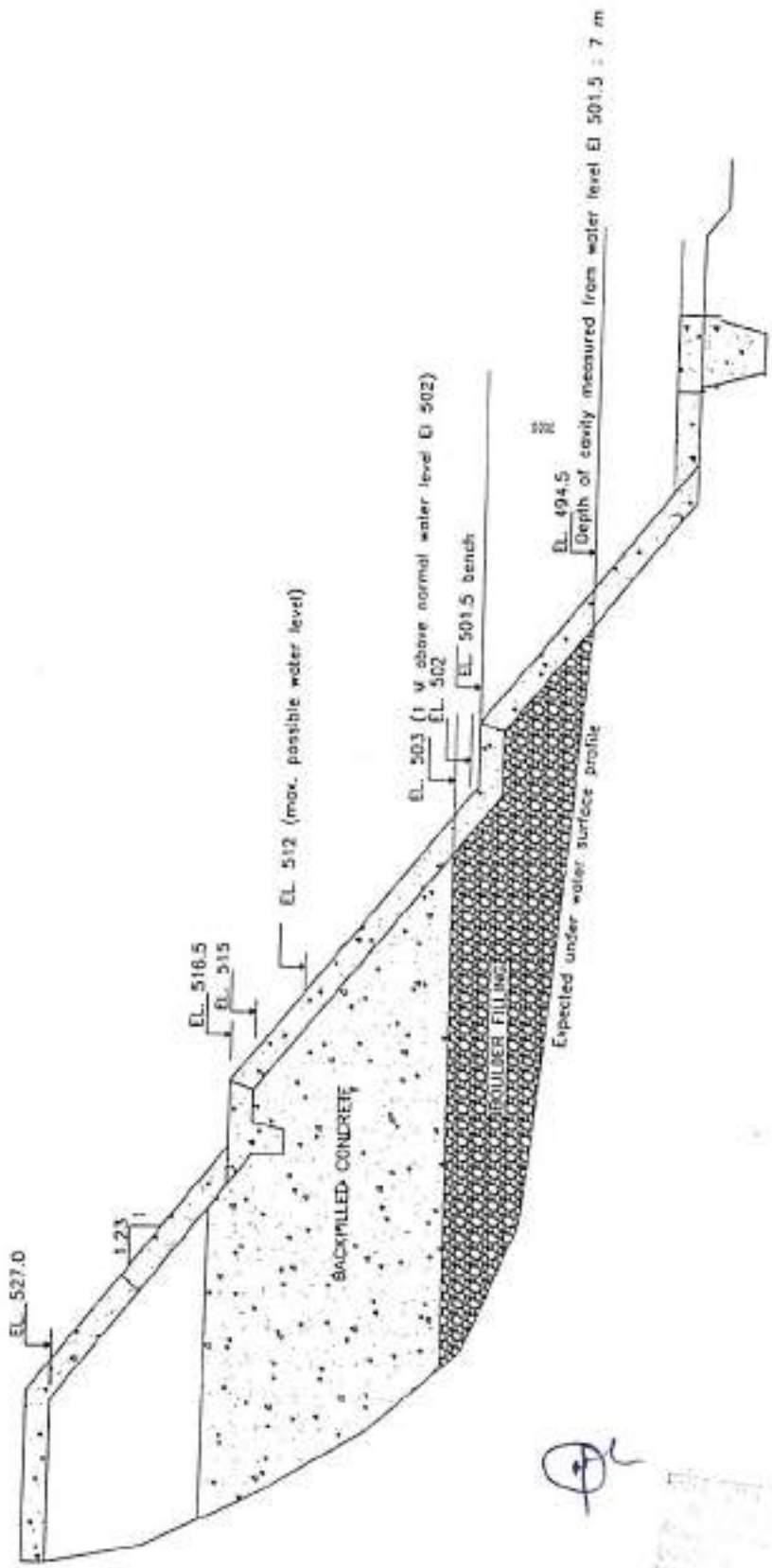
6. ACKNOWLEGDEMENT

Experts express gratitude to Sh. S.M.Chowdhury, GM (Koldam) and his team who accompanied Experts during site inspection and took part in discussions.

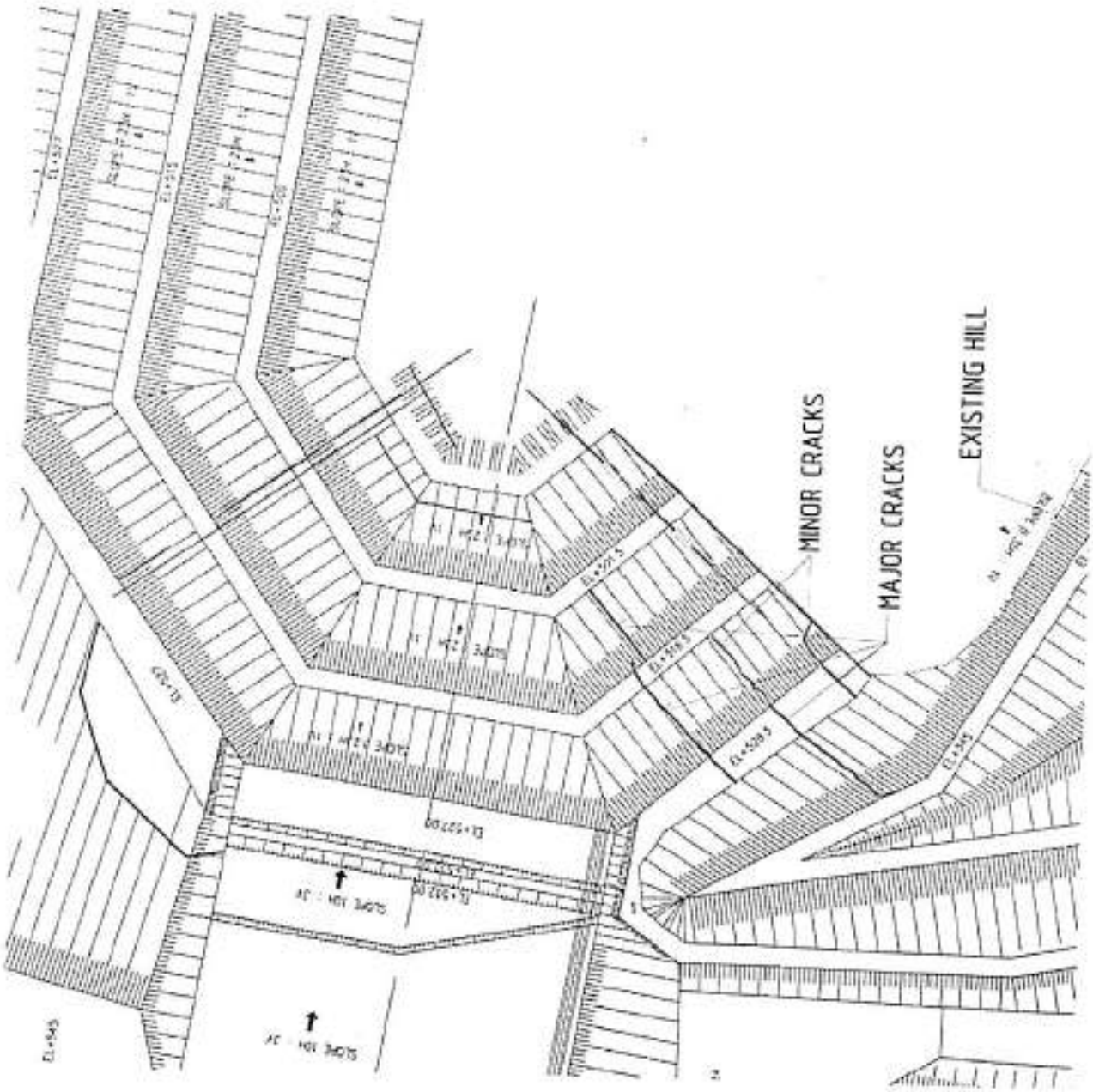
Dr. R S VARSHNEY

4/10/18
Sh. P L NARULA

Annexure - 1



Annexure - 2



POE VISIT TO KOLDAM HEPP FROM 25.06.2019 TO 28.06.2019 FOR THE ISSUE OF FLIP BUCKET

The Project site was visited by POE consisting of Sh. R. Jeyaseelan, Former Chairman CWC and Sh. Gopal Dhawan, Former MD, MECL & ED-NHPC, accompanied by Project representatives and HRHQ officers of NTPC (Annexure-A). The critical issues referred for study were seen at site and detailed discussions were held. After the site visit, General Manager of the Project was appraised about the observations made on the problem identified and the requirement of further drawings and data for analyzing genesis of various types of instabilities and deformation being faced in various components connected with the plunge pool and flip bucket. Project officer have been advised to furnish the following information and drawings/data at the earliest:

a. GEOLOGICAL DATA:

i. Foundation grade geology of plunge pool, flip bucket and spillway be plotted on as built design drawing in 1:1000 scale. The geologist has been advised to plot foliations and all major joint sets, shear zones etc. on the geological map. In addition, all cracks and opening of construction joints, lift joints be also plotted on the geological plan. Further, location of all the bore holes drilled during investigation/ construction/ operation stage be plotted on the geological plan.

ii. Copies of all the drilled holes logs and reports particularly on any geotechnical tests performed in drill holes and drilled cores be provided. While scrutinizing the records provided by NTPC, it came to notice that SPT tests have been conducted in 5 drill holes. Report on SPT test may be provided.

iii. A summary of rock mass parameters (viz rock type, rock strength, orientation of shear zones/ joints with opening, spacing etc. of joints for different litho units such as phyllites, carbonaceous phyllites, basic dyke etc.) from available geological reports and foundation grade maps be prepared. In addition results of rock mechanic testing (UCS, Modulus and shear strength parameters) and plate load testing carried out for assessing bearing capacity for different litho units may be compiled and supplied.

iv. A longitudinal geological section be prepared along centre line of spillway to end of plunge pool.

v. A few geological cross sections are also required to be prepared a) perpendicular to spillway axis (indicated in drawing) and b) along the flip bucket joint (perpendicular to spillway axis).

vi. One cross-section each on the right bank and left bank of plunge pool. These cross-sections shall be perpendicular to the slope of the banks as marked in the drawing.

b. DESIGN/ FIELD DATA

i. Year wise flood peaks observed and used in hydrological studies.
ii. Physical hydrological model study for the chute spillway and plunge pool design.
iii. Plunge pool scour depths computed for various spill discharges, flip flow profile and impingement zone.
iv. Design of the flip bucket block with the forces (static and dynamic) assessed for design.
v. Reservoir operation schedule drawn up (summary).
vi. Tail water rating curve for the outflow from plunge pool.
vii. Topographic map of the plunge pool (extending up to river confluence with the Power house discharge channel) as existing now after the erosion failures that have taken place on both banks.
viii. As constructed drawing of spillway and plunge pool (plan and cross-sections).
ix. The excavation plan showing the bottom level as 470 and 485 in different drawings need to be reconciled and reasons for changing the bottom level from 470 to 485 may be checked up and provided.
x. The bathymetric survey plan along the civil structures superimposed.
xi. All the instrumentation data observed at site for spillway and plunge pool.

c. Since commissioning of the Project, detailed note on the damages which occurred in both the banks and the remedial measures carried out in chronological order.

d. It is understood that layout of spillway arrangement originally planned was modified during construction. A brief note on the need for the changes made and the finalized layout adopted may be provided.

Further, for drawing up the remedial measures, a meeting may be organized at Delhi for discussions with the agency carrying out hydraulic model study and the designers. Report of the panel of experts will be compiled on receipt of the above mentioned additional information/ data/drawings.

Sh. R. Jeyaseelan
Former Chairman
Central Water Commission

Sh. Gopal Dhawan 27/07
Ex Chairman & MD
Mineral Exploration Corporation Ltd.

RECOMMENDATIONS OF POE AFTER THE MEETING HELD ON 01.08.2019 IN RESPECT OF THE ISSUES IN FLIP BUCKET & PLUNGE POOL

POE meeting was convened on 01.08.2019 at EOC , Noida for considering the issue of widening of dilation joint at u/s end of Flip bucket block and distress observed in the cladding of Plunge pool of Koldam HEPP. This meeting is a sequel to site visit of Panel consisting of Sh. R.Jeyaseelan and Dr. Gopal Dhawan in the month of June' 19. Subsequently, information sought by the panel was provided by the Project. It was desired to have a meeting with the Hydro- Engineering group to decide further course of action. Accordingly, this meeting was arranged. This meeting on 01.08.2019, was attended by the POE members namely, Sh. Brijendra Sharma, Sh. R. Jeyaseelan, Dr. Gopal Dhawan and officers from Hydro-Engineering, HRHQ and site given in Annexure-A.

All issues related to flip bucket and plunge pool were discussed and the following recommendations are made:

1. The dilation joints, where the water seal has ruptured, as in the flip bucket be filled with flexible grout to stop seepage of water in the foundation through the joint. The Project in consultation with Hydro-Engineering will decide technical specifications and methodology for executing this work.
2. Cracks are observed in the slope over looking the right bank cladding of the plunge pool. These are wide (up to 30cm) cracks extending deep in the ground. POE is of the view that these be sealed by filling with impervious material with proper compaction at the earliest possible.
3. Logs of two out of the three holes drilled in 2016 indicate possibilities of limited erosion at some locations under the horizontal portions of the apron. It will be prudent to confirm such erosion in the plunge pool area and assess rock conditions below the concrete apron. POE is of the view that additional drill holes will be required around the bottom of plunge pool. Accordingly, the Project has been advised to explore possibilities of drilling additional holes from a barge in the next lean season. Location and number of drill holes will be specified in due course.
4. It is strongly reiterated the spillway operation be strictly operated with a discharge greater than 1000 cumecs so that the nappe impinges beyond the end of sloping concrete cladding/ apron.
5. POE suggested that the hydraulic model study as per existing plunge pool geometry may be carried out with erodible bed and slopes for scouring depth etc. for discharge from 800 to 5000 cumec.
6. Monitoring of the slopes/ concrete cladding in the plunge pool area may be done at site on regular basis by installing survey targets.

1/08/19

(Sh. Brijendra Sharma) (Sh. R.Jeyaseelan) (Dr. Gopal Dhawan)

Annex – F

→ 7. Work shall be carried out as per POE recomandation's. dated 1/8/19.

SN	NAME(S/SH)	DESG	PROJECT	EMAIL	MOBILE NO
1	S.M. Chawdhury	CGM (Koldam)	Koldam	smchawdhury@ntpc.co.in	9650992065
2	R.K. Yadav	GM	PD&M	pkyadav@ntpc.co.in	8894773200
3	M. Bedi	AGM	HRHQ	Manmeetbedi@ntpc.co.in	750040[illegible]
4	N.K. JAIN	AGM	HYDRO-ENGG		
5	VIVEK GUPTA	SR. MGR.	HYDRO ENGG	VIVEKGUPTA@NTPC.CO.IN	9650992072
6	Sumeet Kumar	DGM	PD&M	sumeetkumar@ntpc.co.in	9650992089
7	S.K. Garg	DGM	TS Koldam	surindergarg@ntpc.co.in	9650994599
8	Kapil Meena	Dy. Mgr	Koldam	KAPILMEENA@NTPC.CO.IN	9816850200
9	Rajesh Thakur	Sr. Mgr	Koldam	rajeshthakur@ntpc.co.in	8894773232
10	VIRENDRA KUMAR	SR. MGR	KOLDAM	virendraksingh@ntpc.co.in	9418161328
11	Rakesh Rathee	DGM, C&S	Koldam		7500240405
12	R.K. JAIN	AGM (C&M)	KOLDAM	RAJESHKUMAR08@NTPC.CO.IN	8894773455
13	Vibhu Kaushal	DGM (Civil Engg)	Engg.		
14	D.S. Bist	-do-	Engg.		
15	RAKESH SHARMA	MGR.	ENGG.		7500133888

MINUTES OF THE MEETING OF POE HELD ON 04.12.2019 AT EOC NOIDA FOR THE ISSUE OF FLIP BUCKET AND PLUNGE POOL.

1. Locations of proposed boreholes in the horizontal portion of the apron have been discussed and explained to the site representatives in the meeting. At present, location of 4 boreholes is decided taking into account results of previous drill holes in this area. Locations of new bore holes (to be numbered as **DDH-01 to DDH-04**) is shown on the map and handed over to site representatives. It is expected that after seeing results of the proposed drill holes (**DDH-01 to DDH-04**), some more drilling may be required. Therefore, PoE is of the opinion that provision for a couple of additional drill holes be kept while finalizing the scope of work/ BoQ of drilling Contract.
   It is recommended to drill all the proposed drill holes down to EL-465m. However, if any cavity or sand lens occurs in between EL-470 to 465, the drill hole will be extended 5m below sand lens/ cavity.

2. PoE discussed the issue of widening of flip bucket joints and erosion of plunge pool area. PoE feels that it needs to understand the behavior of movement of plunge pool including spillway holistically. For this purpose, PoE had given definite recommendations in the previous meetings for carrying out certain investigations. Accordingly, results of these investigations be presented to PoE. As such, issue of suggesting Geo-Technical agencies is considered premature.

(Sh. Brijendra Sharma) (Sh. R.Jeyaseelan) (Dr. Gopal Dhawan) 4/12/19

DATE: 20.02.2020

REPORT OF THE MEETING OF THE PANEL OF EXPERTS (POE) AT KOLDAM FROM 18.02.2020 TO 20.02.2020

1. PREAMBLE

Following members comprising Panel of Experts Koldam site from 18.02.2020 to 20.02.2020:

Dr. Gopal Dhawan

Mr. Balraj Joshi

NTPC presented agenda notes to PoE containing the following issues for suggestion and recommendations:

i. *Plugging of DT-1.*
ii. *Plugging of bottom outlet in DT-2.*
iii. *Reviewing the flip bucket joint widening.*

The list of officers of NTPC who accompanied during the site visit is attached as **Annexure-A**.

2. AGENDA POINT NO.1: *Plugging of DT-1.*

2.1 Issue:

a. Suggestion/ Recommendation for plugging the 300NB dia valve.
b. Suggestion/ Recommendation for concreting the gallery in the plug.
c. Suggestion/ Recommendation for grouting the 800/900 mm dia pipes.

2.2 Site Visit and Observations of PoE:

POE along with the Project Officers visited the DT-1 on 19.02.2020 and the following were observed:

a. Seepage through the plug gallery was observed. It appears that the leakage is through the damaged seal of the 300NB dia valve.

b. Heavy seepage through a hole in the crown portion of the DT-1 was observed.

c. Seepage through the connecting gallery (between DT-1 and DT-2) was also observed. It appears that the seepage from the DT-2 and through the rock is flowing through the drainage gallery into DT-1.

d. At present discharge from all the leakages and seepages seems to be to the tune of approximately 0.5 to 1 cumec in DT-1.

2.3 Recommendations/ Suggestions from PoE:

a. The plug gallery existing in the bottom portion of the half plug (balance portion) be concreted as per the methodology proposed and explained by site envisaging channelization of the water through a pipe fitted with suitable valve. The inlet end of this pipe can then be suitable concreted to confine the flow in this newly laid extended pipe. The decision to close the valve and completely seal the water can be taken in due course of time by site.

b. Boulders/ geo bags to be dumped on the inlet gates area as a trial to close the leakage from the inlet gate, using a barge, may be explored.

c. In the crown portion (above the half plug) trial grout through minimum 5 no.s of 5m length holes, 45mm dia may be done. The grouting pressure should not exceed more than 10 bars. The effect of this grouting on the discharge through the crown pipe as well as pipe on the left wall may be monitored and recorded. The grouting results shall be put up before the PoE.

d. *As recommended in 14th PoE report, arrangement for diverting the water from the crown hole along the wall may be carried out by site.*

3. AGENDA POINT NO.2: *Bottom outlet plugging(DT-2).*

3.1 Issue

a. Suggestion/ recommendation for making plug at a distance of approximately 100m d/s from the existing Bottom outlet radial gates (BORG).

3.2 Site visit and observations of PoE:

POE along with the Project Officers visited the DT-2 on 20.02.2020 and the following were observed:

a. It has been observed that water is gushing through the contact/ junction near the crown between the concrete plug and lining. Part of this inflow is flowing through the connecting tunnel/ gallery (between DT-1 and DT-2) and the remaining through the gate operation chamber in to the bottom outlets of DT-2 plug & over the bench at EL-515.20m.
b. Additionally, water is also leaking through the radial gates, however, the extent of leakage through the seals or sides of the radial gate could not be ascertained due to flow of the deflected water over the radial gates.
c. PoE observed approximately 01 feet thick silt on the bench at EL-515.20m.
d. As recorded in the 18th PoE meeting in June 2018, the gate cannot be made operational. It is also noted that it has served its intended purpose.

3.3 Recommendations/ Suggestions from PoE:

a. The water gushing through the contact (between lining and plug concrete) shall be diverted in to the connecting gallery and the area shall be cleaned (hydro-mechanical mechanism, electrical panels etc. lying on the bench should be preferably removed to create working space/ front).
b. The muck lying in front of DT-2 outlet shall be removed and the water should be allowed to flow freely. The extent of this water/ discharge shall be measured.

c. *The decision to construct the plug at the designed location or downstream shall be taken considering the constructability as per the site conditions.*

4. AGENDA POINT NO.3: Review of flip bucket joint widening

4.1 Issue:

Suggestion/ Recommendation of POE to find out the cause and mitigation measures for widening of the flip bucket.

4.2 Site visit and observation of POE:

POE along with the Project Officers visited the flip bucket on 19.02.2020 and the following were observed:

a. As suggested By PoE earlier, site has sealed the dilation joint with flexible material which has been observed to be effective in arresting the seepage through the dilation joint.
b. A crack of about 2 to 3mm thickness was also observed on the surface of the chute i.e. extending along the centerline between module no.20 & 26.
c. The readings of Vinchon apparatus were also presented before the PoE. The copy of the same is attached as Annexure-B. It can be seen that the dilation is showing increase in X-direction

4.3 Recommendations/ Suggestions from PoE:

a. PoE suggested to drill 3 no.s of additional exploratory holes from the bench at EL-516.5 at the downstream of the flip bucket at the indicated locations. The holes shall be drilled up to the depth of EL-470m. Possibility of monitoring these drill holes using inclinometer may be explored.
b. In order to ascertain the depth of the crack in the chute or presence of extent of any cavity a GPR survey may be carried out. Possibility of doing tomography studies in conjunction with GPR may be explored.

c. Regular monitoring of the targets established on the slopes and flip bucket may be carried out.
d. Electronic Vinchon apparatus may be installed on the guide walls at the dilation joint and the junction of the flip bucket and cladding wall and monitored.

(Mr. Balraj Joshi)

(Dr. Gopal Dhawan) 20/2/2020

10.09.2020

MINUTES OF THE MEETING OF POE HELD ON 08.09.2020 FOR THE ISSUE OF FLIP BUCKET AND PLUNGE POOL OF KOLDAM HEPP

1. PREAMBLE

Following members comprising Panel of Experts (PoE) had a meeting on 08.09.2020 through Video Conference with NTPC officers from Koldam site and the Corporate office.

Dr. Gopal Dhawan
Sh. V.K. Gupta
Sh. Balraj Joshi

NTPC presented agenda notes to PoE and appraised about the recent developments and observations at site.

The Vinchon readings were presented to POE for the current season. The reading showed that in the current season, the dilation joint, during the spillway operation has expanded by about 109.24 mm along left wall and by 44.40mm along the right wall in the X-direction (i.e. along the flow). The Vinchon apparatus are installed at EL-535.40m on the left wall and at EL-535.79m on the right wall.

It was appraised that the previous recommendations of PoE regarding GPR survey, Borehole data, WPT/ Groutability test etc. is in the process or likely to be taken up shortly and the reports shall be submitted by the end of this month for perusal.

The Vinchon readings were shown which showed substantial opening of the flip bucket joint in the current season and accordingly NTPC presented for consideration of POE some stabilization measures to prevent further opening of the dilation joint to ensure smooth operation of the spillway in the next season.

Accordingly, various alternatives submitted by the site were deliberated and discussed with POE. The discussion on the measures was in light of the requirement of firming up necessary measures so that the same could be taken up in this season after observing all codal formalities. The results of the on-going investigations & final recommendations of POE after reviewing results of investigations, will be incorporated before finalizing the tenders.

The discussion and Panel's recommendations are as follows:

A. Cable anchors:

The schemes proposed by NTPC are attached at the end of the report.

Alternative-1: Cable anchors up to basic dyke with average length of anchors about 100m.

Alternative-2: Cable Anchors be placed with end anchorage in Phyllite rock mass

Alternative-3: Cable anchors to open blocks.

10.09.2020

POE suggested that:

a) It would be beneficial to provide cable anchors as immediate support to the flip bucket block, however the same may be discussed in details with some expert agency who can design and install the anchors. After discussion the anchors may be planned accordingly.
b) Need to evaluate strength parameters of Phyllite (upstream of Basic Dyke) to consider possibility of anchoring cable anchors.
c) The POE is of the view that taking horizontal load from the piles doesn't seem to be a workable solution and as such they cannot comment on such scheme at the moment.
d) Need to study possibility of providing high tensile holding down anchors (Dywidag or similar) in the bucket at an appropriate designed angle.

B. Grouting:

It emerged during detailed discussions that the entire rock mass needs to be grouted and the same should be decided after the availability of WPT/ Lugeon value and groutability tests. PoE desired that the records of grouting done during construction of the project, in various types of rock types can enable a considered decision on various grout parameters. Such data may be presented. However, on NTPC's insistence, to speed up the tendering process, it was opined that a scheme would be prepared for grouting the entire rock mass by NTPC and various parameters/items required during the grouting process may be kept in the tender specifications. The scheme may be discussed in detail with POE along with the WPT results of at least one hole (preferably EL-528m hole) recommended by PoE.

C. Toe strengthening- Piling:

NTPC has proposed toe strengthening with RCC piles at El 516/500M going up to El 480/475M. POE is of the opinion that Piles may not provide the required lateral support. However, NTPC may explore further in consultation with some Geo-tech expert agencies to ascertain the practicability and effectiveness of piles in such conditions. Further, if the suggested investigation holes encounter large scour cavity/cavities at or near the toe-levels, the same shall require to be filled up preferably by dewatering of the plunge pool by way of constructing a dyke to block the flow from TRT against inundation of the plunge pool pit. A conceptual scheme in this regard may be studied by NTPC.

D. Balance Investigations (As already recommended by POE)

i. Four drill holes earlier recommended by POE in Dec-2019 at EL 489m (one hole) & El 486m (three holes) with Water Pressure/ Lugeon tests.
ii. Two drill holes- One each at EL 528m & El 516.5m recommended by POE in Aug-2020 with WTP/ Lugeon test and Groutability Tests.
iii. GPR Survey by NIRM (Feb-2020)
iv. Fresh Topographical Surveys for entire spillway & Plunge Pool area (August-2020)

10.09.2020

E. Further, in addition to the previous/ above-mentioned recommendations, it's recommended:

a. To update the geological plan on new topographical map by marking cracks, foliation and other details on the geological plan for an overall view. Outcrops on both sides of spillway & plunge pool are also be plotted on updated geological plan. Fresh geological sections along centerline & flanks of spillway to be prepared.

b. To drill two boreholes (along with WPT/ Lugeon test) of approximately 30 to 40m depth through the Phyllites (upstream of Basic dyke). It is suggested that few core samples recovered from all the recommended holes (including previous recommended) may be tested for their mechanical properties like modulus, compressive strength, tensile strength, shear strength parameters etc. in order to ascertain the rock mass parameters for exploring the possibility of cable anchors or any other alternative.

c. To fill the voids/ gap, if any, beneath the slope of the right bank cladding wall.

It is necessary that recommended investigations be completed expeditiously for incorporating the results in the tender, after due appraisal thereof by POE as discussed during this meeting. The works shall be planned to be implemented during ensuing working season in plunge pool and Flip Bucket area.

(Dr. Gopal Dhawan) (Sh. V.K.Gupta) (Sh. Balraj Joshi)

MINUTES OF THE MEETING OF POE HELD ON 12.10.2020 AND 19.10.2020 FOR THE ISSUE OF FLIP BUCKET AND PLUNGE POOL OF KOLDAM HEPP

1. PREAMBLE

Following members comprising Panel of Experts (PoE) had meetings on 12.10.2020 and 19.10.2020 through Video Conference with NTPC officers from Koldam site and the Corporate office:

Dr. Gopal Dhawan
Sh. V.K. Gupta
Sh. Balraj Joshi

NTPC presented agenda notes to PoE and appraised the following and sought advice:

a. Geological logs of bore-holes drilled at EL-528 and EL-516m,
b. GPR survey report (draft) submitted by NIRM,
c. Proposal for grouting the mase beneath and around flip bucket and plunge pool cladding between El-516 and EL-528m,
d. Proposal for cable anchoring to support flip bucket,
e. Proposal for piling to strengthen toe.

NTPC also submitted ATR for PoE's perusal w.r.t. the previous recommendations issued regarding plunge pool and flip bucket.

Accordingly, the submitted data & proposals submitted by NTPC was deliberated and discussed with POE. The discussion and recommendations are as follows:

I. CABLE ANCHORS:

a. NTPC submitted a scheme wherein they had proposed to hold the Flip Bucket by providing Cable anchors to stop further downstream movement of block. The Flip Bucket block is 17mx60mx7m (LxWxH).
b. NTPC mentioned that as per the design report, the hydrostatic pressure on Flip Bucket is 5T/m² at SPF of 11400 cumecs and 1 T/m² at 3500 cumecs flow. Further, the hydrodynamic pressure exerted by water jet is 32 T/m² at SPF and 10 T/m² at 3500 cumecs flow. The total force due to above pressure has been worked out as 42600 T and 12500 T for the two cases respectively. However, considering the Horizontal component of the force, the total horizontal force corresponding to 11400 cumecs flow comes out to be about 6900 T. Further, the horizontal force corresponding to 5000 Cumec comes to 2700T. The details have been included in the memorandum submitted to PoE.

21.10.2020

c. In view of the above, NTPC proposed 60-70 number cable anchors of 100 T design capacity, about 60m deep, with a spacing of 3m c/c staggered on d/s face of Flip Bucket. The rock anchors shall be installed at an angle of 20 degrees from the face of the flip bucket.

II. GROUTING:

a. As per PoE's recommendations, permeability tests were done through the holes at EL-528 (WPT-1) and EL-516.5m (WPT-2). Observed values are 5-28 lugeons for a depth of around 24 m from the surface in WPT-1 and 23-38 lugeons between 19 to 37m depth from surface in WPT-2.

b. Based on the WPT test results, NTPC proposed to carry out the consolidation grouting, in the rock mass beneath and around the flip bucket and cladding wall.

POE's recommendations:

i. Keeping in view the site constraints in providing the larger length of anchors for anchoring the cable anchors in the upstream basic dyke, the anchors have to be anchored in the weak Phyllite, which is said to require a length of about 60 m.

ii. Since the capacity of the anchors is dependent on the rock strength, the rock mechanics tests on the cores from the investigation hole being drilled, is to be accorded the highest priority. The reports obtained from the geo-mechanical testing of the samples may be submitted to the PoE at the earliest. If the core testing is going to be delayed, a few sample blocks of carbonaceous Phyllite may be supplied to the testing agency from available outcrops for evaluation of mechanical properties.

iii. Considering that the cables shall have to be tied in weak Phyllite rock, it would be advisable to reduce the capacity of the anchors to say 60T anchors so as to avoid stressing the weaker Phyllite rock. The anchors shall be installed in accordance with the manufacturer's recommendation to utilize the full capacity of the anchors at the time of design loading.

iv. The number of anchors and the length shall be firmed up by NTPC in view of (i) and (ii). The anchors shall be spread evenly on the downstream face of the bucket.

v. PoE principally agrees for grouting of the area and suggests to start preparatory works keeping in mind the available dry season window.

vi. Possibility and scheme to grout the mass from the existing gallery may be explored by NTPC so as to consolidate the rock mass meant to receive anchorages.

vii. The angle of the grout holes from the cladding wall (between EL-528 and EL-516m) may be adjusted in such manner, so-that the same can grout the mass below the flip bucket to the extent possible.

viii. In absence of grout-ability test data, the proposed holes shall be drilled @ 4m X 4m c/c spacing. If required additional grouting to be done @ 2 m X 2 m based on the grout intake in the area. The depth of the holes shall be preferably 30m or as per site condition/ requirement.

ix. The sequence of the grouting shall be:

a. Grouting through the vertical holes proposed from the bench at EL-516.5m and simultaneously grouting through the gallery,

b. Grouting from the inclined cladding (d/s of flip bucket) between EL-528 and EL-516.5m starting from both the ends so as to confine the area,

c. Grouting through the Vertical holes proposed from the bench at EL-528m starting from both the ends so as to confine the area.

x. The grouting pressure should be kept low so as not to damage the rock mass preferably not exceeding 5 bars.

III. GPR SURVEY:

The report of the GPR survey was discussed in detail in presence of the NIRM representative. It is noted that as per the NIRM's report, the output of the GPR survey is based on the variation in conductivity and the dielectric constant of the rocks. It emerged from the report and the discussions that the anomalies indicated in the report are not conclusive and required to be correlated with actual site geological data to understand actual nature and type of anomalies. PoE advised NTPC to get correlation done in coordination with NIRM. NIRM agreed to review their interpretation. POE

21.10.2020

further advised to supplement NIRM report with cross hole tomography (say two lines) using already suggested holes and if required new holes.

IV. TOE EROSION AND SLOPE STABILITY

As advised in the previous PoE, the possibility to dewater the plunge pool for examining the toe thereof shall be seriously looked at by NTPC, since prima facie, that is the trigger for the movement in the plunge pool slope. In order to confirm the scour below the cladding, PoE had already advised 4 investigation holes last year. The same should be carried out expeditiously and a scheme to dewater the plunge pool and fill up the cavities, should be presented to PoE.

PoE advised to carry out global slope stability analysis of the plunge pool slope. The model should simulate the cracks observed so far after doing a detailed crack mapping and calibrate the model accordingly.

V. The geological plan as discussed in the meeting may be updated and submitted to the PoE at the earliest. The borehole logs, WPT and grout test reports for the balance holes may also be submitted to the PoE.

VI. Survey of spillway glacis as advised by PoE earlier be submitted.

(Dr. Gopel Dhawan) 29/10/20 (Sh. V.K.Gupta) (Sh. Balraj Joshi)

02.07.2021

MINUTES OF THE MEETING OF POE HELD ON 30.06.2021 & 02.07.21 FOR THE ISSUE OF FLIP BUCKET AND PLUNGE POOL OF KOLDAM HEPP

1. PREAMBLE

Following members comprising Panel of Experts (PoE) had meetings on 30.06.2021 & 02.07.21 through Video Conference with NTPC officers from Koldam site and the Corporate office. List of NTPC officers present during the discussions is appended with MoM.

Dr. Gopal Dhawan
Sh. V.K. Gupta
Sh. Balraj Joshi

NTPC presented agenda note to PoE (Annexure-I) and further apprised about the status of ongoing mitigation/ strengthening works as suggested by PoE earlier.

Advice was sought from PoE on the following:

I. PoE observations regarding exploratory holes carried out till date

II. PoE observations on the grouting carried out

III. PoE advice on the pre-stressing load on Cable anchors being provided at Flip Bucket

IV. Review of the proposal to dewater/empty the plunge pool

Accordingly, the submitted data & proposals submitted by NTPC was deliberated and discussed with POE. The seriatim discussion and recommendations are as follows:

I. Observations on the exploratory holes carried out till date.

(i) The data presented in various annexures with the agenda note shows a mismatch between the nomenclature of the new holes and those done earlier.

(ii) Further some aberrations were also observed with reference to the logging of the holes vis-à-vis geological plan.

(iii) Geo-mechanical testing has been got done through NIT Hamirpur, apparently on cores from bore holes. However, the nomenclature of the hole(s), whose cores have been used as samples was not clear.

(iv) The NTPC geology team would look into these and shall update the plan and the logs as advised during the meeting.

II. GROUTING:

a. Discussion:

i. NTPC submitted details of the grouting campaign as carried out at site.

ii. Observed grout intake in various holes was also submitted. The data shows that grout intake in vertical holes at El 516.0m and El 528.0m was 579 Kg & 544 Kg per m length of drilled hole respectively. Grout intake in other holes was 102 Kg – 282 Kg per m length of drilled hole.

b. Recommendation:

i. PoE is of the opinion that based on the available grouting records, detailed analysis may be done for correlating the grout intake with the geology.

ii. Core drilling (About 10 holes) be carried out in some of the grouted areas to evaluate success of grouting. Further, cores be also tested for Geo-mechanical properties.

iii. PoE also advised NTPC regarding corrections needed in the logs of the drilled holes.

iv. Above data & analysis be submitted to PoE for further review.

III. CABLE ANCHORS:

a. Discussion:

i. NTPC informed that 60m long (with 12m fixed end) 60T anchors are being installed. Anchors have been uniformly distributed on d/s face of spillway bucket.

ii. NTPC informed that as per the test results, following elongation of free length of the tendons has been observed during stressing:

S. no.	Load (in Tonne)	Elongation (in mm)
1	22	58
2	40	110
3	66	180
4	82	220

iii. NTPC Site informed that already 13 anchors (located towards right end of the bucket) have been locked at 66 T load and another 7 anchors have been stressed to 22T (but not locked). It was also informed that before the spillway operation in this season, a total of 40 anchors can be completed.

iv. NTPC informed that a total force of 1870 T is expected during the spillway operation with discharge of 3000 cumec. Thus, considering installation / stressing of 40 cable anchor, each anchor shall be subjected to a force of about 47T.

b. **Recommendation:**

Based on the data submitted and various deliberations, PoE advised as under:

i. As per earlier meeting, NTPC was advised to get engineering properties of rock mass falling in cable anchorage area. The NITH test report as submitted by NTPC indicates rock type as Dyke material which is at variance from the geological details (logs & Geological Plan) as shared by NTPC. NTPC geology team needs to reconcile the details.

ii. PoE advise to lock the cable anchors at approx. 30T, leaving balance capacity for stressing during spillway operation.

ii. PoE requested NTPC to share updated observed displacement data of spillway training walls and also advised to establish few observation targets on wall (both side of dilation joint) and movement/ displacement of these points be regularly observed from permanent stations.

02.07.2021

IV. PLUNGE POOL DEWATERING:

a. Discussion:

i. NTPC Site presented various alternatives for emptying the plunge pool for inspection and undertaking strengthening measures along with the anticipated time schedule (around 12 months) for various alternatives.

b. Recommendation:

i. PoE opined that working time period needs to be considered 7-8 months only and resources need to be planned accordingly.

ii. Plunge Pool isolation dyke shall be required to be dismantled after completion of work and needs to be planned accordingly.

iii. Proposed provision of concrete blocks needs to be relooked.

iv. Further detailing of proposal is required and discussed with PoE.

v. The scheme for evacuating the plunge pool should be kept readily available so as to execute the same in next working season depending on the deformations observed in this monsoon season

(Dr. Gopal Dhawan) (Sh. V.K. Gupta) (Sh. Balraj Joshi)

Date: 27.08.2022

Minutes of the meeting of POE through Video Conferencing on16.08.2022 and subsequent site visit from21.08.2022 to 24.08.2022 in respect of the issue of Flip Bucket and Plunge Pool of Koldam HEP.

1. PREAMBLE

Following members of Panel of Experts (PoE) had a meeting on 16.08.2022 over video conferencing and further physical meeting on 27.08.2022 (after site visit from 21.08.22 to 24.08.22):
Sh. R Jeyaseelan
Dr. Gopal Dhawan
Sh. V.K.Gupta

NTPC brought out that huge cracks have developed at the bottom of flip bucket of the spillway and adjoining area during the operation of spillway during this monsoon season. It was reported that flip bucket end is separated from the sloping plunge pool cladding along a continuous crack at El +/- 528 m and the gap along this crack ranges between 1 to 2m. This crack extends beyond plunge pool in the surrounding rock mass on both sides. The site officers have given to understand that this widening of the gap has happened suddenly on 16.08.2022. Photographs of the cracks and surrounding areas of spillway were shown to POE during video conferencing. In view of the critical situation, it was requested that POE may visit the Koldam site at the earliest

Accordingly following members visited Koldam site from 21-24 Aug 2022.
Sh. R Jeyaseelan
Dr. Gopal Dhawan
Sh. V K Gupta, could not be a part of site visit team, but participated in the PoE meeting held at Koldam on 23.08.2022 through video conferencing. After the site visit, the members had meeting on 27.08.2022 at NTPC's office at EOC Noida.

List of NTPC officials who participated in the meeting is placed at Annexure-1.

POE members visited the site on 22 & 23 Aug 2022 and inspected the flip bucket, plunge pool cladding, spillway gallery, right & left slopes of plunge pool and surrounding area. The spillway in operation was witnessed on 23.08.22.

2. BACKGROUND & SITE OBSERVATIONS:

The Flip Bucket & Plunge Pool of Chute spillway at Koldam has been experiencing some distress since few years which are being manifested by way of widening of construction joints and development of cracks in plunge pool cladding and surrounding area. This is under discussion since 2018 and requisite investigations are being carried out by the project on the advice of POE to evolve long term remedial measures.

After installation of 60 m long cable anchors, the rate of widening of gap of upstream vertical joint of flip bucket block of the spillway, which is being monitored through vinchon apparatus.

Date: 27.08.2022

has reduced. The summary of vinchon apparatus readings in form of deformation/joint widening in mm till 23rd Aug 2022 is tahulated below:

Table 1 :Vinchon Readings as provided by the Project

Vinchon Apparatus no / Elevation	Axis	Cumm Before Monsoon Year 2018	During Monsoon 2018	During Non Monsoon 2018-19	During Monsoon 2019	During Non Monsoon 2019-20	During Monsoon 2020	During Non Monsoon 2020-21	During Monsoon 2021	During Non Monsoon 2021-22	During Monsoon 2022 (Upto 23 Aug. 2022)	Cumm
RV6 (Right wall)	R86 X	19.71	3.32	4.96	5.1	-2.2	43.64	12.52	19.44	0.1	20.5	127.29
	R86 Y	-2.19	-0.17	2.42	0.25	6.64	9.13	3.16	1.85	0.37	8.99	23.61
	R86 Z	1.28	2.76	4.34	3.13	-1.77	22.13	7.55	8.22	1.56	4.31	50.53
LV6 (left wall/ 535.92	L86 X	20.43	5.06	9.63	6.34	-0.22	108.89	20.16	44.2	3.48	55.47	266.48
	L86 Y	3.37	1.26	3.56	1.03	3.12	1.65	2.46	-0.87	2.3	12.95	30.89
	L86 Z	2.03	1.36	2.45	2.81	-1.7	28.88	0.61	8.22	-0.74	14.28	58.7

The crack at the bottom of the flip bucket has widened appreciably during this season and extended in the ground on both sides of flip bucket. On the left side of the flip bucket, the crack is widest (around 2m) and further it has followed the construction joints of the plunge pool cladding & bucket bottom and finally merged with the rock surface on right bank. Differential movement in vertical direction has also been observed in the cladding. The trend indicates

(a) Lateral shift/ rotational movement of bucket as indicated by higher values of movement of LV6 as compared to RV6

(b) Downward movement of cladding due to cavities & scouring that might have taken place below and d/s of the key.

On the right side of the flip bucket the crack width is in the range of 0.5m to 1m and it had traversed up to the adjoining hill top and merged with the exposed rock surface after that.

Widening of construction joints in cladding at EL 516 m bench and adjoining slopes have been observed. Longitudinal and perpendicular cracks in the cladding have been observed in both left and right sides above water level of EL 506 m. Bulging has also been observed in the cladding below EL 516 m bench (at El ± 510 m). Right end of cladding below EL 501m has been plugged by concrete whereas on left side end of the cladding is still open/ untreated. Further, both sides cladding has not been connected to existing rock by provision of flare/ wing wall which will be required.

Moreover, downstream of the end face of the existing cladded slopes, rock has been washed out completely on both the sides, and hence this mass tends to move towards downstream and the cracks widening.

Opening of cracks and joints are shown in Fig.1

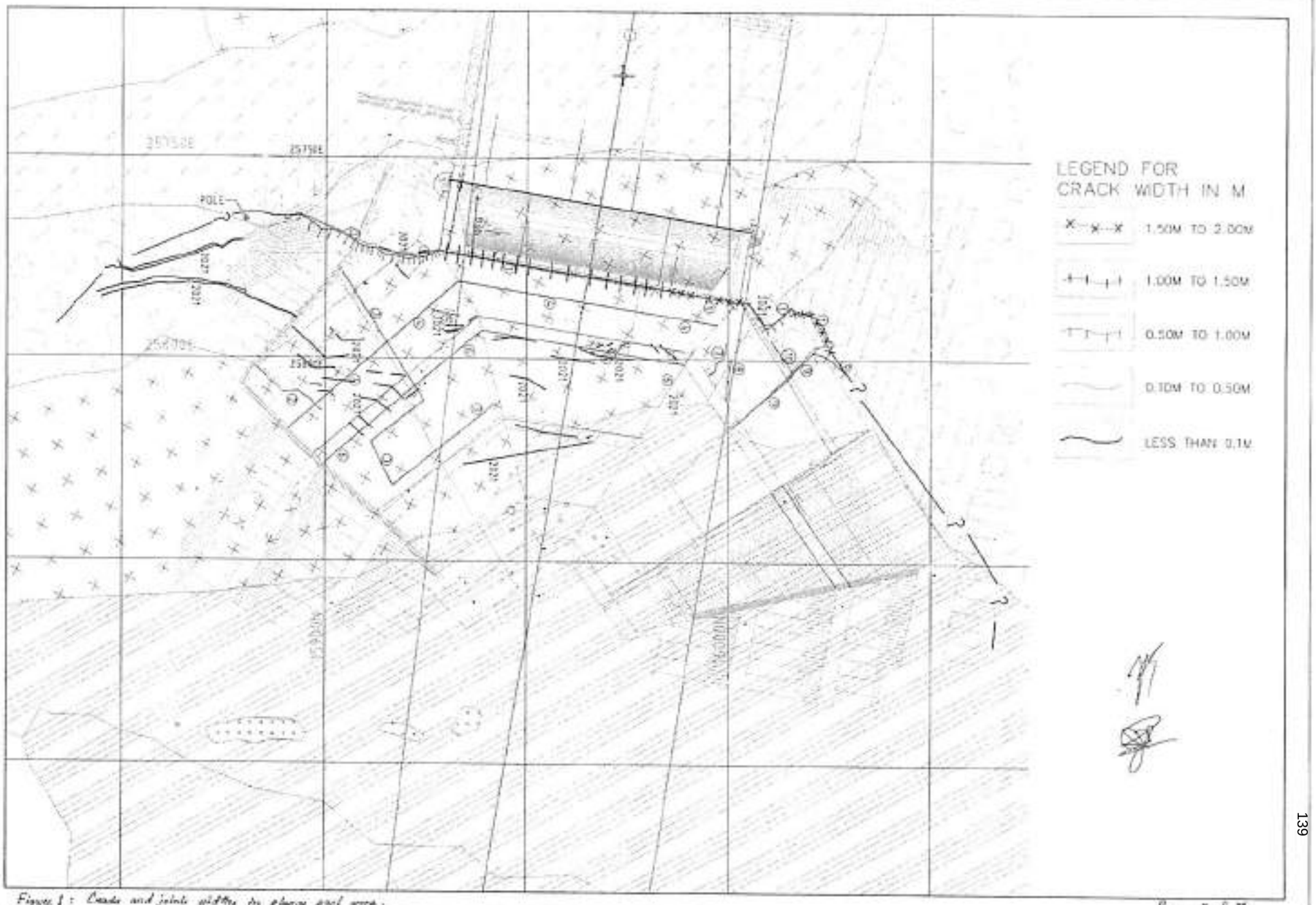


Figure 1 : Cracks and joints widths in plunge pool area.

Page - 3 of 7

Date: 27.08.2022

3. Current status of support measures executed at site as per earlier POE recommendations dated 16.09.2021 is as below:

1. 73 number of 60 m long cable anchors have been installed in the flip bucket.
2. First stage consolidation grouting has been completed below and around flip bucket from benches at EL 516 M & EL 528 M and from the spillway gallery. The second stage consolidation grouting and grouting in remaining portion of plunge pool (below EL 516 M) is yet to be carried out.
3. In the last PoE meeting in Sept 2021, 2D FEM analysis of cladding slope as carried out by NTPC was deliberated. Analysis showed slope as stable. Accordingly, NTPC was advised to provide 32mm dia12m long grouted rock anchors on sloping cladding between El 501m to 528m @ 2m c/c. However, these anchors are not installed as yet.
4. In the last meeting PoE had also advised to carry out 3D analysis of Plunge Pool slopes. NTPC informed that 3D FEM studies have been awarded to NIRM Bangalore and results shall be shared with PoE after receiving the report.
5. Further, the recommended secant piling and drainage holes in the plunge pool cladding suggested earlier could not be executed as yet.
6. In the last meeting PoE had also advised to dewater plunge pool to assess health of toe and decide various protection measures like secant piles, grouting and cast in-situ concreting below EL-485m.
7. In the last meeting, PoE has also suggested monitoring of slopes as well as observation of markers to be installed on the outer faces of the spillway guiding wall. Data shall be shared by NTPC with PoE in next meeting.

It is understood that the Contract for above works is under award stage.

Recommendations:

Based on the discussion held and current site conditions POE recommends following measures:

1. 3D global slope stability analysis of flip bucket and plunge pool area (as recommended by PoE during Sept. 2021) by NIRM by numerical analysis be expedited. Keeping in view the current situation, depth of secant piling, length of anchors etc. recommended by POE in Sep 2021 will be checked and revised to achieve the desired level of Factor of Safety (FOS).
2. GPR/ERT/ MASW geophysical investigations at plunge pool for delineating the failure surface and quality of rock mass below flip bucket and cladding.
3. Recheck of the design of plunge pool, scour depth with current data.
4. Core drilling for establishing the failure surface and rock mechanic testing for rock parameters such as permeability (Lugeon test), poisson's ratio, shear strength (c, phi), compressive strength, modulus of deformation etc. It is proposed that three holes be drilled at each bench (EL 516, 501 & 485 m). Holes at upper benches be aligned perpendicular to sloping cladding and drill holes at EL 485 m bench should be vertical. Each drill hole should be drilled at least 10 m beyond failure surface. Lugeon test in all the drill holes has to be done.

Date: 27.08.2022

5. Examination of the cladding for cracks/damages for adequate restoration

6. Up-dation of Geological data as suggested in POE report dated 16.09.2021 and incorporating results of proposed geophysical investigation and drilling as at item no. 2 & 4 above.

7. Filling of present cracks with cement mortar followed by concrete with 10 down aggregate and grouting pressure by water fill and treat failure surfaces. The filling activity needs to be carried out in steps.

8. Construction of diversion dyke including jet grouting & dewatering of plunge pool as suggested in POE report dated 16.09.2021. During dewatering, drainage holes in cladding needs to be reactivated/ new holes provided to release hydrostatic pressure and the existing cracks/openings will have to be monitored for changes, in view of the removal of stabilizing effect of the water pressure.

9. Secant piling work including drilling and concreting. Secant piling was originally proposed in Sep 2021 at EL 485m. However, the requirement of additional bored piling at EL 501m & EL 516m, diameter and depth of piles may be decided based on the global slope study by NIRM.

10. Drilling and installation of grouted anchors/cable anchors as finalized after global slope study by NIRM.

11. Concreting works, backfilling of all identified cavities below. It is expected that the toe of the cladding could have suffered substantial erosion and scouring could have gone to much lower depth. The backfill concreting below the key of the cladding should be extended down to the scouring depth to create positive toe support. Further modifications, as required, will be done during the construction based on prevailing site conditions.

12. Consolidation grouting below EL 516m as recommended in POE report dated 16.09.2021 and secondary grouting between EL 516m and EL 528m to be done as proposed earlier.

13. Drilling of drainage holes as recommended in POE report dated 16.09.2021.

14. Pipe discharge from upper water tank falling on the spillway floor seems to be eroding the concrete floor surface and it is desirable to divert it suitably.

15. It has been observed that some joints in the spillway chute have opened as a result there is profuse flow of water in the spillway gallery at the time of spillway operation. Open Joints are to be closed again using suitable sealing material with epoxy mortar at top to prevent water seepage to the foundation.

16. Monitoring of the vertical expansion joint (both left and right side) in the upstream of the dilation joint between chute and flip bucket through Vinchon arrangement, as this joint is also opening up.

17. Movement in X, Y & Z directions of the sloped cladding needs to be observed, since bulging and cracking along the construction joints have been observed.

18. All the proposed studies and investigation may be planned to be completed by November 2022 and execution of remedial works below EL 485 needs to be completed before onset of next monsoon season (June 2023).

(Sh. R Jeyaseelan) (Dr. Gopal Dhawan) 27/8 (Sh. V.K. Gupta) 27/08/2022

Date: 27.08.2022

Annexure-I

List of participants

1. Sh. Kulwinder Singh, HOP (Koldam).
2. Sh. Lav Tandon, GM (O&M).
3. Sh. Madhukar Aggarwal, AGM (Hydro Engg.) HRHQ
4. Smt. Vibha Kaushal, AGM (Geology), Rammam.
5. Sh. S.K.Garg, DGM (C&I/P&S).
6. Sh. Rakesh Rathee, DGM (FES).
7. Sh. Durgesh Kumar, DGM (Civil).
8. Sh. Jagat Singh Yadav, DGM (Hydro Engg.) HRHQ
9. Sh. Virendar Walia (DGM-Geology), Koldam
10. Sh. Arvind, DGM(Civil).
11. Sh. Bhagirath Choudhary, Sr. Manager (Engg.)HRHQ
12. Sh. Nitin, Manager (Civil)

30.05.2023

Summary Record of PoE meeting/Site Visits held on 12.05.2023, 23.05.2023, 26.05.2023 & 30.05.2023 in respect of the issue of Flip Bucket and Plunge Pool of Koldam HEP

1. Preamble

In continuation to the previous meetings held regarding Koldam Spillway Flip Bucket-Plunge Pool issue, a meeting was held on 12.05.2023 followed by site visit by the POE (Sh. R Jeyaseelan, Sh. P B Deolalikar & Sh. Y P Sharda) on 23.03.2023 and visit to Hydraulic Model Study Laboratory by POE Sh. P B Deolalikar on 25.05.2023. Subsequently a meeting was held on 27.05.2023 in the corporate office of NTPC at Delhi to discuss all the related aspects and assess current status. and PoE discussions on 26.05.2023 & 30.05.2023.

Following members of PoE were present during the meeting held on 12.05.2023:

Sh. R Jeyaseelan

Sh. A K Mishra

Dr Gopal Dhawan

Sh. V K Gupta

Dr Y P Sharda

Sh. P B Deolalikar

List of NTPC officials who participated in the meetings is placed at ***Annexure-A.***

2(a) Presentation by NTPC on 12.05.2023 and Discussion

(PoE members Dr Gopal Dhawan, Sh V K Gupta, Dr Y P Sharda and Sh P B Deolalikar attended meeting online)

This meeting was organised to present the status of works and review of the same. Following was presented to PoE during the meeting:

i. It was apprised to PoE that the dewatering of plunge pool is in progress, and it will take few more days (approx. 6 more days) to get completed. Dewatering activity even with 16 number of pumps (capacity ranging from 100Hp/ 50 HP) is taking some time, as there is some leakage from the dyke. To seal the leakage of dyke, necessary action

(like permeation grouting, additional jet grouting) is being taken in parallel. Water level on 12.05.2023 was at EL 493.00m.

ii. Loose material removal from the plunge pool shall start after dewatering and shall be completed in 4 days.

iii. Installation of rock bolts (36mm, 20m long is also in progress. Installation of 151 number of bolts out of total 505 (approx.) at the slope between EL 527m to EL 516m has been completed.

iv. Drilling of remaining 4 bore holes for Seismic Tomography by NHPC are in progress from EL 501m. In addition, remaining bore holes suggested by PoE are also in progress.

v. Consolidation grouting between EL 527m- EL 501m is also under progress, 4191.2 RM (about 25%) out of total 16000RM completed.

vi. Cable Anchoring works from EL 501 to EL 485m is yet to start. Due to site constraints i.e. lack of time, completion of 55 numbers of cable anchors (out of total numbers of cable anchors) installation was proposed by the site. For the same, material is on the way, expected to reach site in 4-5 days.

vii. Balance stabilisation works (as indicated in RFC drawings/ recommendations) like secant piling at EL 485 and 5m thick concrete padding etc are yet to get started.

viii. Observations of Vinchon installed at flip bucket joint was presented to POEs and it was mentioned that at this joint no major movement is observed from 16.08.2022 to till date.

ix. Observations of Prisms installed at some locations of plunge pool cladding was presented.

x. Hydraulic Model study of the plunge pool: As per the information from the IRI, correction in model in line with drawing/ details received from NTPC is under progress and model shall be ready by 21.05.2023 for performing/ witnessing the model studies by POE.

xi. Issue related to rock properties was also apprised. The rock properties as tested at CSMRS for Phyllite was discussed with NIRM and it was viewed that these data should not be taken for analysis and fresh tests may be done to arrive towards realistic

values. Accordingly, CSMRS was requested to visit the site in the last week of Feb'23 and have submitted the note dated 28.02.2023 proposing to work out the rock properties through in-situ test. Keeping in view the limited time available, it is felt that in-situ testing may not be possible in this working season.

In this regard, it is informed that during drilling for tomography, cores of carbonaceous phyllite could be recovered and the same shall be used for testing.

xii. Progress of works as on date and planning for completing balance works possible were presented.

2(b) **Recommendations:**

a) All the concrete works need to be completed at least few days before the water is released so that concrete sets well and develops the required strength.

b) POE apprehended that quantum of balance works w.r.t time left is huge; hence cannot be completed unless it is planned and executed meticulously. In view of this, site need to work out the detailed plan of activities (week wise schedule), approach road details and present the same to POE. NTPC agreed to present the same to POE by 15.05.2023.

c) POE also apprehended that all the proposed works may not be completed in this season; therefore, the stabilization measures being implemented in this season is interim only. The balance work shall get deferred to next season.

d) POE advised that Exposed Surface profiling need to be done.

e) POE further stressed upon the need of wrap around at both ends of cladding wall to minimize further erosion and to provide some passive support to present rock mass slopes.

f) PoE opined that rock mass properties of sheared/ carbonaceous phyllite is essential and urgently required. Since, earlier attempts for getting the rock sample tested at NIT Hamirpur and CSMRS did not provide the reliable values for rock mass parameters of sheared/ carbonaceous Phyllite. Therefore, it is recommended to perform all the recommended test (UCS in saturated condition, C, Phi, Ed etc) on the core samples recovered from drill holes being done for seismic tomography and other drill holes recommended by POE in the plunge pool area. As this rock mass is very weak extra precaution should be taken during drilling, core extraction, transporting them to laboratory and during testing. Further, it is recommended to determine dynamic elastic and strength parameters of rock mass by seismic investigation method, when NHPC team conducts tomography at site.

3(a) Site Visit from 22.05.2023 to 24.05.2023 and meeting on 26.05.2023

Site Visit:

(POE members Sh R Jeyaseelan, Sh P B Deolalikar & Dr Y P Sharda along with HRHQ team visited site from 22.05.2023 to 24.05.2023.)

Water level was at about EL 488m. Works like drilling, consolidation grouting, dewatering, rock bolt installation, crack/ joint filling at chute/ flip bucket were under progress.

After dewatering, exposed condition of plunge pool, cladding was discussed in details at site.

Plunge pool area (left and right bank) at EL 528 and inspection chute top up to first aeration was also under taken.

Site Pictures are enclosed at ***Annexure-I***.

After dewatering, in the exposed condition of plunge pool, damages seen were much more than anticipated. Cladding concrete block below El.501m were dislodged, twisted, settled, pushed up, cracked and crushed in different locations. Extensive under cutting and scouring out of rock from behind the cladding was extensive, rendering the mass above to an unstable condition. Cladding concrete was also crushed, cracked over long lengths, settled and heaved up. Perhaps the existing

cladding cannot be depended upon at some locations. Actual condition below El.488m could not be seen as the excavation could not be taken up by site due to dewatering constraint. There is every reason to believe, as anticipated earlier and as seen from the drill holes, that the scouring could have been deeper. This has led to the movement of the rock mass forward and settlement of cladding. The condition appears quite unstable at places and is a matter of concern. Damages observed earlier above El.501m or so above the filled water line did not appear as bad. Plunge pool scour seems to have extended down below to El.480m or so which could be expected with the spillway discharge at around 3,000 cumec itself. For higher discharges it will be deeper as seen from model studies. The damage has occurred sooner than later.

Spillway chute has also developed several long cracks in concrete both in longitudinal and perpendicular directions at several places. The longitudinal cracks have extended below also, as evident from the transvers cracks in the gallery below. The situation as at present requires extensive study to assess the cause of the failures/cracks and possible solutions.

Site Pictures are enclosed at ***Annexure-II***.

Recommendations:

a) POE suggested that the steel liner of first aeration chamber which was found damaged, needs to be repaired.

b) Aeration chamber cleaning be ensured so that these are free to draw the air.

c) Damages at the location of bucket lip need to be repaired.

d) Regarding the dyke whether to remove it or not before the release of water from spillway was discussed. POE advised that it is preferable to remove the complete dyke. However, at least 1/3 of dyke on left side be cut up to El 501m (river bed level) to give passage to/ guide the flow.

PoE also apprehended that there is a possibility of formation of a bund on the right side because of washing of material from the dyke and getting deposited across the river. This may result in higher water levels at d/s of Powerhouse, hence, proper care may be taken for removing the formation of bund across the river while keeping the spillway closed for few hours.

e) Since the distress is extensive, it requires a deep study and analysis for addressing the problem.

3(b) **Discussion during the meeting at Site on 23.05.2023**

(POE members Sh. VK Gupta & Sh. A K Mishra joined this discussion virtually on 23.05.2023. Sh Gopal Dhawan could not attend.)

During the meeting, it was apprised by site that dewatering and slush/silt removal was achieved up to about El.488m on 21.05.2023. During the meeting site showed picture of plunge pool area and informed that dewatering below El 488m is difficult to achieve as, when the Power house machines run and water level in the river rises, seepage through the dyke leads to pooling of water in the plunge pool again. It was further expressed that since duration of machine running would increase day by day, pooling of water in plunge pool cannot be avoided, and efforts to further seal the dike (i.e., permeation grouting, jet grouting) is being taken simultaneously.

As the time left out in this season is very short with respect to the quantum of balance works, i.e. removing slush and then doing concreting of apron with top at El 485m, the secant piling, concrete padding, backfilling concrete, cable anchoring etc, it would be tough to complete them in the available time. It was also expressed that it may not be possible to excavate below El.488m and further works have to be replanned at this level.

It was noted that the 20m long rock bolts have not been prestressed as recommended by PoE earlier. Prestressing as per the earlier recommendations needs to be followed.

(i) In view of all the above, it was suggested by site that, rather than removing the slush which is more or less granular kind material only, jet grouting may be carried out from the existing level of silt as soil improvement exercise for cementation of the existing material. Further, on top of the jet grouted soil, plum concreting may be done topped up with high strength erosion resistant concrete. Site requested to accept this proposal as interim measure so that this work can be completed.

(ii) It was submitted by the site that jet grouting (ground improvement), the activities of cable anchoring (from EL 489m to EL 501.50m), secant piling at EL 485m will

be taken up and backfilling the gap behind existing (tilted) cladding, & formation of wrap-around wall would be carried out.

Recommendations:

i. Site to look into possibility of jet grouting in standing pool of water and also suggested to get a test pile executed at site and report details in 2-3 days to PoE.
ii. Site to share activity wise realistic construction programme considering limited available time as well as contractor mobilised resources at site.
iii. Site to provide pre-tension to the rock bolts as advised earlier.
iv. NTPC to look into possibility of eliminating existing plan convergence in flip bucket walls to reduce force acting on flip bucket in the direction of flow.

4. Visit to IRI by POE Sh. Deolalikar on 25.05.2023

Sh. Deolalikar had visited IRI earlier and submitted ToR for physical model studies vide his E-mail dated 16th March 2023 and some observations thereon were given by Sh. R. Jeyaseelan vide E-mail dated 24th March 2023.

In continuation, IRI was visited on 25.05.2023. It was observed that some corrections were required in plunge pool and river bed profile. In this regard, details of fresh survey carried out at site shall be provided to IRI.

However, the model was run and throw distances were observed for various discharges. It was observed that the flow from Flip Bucket impinges in Plunge pool at distance of about 75m, 100m, 135m, 160m, 175m away from Flip Bucket face for discharges of 1000, 2000, 3000, 5000 and 7000 cumec respectively. For flows less than 1000 cumecs, it cascades over the Cladding.

Recommendations:

i. Tailrace water curve need to be developed using HEC-RAS
ii. In Model downstream river part need to be further extended by 2m.
iii. Heavy return flow was observed in model for discharge beyond 3000m3/sec.
iv. In view of flow corresponding to 1000 cumecs impinging the plunge pool at about 75 from Flip Bucket, it is recommended to operate spillway at a minimum of about

1500 cumec to avoid any direct damage to the toe of cladding and other strengthening works carried out this season at bottom.

v. Final model runs are to be expedited as per ToR. After relaying the model with existing river morphology, be first inspected by NTPC officers before taking up the model experiments.

5(a) Points Discussed on 26.05.2023 during the meeting at EOC

(POE members Sh. V K Gupta & Sh. P B Deolalikar attended the meeting virtually)

i. In continuation of the discussions held during site visit, Koldam site shared picture of Plunge Pool with negligible water as against a pool as shown on 23.05.2023. The situation shown was obtained with continuous dewatering and sealing of seepage water. Further, the activity of construction of approach road on left bank side was in progress. Site explained a proposal regarding the stabilisation works planned for this season keeping in view the time constraint and the level of site preparedness. Various activities proposed during this season are as below:

   a. **Activity 1**: Mixing of existing material in Plunge pool with dry River Borne Material (RBM) available in nearby vicinity

   b. **Activity 2:** Executing the Jet Grouting work of 2m dia column upto a depth of 15m from EL.485m to EL.470m (1800 rm approx.)

   c. **Activity 3**: 900mm diameter Secant Pile, 20m depth shall be carried out as per engineering drawing.

   d. **Activity 4**: PCC M-30 Grade to be carried out from El 487-485m over Jet grouted Columns (After removal of Material from EL 487 to EL 485m.

   e. **Activity 5**: Cavity Filling by using concrete of M20 grade in the apron sloped slab/ cavity filling starting from EL 487.00 to El 516-bench including wrap wall.

   f. **Activity 6**: Consolidation grouting, drain holes & Cable anchoring work to be carried out from El 501.5 to EL 489m

ii. NTPC submitted that work for sealing of all the cracks on chute floor is under progress and shall be completed well before spillway operation in this season.

5(b) Recommendations:

i. Keeping in view the time constraint, POE felt there is no other alternative but to go ahead with the proposal as an interim measure as presented by site.

ii. Cracks on the surface of spillway chute and flip bucket be monitored regularly.

iii. The jet grouting shall cover about 500 m^2 of area adjacent to plunge pool cladding toe leaving no un-grouted zone in-between (alternate row jet grouted columns to be staggered).

iv. Cores may be taken out from the jet grouted column to establish the strength.

v. Crack at El 527m extending into the hillock on right side may be filled with clay/ bentonite grout (after taking out about 1m of filled boulders) and movements may be monitored continuously.

vi. All type of concreting may be completed well in time to gain strength before spillway operation and before executing subsequent works.

vii. Filling of Joint (flip Bucket- Plunge Pool Cladding), Joint (Flip Bucket-Chute) and filling of other joints on chute slab may be completed on priority.

viii. NTPC to ensure completion of ongoing studies by NHPC and NIRM as well as rock testing through CSMRS at the earliest.

ix. NTPC to take up construction of wrap around wall on both ends of cladding wall as a parallel activity and ensure walls completion at least up to El 501m in this working season.

x. Backfilling of the cavities and gaps behind existing (tilted/damaged) cladding needs careful planning and execution to ensure monolithicity. Removal of the damaged blocks or backfill and treatment shall be decided based on the type and extent of the damages.

xi. Since only 55 nos of cable anchors are planned to be executed during this working season as such the same be installed in central cladding and adjacent panels of the right and left cladding. Further, cable anchors shall be oriented

15 degrees downward to horizontal and shall be locked at 30% of the designed load.

xii. Since the existing concrete cladding is damaged at many locations, its condition shall be checked before installing cable anchors i.e. cable anchors be installed in cladding without damage.

xiii. Physical model studies are to be completed early for planning adequate safety measures.

(Sh. R. Jeyaseelan) (Sh. V.K. Gupta) 30/5/2023 (Dr. Gopal Dhawan) 30/5/23

(Sh. A.K. Mishra) (Dr. Y.P. Sharda) (Sh. P.B. Deolalikar)

Meeting of PoE held on 12.09.2023 at EDC-Noida for the issues of Koldam Spillway Plunge Pool Works

1. **Preamble**

A meeting was held on 12.09.2023 at EDC-Noida as a follow-up of the recommendations of the meeting dated 14.07.2023.

Following PoE members were present during the meeting:

Sh R Jeyaseelan

Sh A K Mishra

Dr. Gopal Dhawan

Sh. V K Gupta

Dr. Y P Sharda

Dr. P B Deolalikar (through Online mode)

2. **Discussions and recommendations by PoE:**

a. **The wraparound/ diaphragm wall on left and right side of the plunge pool:**
NTPC presented the profile and details of wrap around/ diaphragm wall on right side and left side of the plunge pool.

After deliberation, PoE recommends that the layout of wrap around wall needs to be re-profiled starting from end of existing cladding to the rock on the sides to have a smooth curvature for better flow conditions, keeping with the observations in ongoing physical model studies. Foundation level is to be decided keeping in view the anticipated scour damages and availability of rock. It will be prudent to get the area geologically mapped and prepare geological sections to decide layout and foundation level of proposed wraparound wall.
NTPC shall prepare the modified scheme considering various suggestions and shall submit to PoE for review. NTPC may also keep a drilling agency ready to drill a couple of holes to supplement results of geological mapping, if required, before construction of wraparound wall.

b. **Cable anchors in plunge pool cladding:**
NTPC presented the scheme for providing the cable anchors in left, centre and right side of plunge pool cladding.

After deliberations, PoE recommends that the scheme is acceptable in general, however, combination 40m & 60m long cable anchors may be provided in staggered manner.

c. **Cable anchors for Cross-stitching in flip bucket:**
NTPC submitted that practically it is very difficult to place the cross-stitching cable anchors in flip bucket block as there are chances of damaging the existing cable anchors, reinforcements and concrete while executing the same.

After deliberations, PoE recommends that details be rechecked by NTPC and put up in the next meeting. Further, as recommended earlier, scheme for chipping off of the curved portion (in plan) of flip bucket may also be explored, possible options developed and put up.

d. **Right bank slope protection works:**
PoE opines that this shall be decided after the site visit. Physical model study will indicate the extent of throw of the flip jet on the slope. Topography and geology of the affected area will be required. A map including the existing structural features such as diversion tunnel/its outlet, road etc may also be prepared. Available construction stage geological maps of right bank area will also be helpful for deciding treatment in this area.

e. **Physical model studies/Tailwater rating curve:**
It was informed that construction of the model is nearing completion at IRI and studies will be taken up shortly. Reasonable tailwater rating curve is an essential requirement for physical model studies. There are some variations in the results from two sources. Specific location for which it is applicable, assumptions made for the roughness coefficient and methodology adopted may be checked up and confirmed. The flow condition and velocity patterns for various discharges up to 11,200 cumec will be helpful in assessing the hydraulic efficiency of the alignment of the wraparound wall along the right side.

f. **Rock parameters of sheared Phyllite:**
NTPC presented the test results of sheared phyllite as carried out by CSMRS. It is suggested to have testing / results of all the litho units i.e. Basic dyke, Carbonaceous phyllite, phyllite, Sheared phyllite and black carbonaceous slates.
Final report from CSMRS may be put up to PoE to take a view.

g. **Mapping and monitoring of all the cracks:**
It is suggested that all the cracks observed in the chute and plunge pool area may be updated in plan and sections, particularly those extending into ground beyond main structure be mapped and plotted on geological map along with features indicating instability on ground.

Tell tales may be fixed across the cracks observed in drainage gallery and, if possible, on cracks in spillway glacis.

In case of slides on the right bank of the river, close inspection of these is needed to see whether there are indications of movement of slope or these are simply erosion scars, as treatment measures have to be evolved accordingly. Field Geologist to examine these slopes critically.

h. **Dewatering and assessment of the damages:**
It was recognised that the damages/cracks observed above the water surface resulted from the scour in the central zone and due to return flows on the sides. Whenever the dewatering is done, all the damages will have to be assessed and restoration measures in progress will be reviewed and modified as found necessary.

i. **Concrete pad support in the central zone of plunge pool:**
A large 5m thick concrete pad was proposed as toe support at the toe of the cladding. Due to some constraints, as suggested by the site, limited jet grouting of the in-situ material was carried out adjacent to the toe. The efficacy and strength of the jet grouted area may be checked by taking out adequate number of cores and testing. In any case concrete pad

will be required as suggested earlier.

I. **Investigations in progress:**

All the works taken up by CSMRS for rock testing, NIRM for [illegible] for identifying the failure surface, NIRM for stability and safety assessment and physical hydraulic model studies at Roorkee are to be expedited.

(R Jeyaseelan) (V K Gupta) 27/09/23 (Gopal Dhawan) 27/09/23

(A K Mishra) (Y P Sharda) (P B Deolalikar)

Minutes of Meeting of PoE held on 10.10.2023 through MS Teams for the issues of Koldam Spillway Plunge Pool Works

1. Preamble

A meeting was held on 10.10.2023 through MS Teams to further discuss the issues related to Koldam Spillway Plunge Pool.

Following PoE members were present during the meeting:
Sh A K Mishra
Dr Gopal Dhawan
Sh V K Gupta
Dr Y P Sharda
Dr P B Deolalikar
Sh R Jeyaseelan (could not attend meeting)

2. Discussions and recommendations by PoE:

i. **The wraparound wall on Right side of the plunge pool:**
NTPC presented four alternative plans indicating the profile and details of wrap around wall on right side of the plunge pool (Annexure 1).
After deliberation, PoE recommends that the layout of wrap around wall as per the Plan-4, as presented by NTPC, is agreeable. However, following may be incorporated:

a) The wraparound wall may be extended beyond point P4 on river main course (point where high velocity has been observed in the model), on right side of plunge pool.
b) At pile cap level, about 5m wide bench may be provided which would help in providing support to wraparound wall and would reduce the quantity of backfill as well.
c) 12m long anchors (10m in rock, 2m in backfill) may be provided at a spacing of 3m c/c both ways.
d) Foundation level of piling may be kept keeping in view the anticipated scour damages based on model study by IRI, Roorkee.
e) In view of continuous cracks in right bank hill overlooking the proposed wraparound wall shown by NTPC on aerial photographs, area from river bank to hill top may be geologically mapped on priority. Agency for investigation drilling (core drilling) may be engaged to drill a couple of drill holes (50 to 80 m deep) to understand foundation conditions and study stability of slope around the proposed wraparound wall.
f) NTPC needs to ensure construction of wraparound wall on priority, as highlighted by PoE during earlier meetings also, to minimise further erosion of plunge pool banks.

ii. **Testing for Rock properties by CSMRS**
NTPC presented the results of Basic Dyke and Sheared Phyllite as per the final report submitted by CSMRS. The rock properties as derived earlier mathematically were also presented. After deliberations, PoE recommends that Rock mass parameters for Basic Dyke may be derived from the results of various tests for intact rock as brought out in CSMRS report. Further, test results as obtained from Direct shear test for Sheared Phyllite may also be considered to arrive at values to be adopted for Sheared Phyllite. Further, opinion of CSMRS on the same may also be obtained.
NTPC shall put up the values accordingly at the earliest for finalisation by PoE for adopting the same for 3-D analysis to be carried out by NIRM.

iii. **Flip Bucket – stitching cable anchors and removal of curvature**

(a) During PoE meeting dated 12.09.2023, NTPC had submitted that practically it is very difficult to place the cross-stitching cable anchors in flip bucket block as there are chances of damaging the existing cable anchors, reinforcements and concrete while executing the same. NTPC reiterated their view during the meeting.
After deliberations, PoE agreed to NTPC view.

(b) Regarding scheme for chipping off the curved portion (in plan) of Flip Bucket walls, NTPC put up calculations explaining that there would be insignificant impact of removal of curved portion on behaviour of Flip Bucket in direction perpendicular to Spillway flow.
PoE recommends that the issue/ calculations may be reviewed and put up during next meeting.

iv. **Model studies at IRI, Roorkee:**
NTPC submitted that physical model at IRI Roorkee has been updated to latest site topography and one set of observations with discharges of 1000,2000,3000,5000 and 11400 Cum have been taken. NTPC presented the observations of the study with respect to velocity, water levels & pressure. PoE noted the observations.

v. **Mapping of cracks/ joint openings:**

a. Traces of cracks appearing on right side hill of Plunge Pool (between Plunge Pool & Power house) has been marked by NTPC on an aerial photograph. NTPC presented the same. PoE noted the same. Further PoE recommends including this area also while geologically mapping the right side of plunge pool as brought out in para i(e) above. Dr Gopal Dhawan and Dr Y P Sharda expressed their willingness to visit the project for reviewing geological data after completion of geological / crack mappings suggested by PoE.

b. As discussed during earlier meeting, NTPC submitted that the gaps as observed on Chute floor are along the dilation joints in Chute slab. Filling of these joints and cable gallery joints were carried out with PU before 2023 monsoon. No openings/ gaps have been observed after the spillway operation. Further, no openings/ gaps/ leakage was observed in the cable gallery below chute floor at joints.
PoE noted the same. Further, as recommended earlier, Tell tales may be fixed across the cracks observed in drainage gallery and, if possible, on cracks in spillway glacis. The cracks/ details shall be further examined and deliberated during next site visit.

c. PoE further reiterated that geological mapping of right bank of river in front of plunge pool be completed as discussed and recommended in last PoE meeting.

PoE further recommends that all the works taken up by NHPC for rock tomography for identifying the failure surface, NIRM for stability analysis and safety assessment and physical hydraulic model studies at IRI, Roorkee are to be expedited.

(V K Gupta) (Gopal Dhawan) (A K Mishra)

(Y P Sharda) (P B Deolalikar)

Asst. General Manager (Commercial)
NTPC Limited

Record Note of Visit to Koldam Spillway & Plunge Pool area

(25.10.2023 to 29.10.2023)

1.0 Preamble

As a follow up of POE meeting at EOC Noida on 10.10.2023, Dr Y.P. Sharda and Dr Gopal Dhawan visited Koldam HPS from 25.10.2023 to 29.10.2023 for appreciating the ground conditions after the last monsoon pending completion of geological mappings as advised by POE during previous meetings.

2.0 Field Observation

The team visited the spillway chute, flip bucket, cable gallery, plunge pool, hillock encompassing plunge pool and right bank of river Satluj opposite to plunge pool during this visit. Our observations are as follows.

2.1 Spillway Chute-Flip Bucket

The Flip bucket joint which is showing noticeable movement since year 2020 is being monitored by installing vinchon instruments. Though the rate of movement has diminished after installation of cable anchors in the flip bucket in the year 2021 but the movement has not yet been fully arrested. Net movement at joint for the monsoon 2023 is 16.26mm (X-direction) at Right Guide wall, and 18.27mm (X-direction) at Left Guide Wall. Cumulative movement till date at this joint till September 2023 is of the order of 206.55 & 342.44mm at Right Guide Wall and Left Guide Wall, respectively.

The Team walked along spillway glacis from flip bucket to third aerator to examine the cracks which are appearing on concrete surface and were discussed during previous POE meetings.

As per construction drawings of spillway chute, dilations joint has been provided in both the directions i.e., parallel and perpendicular to the spillway flow. Development of cracks and opening of dilation joints was observed in the past and the same was recommended to be filled with PU and cement by POE which was executed during the year 2023 before monsoon.

It is noticed that opening of dilation joints between the spillways blocks is more pronounced. These joints are perpendicular to the flow direction. On the other hand there are four continuous dilation joints in the spillway chute extending right from flip bucket to spillway gates. During earlier

visits POE has pointed out that the longitudinal dilation joints which are parallel to the spillway flow also display cracks / opening at places.

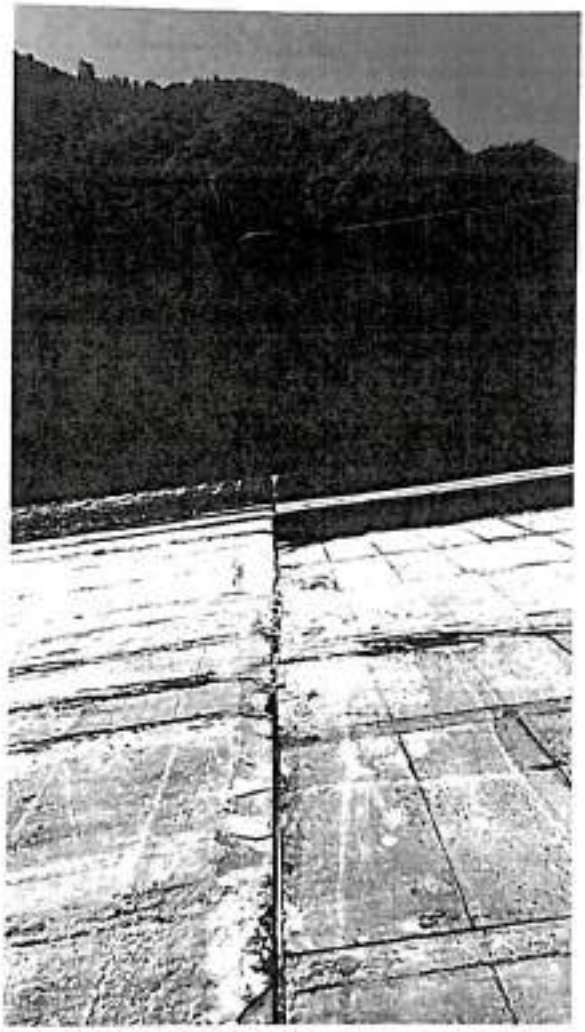


Photo 1 : Dilation joint between first & second spillway block from flip bucket

The dilation joints between flip bucket & first block as well as between first & second spillway blocks were filled with concrete / mortar during previous years. It was observed that due to further movement of flip bucket in flow direction, the gap at these joints has further increased resulting in caving in / loosening of filled material in the joints.

Photo 2 : Typical Longitudinal Dilation joint which is smooth and straight and doesn't show signs of cracking

In the longitudinal direction i.e. in the direction of Spillway flow, there are four dilation joints as per the construction drawings. It was observed that in line with the earlier PoE recommendations, these joints were filled with PU material. It was given to understand by construction engineers that after filling the joints with PU material, surface was smoothened by plaster. Continuous lines from Flip Bucket towards Aerators is observed along all the four longitudinal dilation joints. These joints are generally tight but contact between two blocks display rough edges all along the dilation joints. It is observed that at some places, for grouting the joint openings it was chipped off in V shape and backfilled with plaster. Cracks are observed on this plastered surface which are in wavy/ haphazard in nature.

Photo 3 : PU grout filled in the cracks, covered with plaster

In addition to above, at some places small blocks of concrete (about 150cm in length & about 20cm in width) are observed to be detached along edges of dilation joints. This may be result of minor cracking in concrete along pre-existing dilation joints. The same needs to be backfilled with high strength concrete.

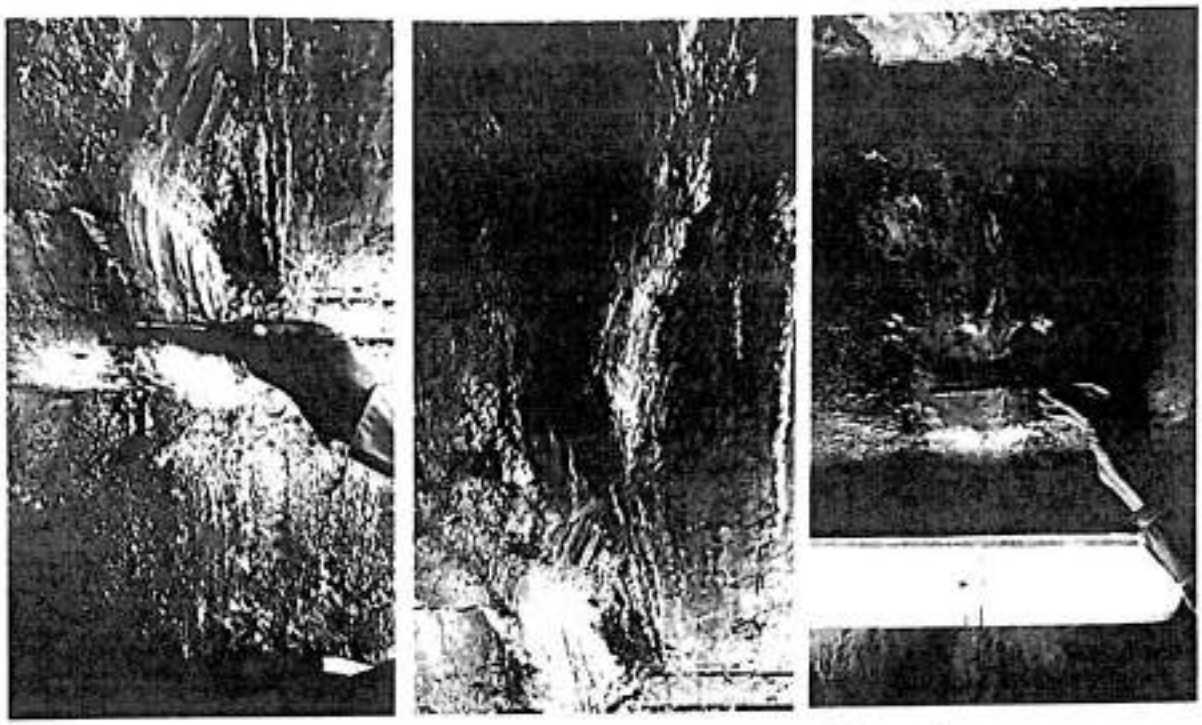


Photo 4 : The dilation joints as visible in the cable gallery

Cable gallery provided below Chute floor was also visited to examine the dilation joints and any other cracks in the concrete. Cracks/ widening of dilation joints observed in the gallery during last visit of PoE were filled back before 2023 monsoon and no disturbance has been observed along these joints during the present visit.

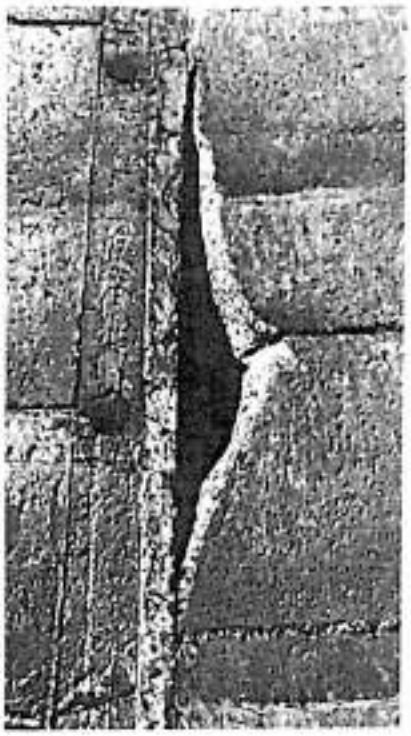


Photo 5 : Small block detached along Longitudinal dilation joint

Photo 6 : Outcrop of basic dyke on the left guide wall.

The ground adjoinding the left guide wall was also inspected upto first aerator and attempt was made to see whether the joint opening in the guide walls and floor are extending into the rock also. It was observed that no extension of joint opening (joint between flip bucket & chute and first block & second block) was visible into the ground beyond guide wall. The crack between flip bucket & plunge pool was observed to be extending into the ground beyond guide wall also . Further, gaps were observed between left guide wall concrete and basic rock exposure in the ground at some locations where water was flowing out which requires to be suitable treated.

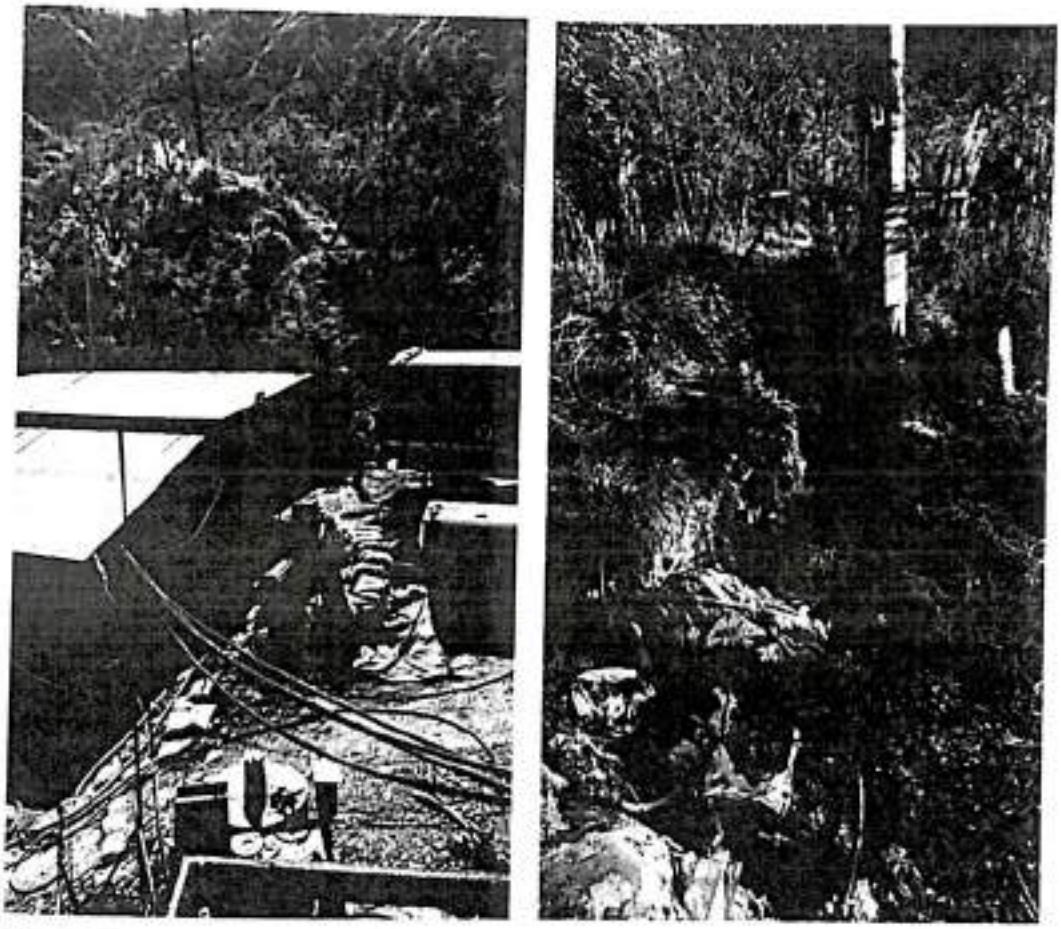


Photo 7 : Major crack at junction of Flip Bucket and Plunge Pool Cladding traversing into hill on right side

3.0Plunge Pool

After Spillway operation during 2023 monsoon, disturbance in right side cladding was observed; the extreme block was detached, and wide opening was observed between first & second block of cladding. The major crack which has developed between flip bucket & plunge pool

cladding in August 2022 after installation of cable anchors is also observed to be extending in the right bank hill upto the electric pole. There are several sympathetic cracks in this hill extending till end of the hillock on both sides of the hill i.e. towards plunge pool and power house.

It appears that overburden which consists of River Borne Material (RBM) is disturbed and dissected with several cracks in the hill slope towards the plunge pool this area was also accessed from the Power House side and it was seen that blocky Volcanic Rock / Basic Dyke is exposed below the RBM at the river edge. However, the area where the wrap around wall is to be constructed could not be accessed from any side. View of this area from the other bank of the river provides a clear picture of this area which is brought out as follows

- Bedrock of Basic Dyke is exposed all along the river edge (~501m Level from tail race to edge of broken plunge pool cladding) The Basic Dyke rock is exposed due to erosion of Sheared Phyllite which was covering Basic Dyke during the spillways operations in last few years.
- As present the Basic Dyke is exposed as a steep escarpment from the river edge to about 25m to 30m in height.
- The Basic Dyke is overlain by a thick pile of RBM having a thickness of about 15 to 20m. As observed from the top this RBM is dissected with several cracks mostly following longer axis of the hillock but there are some Criss Cross cracks also. At some places, these cracks are as wide as one meter.
- The riverine overburden forming the hill slope towards plunge pool side is prone to fall due to toppling along the cracks penetrating deep into the RBM. It appears that these cracks are restricted to RBM only.
- The hill slope towards Power house constituting the southern flank of this hill is relatively stable. However, the slope above the parking area of Power House indicate tilting of the trees which may be due to creep in the hill. Here a part of this slope has been covered with stone pitching which does not show any signs of disturbance. A drain is also observed in the middle of the slope at the first bench. This is non-functional at present.

In view of the above observations, POE may consider removal of RBM which is showing wide gapping cracks to a suitable level. In addition, it is suggested that the existing drain may be repaired and made functional.

Further, in addition to drill holes suggested along foundation of wrap around wall during last PoE on 10th October, 2 nos inclinometers may be provided on the surface at suitable locations after removal of RBM for monitoring movement in slope, if any.

Photo 8 : The non-function drain at power house side of the hillock

After the field visit, available geological data was studied and the project was advised to update geological plan and sections as follows.

- The area where wrap around wall is proposed to be geologically mapped after it becomes accessible.
- Compilation of joint data in tabular form for each litho unit viz Phyllite, Sheared / carbonaceous Phyllite, basic Dyke, Black carbonaceous slate etc from the foundation logs available at the project. This joint data will be processed to estimate average orientation of main joint sets.
- Updation of the three geological sections (along left wall, Centre line of Spillway & Right wall of Spillway) as discussed.

- The project geologist is advised to develop a geological section from river edge to the hill top (10m beyond Light Mast) along centre line of proposed wrap around wall.

Photo 9 : Left side of plunge pool

The bottom of the clip bucket shows damage in concrete due to crack and there is displacement along the flow direction of the spillway. This displacement is around 1.5 to 2m.

4.0Right Bank of River, opposite Plunge Pool

Photo 10 : Right bank of river Sutlej, opposite to Koldam plunge pool

The right bank of the river opposite to plunge pool has suffered damages due to spillway operation during the last season. The Gabion walls are tilted and disturbed. In some portion concrete toe walls at intermediate levels are broken but concrete toe wall at the lower level resting on bedrock of phyllites is intact. Nevertheless, at two locations below the road level there is intense erosion and accumulation of muck due to blockage of drains and overflowing of water on the road. The proper drainage along the road needs to be ensured for avoiding the repetition of the same. The cladding wall which has been provided in central portion may be extended on both sides in the effected zone upto the level of road along with providing suitable drainage arrangement.

5.0 Rock parameters for 3D analysis

During last meeting of PoE dated 10.10.2023, results of Basic Dyke and Sheared Phyllite as submitted by CSMRS were presented. PoE recommended that rock mass parameters for Basic Dyke may be derived from results of intact rock as brought out in CSMRS report. Further, it was advised that Direct Shear test results for Sheared Phyllite may also be considered to arrive at final values. It was also advised that opinion of CSMRS may also be obtained.

NTPC informed that matter was discussed with CSMRS however it was informed by CSMRS that it is beyond their scope of work.

Accordingly, NTPC presented results of RS Data analysis carried out by them in-house for estimation of rock mass parameters for Basic Dyke. Table indicating compiled values is as below:

Parameter	Unit	Sheared Phyllite		Basic Dyke	
		CSMRS		RS Data	CSMRS
		Direct Shear	Triaxial		
Uniaxial Compressive strength	Mpa	0.047		0.359	14
Poisson Ratio		0.33		0.25	0.25
Young modulus/Tangent Modulus	Mpa	0.024		1.07	10
Cohesion	Mpa	**0.03**	**0.06**	0.215	1.5
Friction Angle	Degree	**30**	**17**	33.143	50
Tensile Strength	Mpa			0.016	2

The results of analysis were discussed with NTPC team. It was given to understand that for calculating rock mass parameters, value of Geological Strength Index (GSI) is taken as 50 based on outcrops of basic dyke exposed along river on the left bank (right side of Plunge Pool). However, this appears to be on higher side particularly in view of the fact that a crack has developed at joint between Flip Bucket and Plunge Pool cladding wherein cladding has moved by about 1.5 to 2m and the rock mass above this failure envelope is disturbed. Moreover, the condition of rock mass as shown by NTPC through construction stage photographs also seems to be on weaker side than rock mass exposed on right side of Plunge Pool. Therefore, it is suggested that NTPC may revisit rock mass parameters for Basic Dyke and present it to POE during next meeting.

As far as rock mass parameters for Sheared Phyllites are concerned, PoE has already suggested to consider results of Direct Shear test and the same are presented in above table. In the given circumstances, this appears to be reasonable.

6.0 Acknowledgements

We would like to put on record our sincere gratitude to HoP Koldam and all the officers from the project and Hydro Region HQ for extending best support and courtesies for conducting the site visit and preparation of report.

28/10/23

(DR. Y.P.Sharda)

(Dr. GOPAL DHAWAN)

Minutes of Meeting of PoE held on 04.11.2023 in respect of Koldam Spillway Plunge Pool works

1. Preamble

A meeting was held on 04.11.2023 at NTPC Noida office in respect of issues related to Koldam Spillway Plunge Pool works

Following PoE members were present during the meeting:

Dr Y P Sharda

Dr Gopal Dhawan

Sh V K Gupta

Sh A K Mishra

Dr P B Deolalikar (attended online)

The minutes of the meeting were also deliberated during meetings on 28.11.2023 and 09.12.2023.

2. Issues for Discussions/ Agenda

a. Testing for Rock properties by CSMRS – presentation of results and adoption of parameters for 3D analysis by NIRM

b. Review of
   - Chute Floor - Joint pattern
   - Cracks on Right side hill
   - Right bank of river (opposite Plunge Pool)

c. Model studies at IRI Roorkee – Observations

3. Discussions and Recommendations by PoE

i. Testing for Rock properties by CSMRS – presentation of results and adoption of parameters for 3D analysis by NIRM

➢ NTPC had informed that CSMRS was engaged to conduct testing for determination of rock mass parameters for rock units in the spill way – plunge pool area. However, CSMRS could not conduct insitu tests for determination of strength, modulus, cohesion and Phi. Accordingly, testing on intact rock samples was performed in CSMRS lab on samples collected by them. Further it is understood that sheared phyllite being weak & fractured rock mass had shown wide range of scattering in triaxial test results. Accordingly testing on remoulded samples was also done by CSMRS. Therefore, following course of action has progressively

evolved for finalisation of strength and shear parameters for rock units to be considered by NIRM in their model.

- During PoE meeting held on 10.10.2023, PoE recommended that rock mass parameters for Basic Dyke may be derived from results of various tests for intact rock as brought out in CSMRS report. Further, test results as obtained from Direct Shear test on remoulded samples for Sheared Phyllite may also be considered to arrive at values to be adopted for Sheared Phyllite and the same be adopted for carbonaceous phyllite. It was also advised that opinion of CSMRS be obtained.

- The matter was further discussed during site visit dated 25th to 29th October 2023 wherein NTPC informed that the matter was discussed with CSMRS however they had shown their inability to take this matter further as it is beyond their scope. In view of this, NTPC carried out analysis using RS Data software for assessing rock mass parameters of Basic Dyke rock considering GSI values as 50. As GSI for such rock mass is on higher side, NTPC was advised to revisit rockmass parameters by taking lower values of GSI.

- NTPC carried out the analysis again with GSI values as 45 & 40 and the same was put up to PoE during the meeting dated 04.11.2023.
  - During the meeting, it was opined to consider C & Phi values reported in CSMRS report for remoulded samples considering that Triaxial tests show scattering values. For Basic Dyke, C& Phi values corresponding to GSI value of 40 may be considered for blocky rock mass.
  - Draft minutes were circulated for finalisation of Minutes. Sh R Jeyaseelan vide his whatsapp message dated 22.11.2023 advised that rock parameters need to be decided in consultation with Geotechnical engineer.
  - The above draft minutes were also deliberated for finalisation during PoE visit to IRI Roorkee on 28.11.2023 wherein Sh P B Deolalikar, Sh. Jeyaseelan & Dr Y P Sharda were present and Dr Gopal Dhawan & Sh V K Gupta joined meeting online. After detailed discussions, PoE advised NTPC Dr. Anubhav AGM(Hydro Engg), who is Geotechnical engineer to prepare a note on the above subject for further deliberation by PoE during next meeting.
  - Accordingly, a note on Geotechnical parameters as prepared by Dr. Anubhav was circulated to PoE on 07.12.2023 for deliberations by PoE. Further, a revised note was presented during the meeting held on 9th December (copy enclosed as Annexure-1).

- Considering the note submitted by NTPC, the matter was further deliberated during the meeting on 09.12.2023 and following are the recommendations:
  - For Sheared Phyllites, PoE recommends adoption of value of C= 0.03 MPa & Phi=30 degree as reported by CSMRS in their report. Further, analysis be also checked considering C= 0.02 MPa & Phi=30 degree as considered by EDF.

- For Blocky Basic Dyke, GSI may be considered as 40 and for sheared Basic dyke, GSI may be considered as 10. Thus, the weighted average GSI value as reported in note is 28. Accordingly, the C & Phi as worked out to be 0.113 MPa & 22.8 degree respectively be considered.

ii. **Review of Cracks:**

Chute Floor - Joint pattern

During PoE meeting held on 10.10.2023, NTPC put up that gap/ cracks as observed on Chute floor are along the dilation joints in Chute slab. PoE expressed that these shall be further examined and deliberated during next site visit. The same was examined by PoE members Dr G Dhawan & Dr Y Sharda during their site visit from 25th to 29th October 2023.

The Team walked along spillway glacis from flip bucket to third aerator to examine the cracks and details have been brought out in their site visit report dated 25.10.2023 to 29.10.2023 (Copy of report attached for ready reference).

PoE recommends that the issue needs to be further looked into with respect to construction methodology adopted at site during construction. NTPC shall review and put up the matter during next meeting. Further, as recommended earlier tell-tales may be provided along the cracks/ joints in spillway glacis and Cable Gallery to monitor the movement.

Cracks on Right side hill

- PoE recommends that the recommendations of Site visit report dated 25.10.23 to 29.10.2033 may be adopted.

Right bank of river (opposite Plunge Pool)

- PoE recommends that the recommendations of Site visit report dated 25.10.23 to 29.10.2033 may be adopted.
-

iii. **Model studies at IRI Roorkee – Observations**

The Model Study observations with and without curved wraparound wall was put up by NTPC. The matter was further discussed with Sh Deolalikar and it emerged that a visit to IRI Roorkee is required to further review the matter. Accordingly, a visit to IRI Roorkee shall be planned by NTPC.

iv. **General**

1- PoE emphasise that all the works as identified for strengthening of Plunge Pool needs to be completed during this season. NTPC is advised to ensure adequate mobilisation & deployment by agency of skilled manpower and critical construction equipment for timely completion of work considering constraints faced during last year. Further, all quantities shall be planned considering area wise activity breakup and shall be monitored on daily basis.

2- The entire slope on which spillway, flip bucket and plunge pool is situated needs to be monitored comprehensively in the long term. Some suggestions for strengthening existing monitoring system by installing inclinometers etc have already been made in earlier meetings. NTPC is requested to prepare a note on balance investigations such as geophysics, drilling, instrumentation etc along with timelines so that the same be reviewed by POE for use of this data gainfully.

3- Sh R Jeyaseelan, member PoE, vide his email dated 27.11.2023 has highlighted various issues pertaining to Spillway & Plunge Pool. In this regard, PoE advices NTPC to submit detailed Action taken Report on various points highlighted for consideration of PoE in next meeting.

(Sh A K Mishra) (Sh V K Gupta) (Dr Gopal Dhawan)

(Dr Y P Sharda) (Sh P B Deolalikar)

Annexure – 1

NOTE ON SHEAR STRENGTH PARAMETERS OF ROCKS IN PLUNGE POOL AREA OF KOL DAM

A. BACKGROUND

a) It is recommended by PoE to get the rock parameters of various rock type lying in Plunge Pool area. Accordingly, CSMRS was contacted and samples of basic Dyke and Sheared Phyllites were sent to them. CSMRS tested those samples, however, values of Sheared Phyllites were not appearing to be matching with the rock prevailing in Plunge pool area. Accordingly, CSMRS was requested by NTPC to visit site again and take samples themselves. CSMRS team visited Koldam site in June 2023 when Plunge Pool was dewatered, they took the samples from site and the same were tested by them at CSMRS lab.

b) POE meeting on 10.10.2023

Based on the CSMRS testing report, NTPC submitted following rock properties table for POE meeting on 10.10.2023:

Property/Parameter	Rock Type	
	Basic Dyke	Sheared Phyllite
UCS (MPa)	14	.047
Apparent Cohesion c (MPa)	1.5	.06
Angle of internal friction, degree	50	17
E (GPa)	10	.024
Bulk density (dry), kg/m3	2580	2210

In this PoE meeting, following table including parameters considered by EDF during 2013 along with parameters computed subsequently using RS Data software as per suggestions of PoE was also presented:

Details of Rock Mass Parameters- Plunge Pool Area

Sl No	Type of Rock	TYPE OF TEST	Test Agency/ Ref & Date	PoE 16.09.2021 (estimated using roclab)	Rock mass properties based on RS Data (May 2023)	Test Agency/ Ref & Date
			EDF (CAS 0616 Jan-2013)			CSMRS Dec-2022 / Oct-2023
1	Basic dyke	UCS(MPa)			0.359	14
		Tensile Strength (Mpa)			0.016	2
		C (kPa)	50	286	226	1500
		Phi (deg)	41	42	33.32	50
		BULK DENSITY (SATURATED) kN/m3	27	27	27	26
		Ee (Gpa)		1.28	1.07	10
4	Sheared Phyllite	UCS(MPa)			0.062	0.047
		Tensile Strength			0.003	
		C (kPa)	20	76	105	60
		Phi (deg)	30	20	20.77	17
		Ee (Gpa)		0.298	0.09134	0.024
		BULK DENSITY (SATURATED) kN/m3	27	27	27	24.2

After the meeting PoE recommended:

Quote:

Testing for Rock properties by CSMRS

NTPC presented the results of Basic Dyke and Sheared Phyllite as per the final report submitted by CSMRS. The rock properties as derived earlier mathematically were also presented. After deliberations, PoE recommends that Rock mass parameters for Basic Dyke may be derived from the results of various tests for Intect rock as brought out In CSMRS report. Further, test results as obtained from Direct shear test for Sheared Phyllite may also be considered to arrive at values to be adopted for Sheared Phyllite. Further, opinion of CSMRS on the same may also be obtained. NTPC shall put up the

values accordingly at the earliest for finalisation by PoE for adopting the same for 3-D analysis to be carried out NIRM .

:Unquote

c) Site visit (25-29 Oct 2023)

In view of the PoE recommendations during 10th Oct. meeting, NTPC carried out analysis on RS Data & presented following table:

		Sheared phyllite		Basic Dyke	
Parameter	Unit	CSMRS		RS Data	CSMRS
		Direct Shear	Triaxial		
Uniaxial Compressive strength	MPa	0.047		0.359	14
Poisson Ratio		0.33		0.25	0.25
Young modulus/Tangent Modulus	MPa	0.024		1.07	10
Cohesion	MPa	**0.03**	**0.06**	0.215	1.5
Friction Angle	Degree	**30**	**17**	33.143	50
Tensile Strength	MPa			0.016	2

After site visit and meeting, POE in their site visit report recommended that:

Quote:

The results of analysis were discussed with NTPC team. It was given to understand that for calculating rock mass parameters, value of Geological Strength Index (GSI) is taken as 50 based on outcrops of basic dyke exposed along river on the left bank (right side of Plunge Pool). However, this appears to be on higher side particularly in view of the fact that a crack has developed at joint between Flip Bucket and Plunge Pool cladding wherein cladding has moved by about 1.5 to 2m and the rock mass above this failure envelope is disturbed. Moreover, the condition of rock mass as shown by NTPC through construction stage photographs also seems to be on weaker side than rock mass exposed on right side of Plunge Pool. Therefore, It Is suggested that NTPC may revisit rock mass parameters for Basic Dyke and present it to POE during next meeting.

As far as rock mass parameters for Sheared Phyllites are concerned, PoE has already suggested to consider results of Direct Shear test and the same are presented in above table. In the given circumstances, this appears to be reasonable.

:Unquote.

d) PoE meeting (04.11.2023)

As suggested by PoE, analysis was carried out using RS Data software and keeping other input parameters as the same, rock mass parameters have been assessed for Basic Dyke rock corresponding to GSI values of 50, 45 & 40 and following parameters for Basic Dyke was presented to PoE:

Basic Dyke							
Parameter	Unit	CSMRS (intact rock)	RS Data (Rock mass) values			Rock mass Parameters Proposed to be adopted	
			GSI=50	GSI=45	GSI=40	Major area	Assumed Fractured area
UCS	MPa	14	0.359	0.244	0.07	0.359	0.07
Poisson Ratio	-	0.25	0.25	0.25	0.25	0.25	0.25
Modulus	GPa	10	1.07	1.07	1.07	1.07	1.07
Cohesion	MPa	1.5	0.215	0.188	0.122	0.215	0.122
Friction Angle	Deg.	50	33.143	30.87	23.83	33.143	23.83
Tensile Strength	MPa	2	0.016	0.01	0.003	0.016	0.003

During the meeting, it was discussed that c & ø values reported in CSMRS report for remoulded samples may be considered as Triaxial tests show scattering values. For Basic Dyke, c & ø values corresponding to GSI value of 40 may be considered for blocky rock mass.

In the meantime, during further discussion in the meeting on 22nd & 23rd Nov. 2023, based on the foundation below El. 515m bench (extracted from old records) geological maps geological model of Spillway Flip Bucket/ Plunge pool area was rationalized.

Further during the meeting on 28.11.2023, it was asked by PoE that in the next meeting a geotechnical note on the rock parameters prepared by a Geotechnical Engineer may be put up for further deliberations.

B. GEOTECHNICAL ANALYSIS

Construction of Plunge pool was completed in year 2015. During construction, in April 2012, large crack at El. ± 513 m in basic dyke (at mid-section of the apron) was observed. Foundation of partially casted concrete cladding at El. 515 m settled by about 250 mm creating a gap between concrete and foundation rock Cracks were also observed in foundation rock till El. ± 500 m. Immediate remedial measures were provided by Engg. and EDF by providing additional anchors at toe in May 2012. Based on geological sections developed in 2012 after the development of crack, EDF suggested final remedial measures in Jan. 2013 for plunge pool slopes. After spillway was put in operation since year 2015, movement in flip bucket and plunge pool cladding were observed. Various measures have been taken since then for stabilization of plunge pool slopes. The geotechnical analysis of the shear strength parameters based on the laboratory tests result done by CSMRS (Report No. 02/ RM-L/ CSMRS/ E/ 9/ 2023) are as follows:

a) Sheared Phyllites

After dewatering of the plunge pool in June 2023, the Sheared Phyllite rock at middle region of plunge pool was collected for assessment. Triaxial and direct shear tests were performed by CSMRS for shear strength parameters of Sheared Phyllite.

As per CSMRS report, for triaxial test, entire test data is scattered in two different zones (Fig. 1). For low confining pressures (0.6 kg/cm^2 to 1.9 kg/cm^2) upper bound value of c=0.6 kg/cm^2 and ø =17° and for high confining pressures (0.2 kg/cm^2 to 10 kg/cm^2) lower bound value of c=0.2 kg/cm^2 and ø =6° are suggested by CSMRS.

As mentioned in the CSMRS report, Direct Shear Tests were performed on remolded samples of Sheared Phyllite at normal pressures 1 kg/cm^2 to 4 kg/cm^2. The normal stress vs. shear stress curve shows excellent fit with R^2 = 0.90 (Fig. 2).

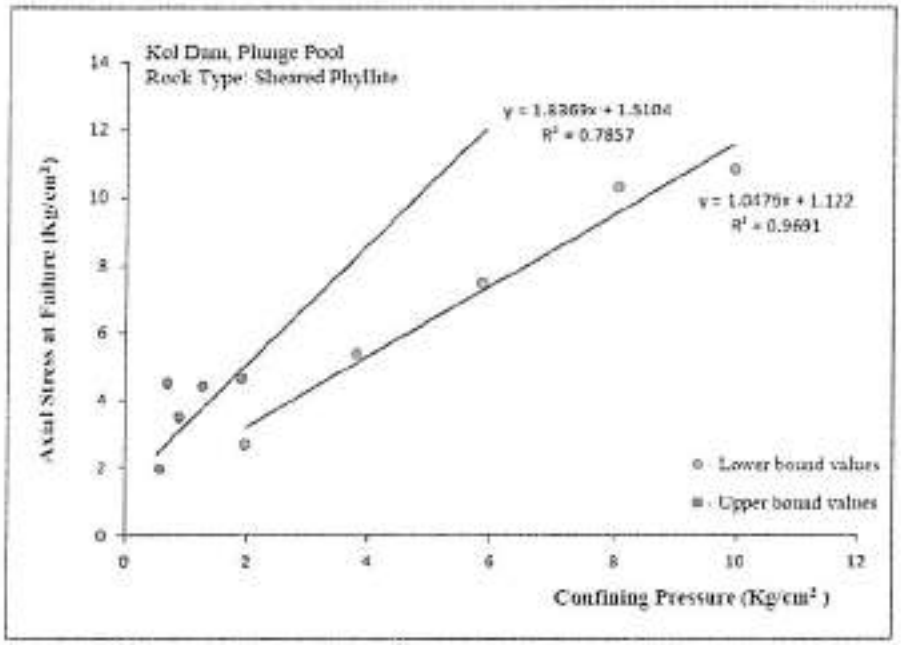


Fig. 1: Triaxial Test Results for Sheared Phyllite (CSMRS report Figure 20)

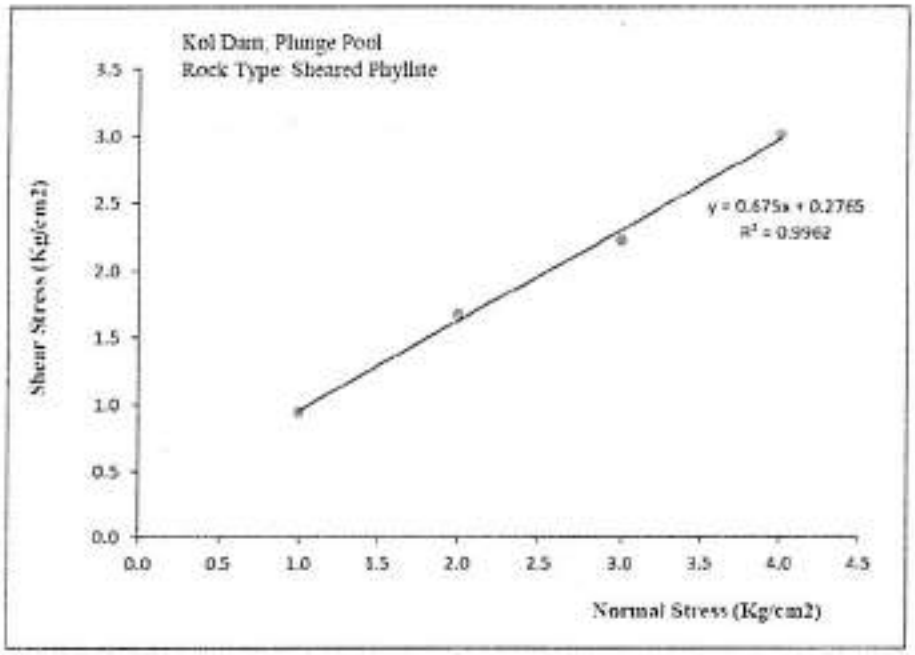


Fig. 2: Direct Shear Test Results for Sheared Phyllite (CSMRS report Figure 21)

Test results of Sheard Phyllite samples by Triaxial & Direct Shear tests done by CSMRS are as under:

Parameter	Unit	CSMRS (intact rock)	
		Direct Shear (remoulded)	Triaxial
Uniaxial Compressive strength (by point load test)	MPa	0.047	
Poisson Ratio		0.33	
Modulus	GPa	0.024	
Cohesion	MPa	**0.03**	**0.06**
Friction Angle	Degree	**30**	**17**

It can be seen from Fig.1 that there is a large scatter in the triaxial test results, whereas, direct shear test on remolded samples done treating the material as soil shows consistent results. Therefore, considering uncertainty in results of triaxial test, it is recommended that shear strength parameters derived from Direct Shear tests on remolded samples may be used for the stability analysis.

Following parameters were taken into consideration in the original design by EDF during 2013::

Parameter	Unit	Value Considered by EDF
Cohesion	MPa	0.02
Friction Angle	Degree	30

The shear strength parameters as obtained from direct shear test done by CSMRS recently and the considered by EDF in original design are nearby. Therefore, It is proposes to consider values as per CSMRS, derived from Direct Shear tests on remolded samples (C= 0.03 MPa & Phi=30 degree) for stability analysis.

b) Basic Dyke

For basic dyke, CSMRS done the UCS, triaxial test and direct shear test on intact rock samples. Triaxial test data of eight samples of basic dyke also shows the scattering.

CSMRS has provided the best fit line for upper bound and lower bound values. Considering the recommended UCS of 14MPa and the variations in the test data, the apparent cohesion (c) and angle of internal friction (Φ) values of 1.5 MPa and 50° are recommended as triaxial shear strength parameters for this rock type by CSMRS.

From direct shear test, peak apparent cohesion (c) of 1.07MPa and angle of internal friction (Φ) of 31° and residual apparent cohesion (c_R) of 0.6MPa and angle of internal friction (Φ_R) of 24° reported by CSMRS for Basic Dyke.

As discussed with CSMRS, the triaxial tests were done on intact rock samples and direct shear tests were done considering joint as pre-defined failure plane. Therefore, these strength parameters cannot be considered as in-situ rock mass parameters. Accordingly, it is decided to calculate shear strength parameters of rock mass using Hoek-Brown criteria. For this purpose, the UCS obtained by CSMRS for basic dyke is used.

Parameter	Unit	CSMRS (intact rock)
Uniaxial Compressive strength	MPa	14
Poisson Ratio		0.25
Modulus	GPa	10
Cohesion (c), Triaxial	MPa	1.5
Friction Angle (Φ), Triaxial	Degree	50

Shear strength parameters taken into consideration in the original design by EDF during 2013 as brought out in the following table:

Parameter	Unit	Value Considered by EDF
Cohesion	MPa	.05
Friction Angle	Degree	41

Geological Strength Index (GSI) is one of the parameters required to calculate shear strength parameters using Hoek-Brown criteria. As suggested in PoE meetings, mentioned in above paragraphs, the value of GSI for basic dyke, as obtained from fresh outcrop exposed in last monsoon (2023) is about 40. However, the condition of basic

dyke behind the cladding which has s been moved / slided along with the rock mass is not visible. It was also suggested that the geological maps of foundation below El. 515m bench (extracted from old records) provided by site (Fig. 3) shall also be considered for obtaining shear strength parameters of rock mass of Basic Dyke.

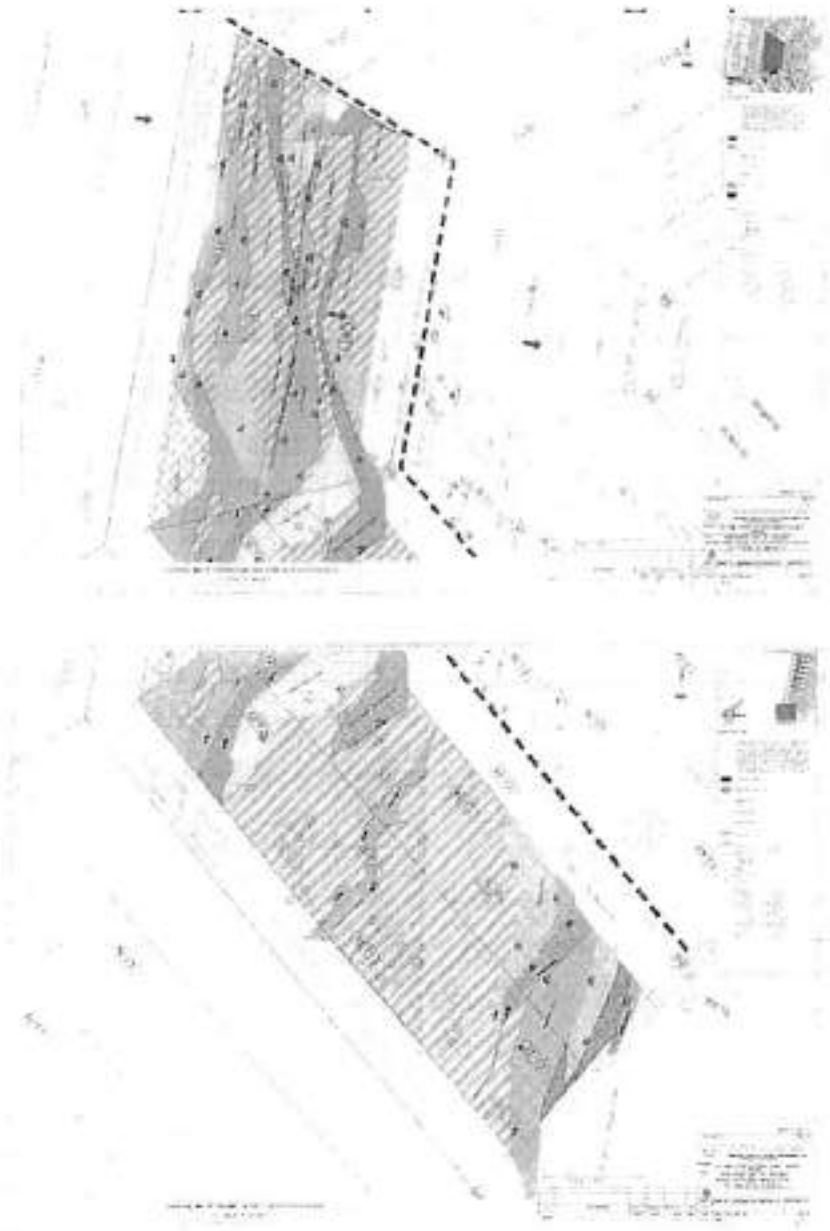


Fig. 3: Direct Shear Test Results for Sheared Phyllite

It was also suggested that GSI of these shear bands may be considered as 10; whereas, for blocky dyke GSI can be considered as 40. Site has calculated and provided the details of area of shear bands and blocky rock mass as follows:

Mapping Available only for Centre & Right side between El 488m to 500m (Fig. 3)

Type of Basic Dyke	Area (m^2)	% of Total Area
Blocky	1522	59
Sheared	1067	41
Total	2589	100

Further, rock mass values as derived from intact rock parameters as reported by CSMRS, considering various values of GSI are as given below:

CSMRS Basic Dyke (intact rock)	RS Data (Rock mass) values					
	GSI=50	GSI=45	GSI=40	GSI=35	GSI=30	GSI=10
UCS=14 MPa	0.359	0.244	0.164	0.108	0.07	0.007
Poisson's ratio = 0.25	0.25	0.25	0.25	0.25	0.25	0.25
C= 1.5 (MPa)	0.215	0.188	0.164	0.142	0.122	0.045
Phi = 50 (degree)	33.143	30.87	28.57	26.22	23.83	13.24

*While deriving rock mass values for various GSI values, all other parameters like mi=10, D=0.7, intact rock UCS=14 MPa, etc has been taken as the same.

In line with the mapping available for two slopes, (one central portion & one right portion), the percentage of blocky & sheared portion works out to be 60% and 40% respectively.

Considering, GSI of Blocky basic Dyke as 40 and sheared basic dyke as 10, the weighted average value of GSI works out to be 28. Accordingly, the c & Ø works out to be 0.113 MPa & 22.8°, respectively.

(Dr. Anubhav)

AGM (Hydro Engg. – TVHPP)

MINUTES OF MEETING OF PoE VISIT TO IRI ROORKEE ON FOR PLUNGE POOL MODEL STUDY ON 28/11/23 AND 29/11/23

1. PREAMBLE:

A visit to IRI Roorkee was made on 28/11/23 and 29/11/23 for the hydraulic model studies of spillway and plunge pool on 1:55 scale comprehensive model.

Following PoE members visited IRI and witnessed the model:

Dr Y P Sharda

Dr P B Deolalikar

Sh. R. Jeyaseelan

Following members attended the meeting online on 28/11/23 & 29/11/23:

Sh A K Mishra

Dr Gopal Dhawan

Sh V K Gupta

IRI officials present during the meeting:

Sh. Rajendra Kuriyal, Executive Engineer

Sh. Sumit Malwal, Asst. Engineer

Sh. Anil Tyagi, Asst. Engineer

Sh. Jitendra Bhardwaj, Research Supervisor

NTPC Officers:

Sh. Madhukar Aggarwal, GM (Hydro-Eng), Koldam

Sh. Rakesh Rathee, DGM (Site FES)

Sh. Rakesh Sharma, Sr. Manager (HRHQ-Eng)

2. The model bed was reproduced rigid as per the post monsoon 2022 topographical survey. The tail water rating curve was finalized by NTPC taking into account all the previous tail water rating curves and recent prototype observations. The same was submitted during the previous PoE meeting. The tail water level was maintained in the model at CH-800m during

the various model experiments. The model was run for discharges of 11400, 8000, 5000, 3000, 2000 and 1000 cumec by maintaining corresponding tail water level.

3. The observations and discussion with the IRI Engineers indicated that for the discharges higher than 5000 cumec up to 11,400 cumec, the flow conditions were turbulent and water levels were fluctuating along the Powerhouse wall, up to 5 metres. The ski-jump jet after falling in the plunge pool was seen riding over the right bank of the river and turning towards Powerhouse. It creates strong return flows along the right wrap around wall and in the plunge pool area. The tail water levels were fluctuating from EL 530m to 535m along the river, due to heavy turbulence and high discharge intensity for the SPF 11,400 cumec. For the discharge of 5000 cumec, tail water level fluctuated from EL 520 m to 518m in the river portion. The return velocities across the wrap around wall varied from 4m/sec to 10m/sec, near the junction with existing cladding.

   The flow issuing from the ski-jump jet was seen riding over the hill slope on the right side of the river in front of the plunge pool with heavy turbulence. The fluctuating water level was seen riding around EL 540m. In view of this, adequate protection needs to be evolved so as to withstand these heavy turbulent flow conditions to avoid undercutting and slope failure. Similar apprehensions were also raised by PoE members during their site visit from 25/10/23 to 29/10/23.

   The velocities along the left side of the plunge pool were relatively lesser and were of the order of 5m/sec. It was observed that the velocity towards river, along the left side of the river were increasing and were of the order of 8m/sec. In view of these velocities necessary protection has to be evolved so as to protect the left side of the plunge pool.

   For the studies conducted for lower discharges ranging from 1000 to 5000 cumec, almost similar flow conditions were observed. However, for the discharges in the range of 5000 cumec, the velocities were higher than those observed for the higher discharges because of less tail water depth. Maximum velocities observed were of the order of 12m/sec near the wrap around wall.

   The values of velocities as indicated in above paras are tentative and shall be as per the final report to be submitted by IRI (HRS), Bahadrabad.

   In view of the above, the profile of right-side wrap around wall as per Plan-4, which is reproduced in model is generally in order. Further, similar arrangement of the wrap around wall on the left side is also to be provided.

4. The tail water level across the river varies from EL 510m to 518m for the discharges from 1000 to 5000 cumec.

5. The flow issuing from the ski-jump jet was seen riding over the right bank of the river for discharges ranging from 3000 to 5000 cumec. Necessary protection needs to be evolved as already mentioned above.

6. The above studies indicated that the fluctuating water levels along the Powerhouse walls were higher than the protection wall of the Powerhouse in the case of discharge of 11,400 cumec. It may be mentioned that these fluctuating water levels would reach up to the toe of the Dam. IRI would also observe the water levels near the Powerhouse walls and its effects, in their report.

7. The studies have been carried out for the discharges up to SPF i.e. 11,400 cumec. The PMF is 16,500 cumec.

8. The ski-jump jet was impinging in the plunge pool in front of the flip bucket for flows higher than 1500 cumec. The model studies to be carried out with erodible bed material would indicate the depth of scour attained in the plunge pool for entire range of discharges.

   The reproduction of river bed for erodible river bed studies were discussed in detail with the IRI officials. It was opined by the IRI officials that for erodible studies, the river bank and the bed of the river would be reproduced in different grain size materials. The proposal in this regard would be submitted by IRI at the earliest.

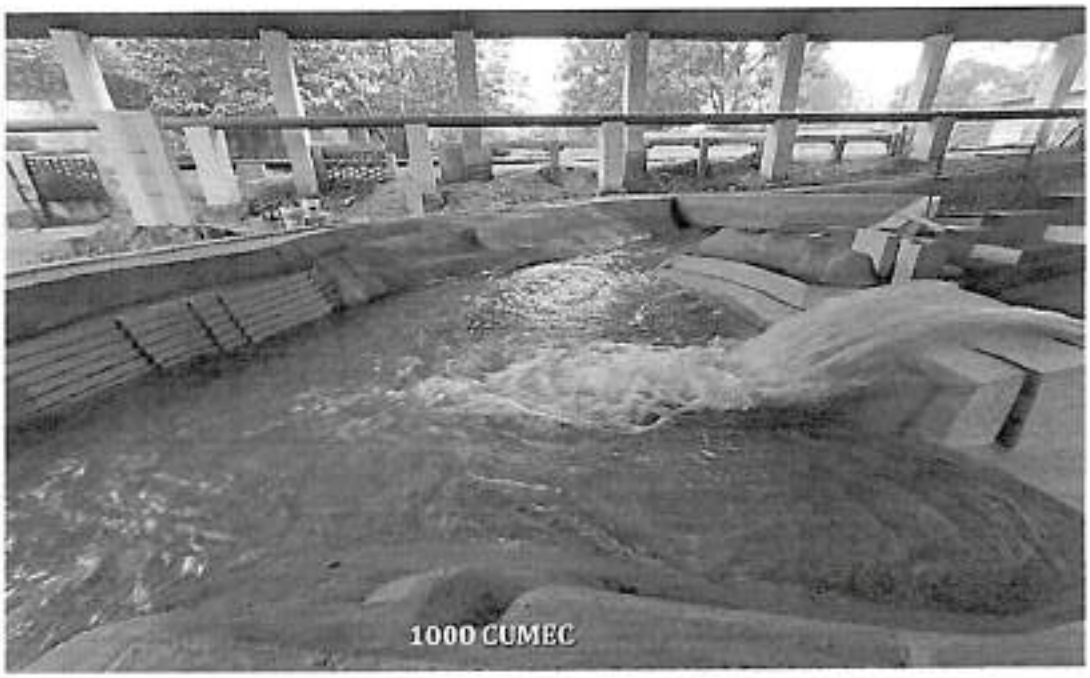
   Impact of the curvature provided in the flip bucket was observed in the model. The flow from both the training walls gets converged towards the centre of the Flip Bucket and heavy pressures were observed along the curved portion of both the training walls.

   Representative photographs for 11400, 8000, 5000, 3000 and 1000 cumec are attached.

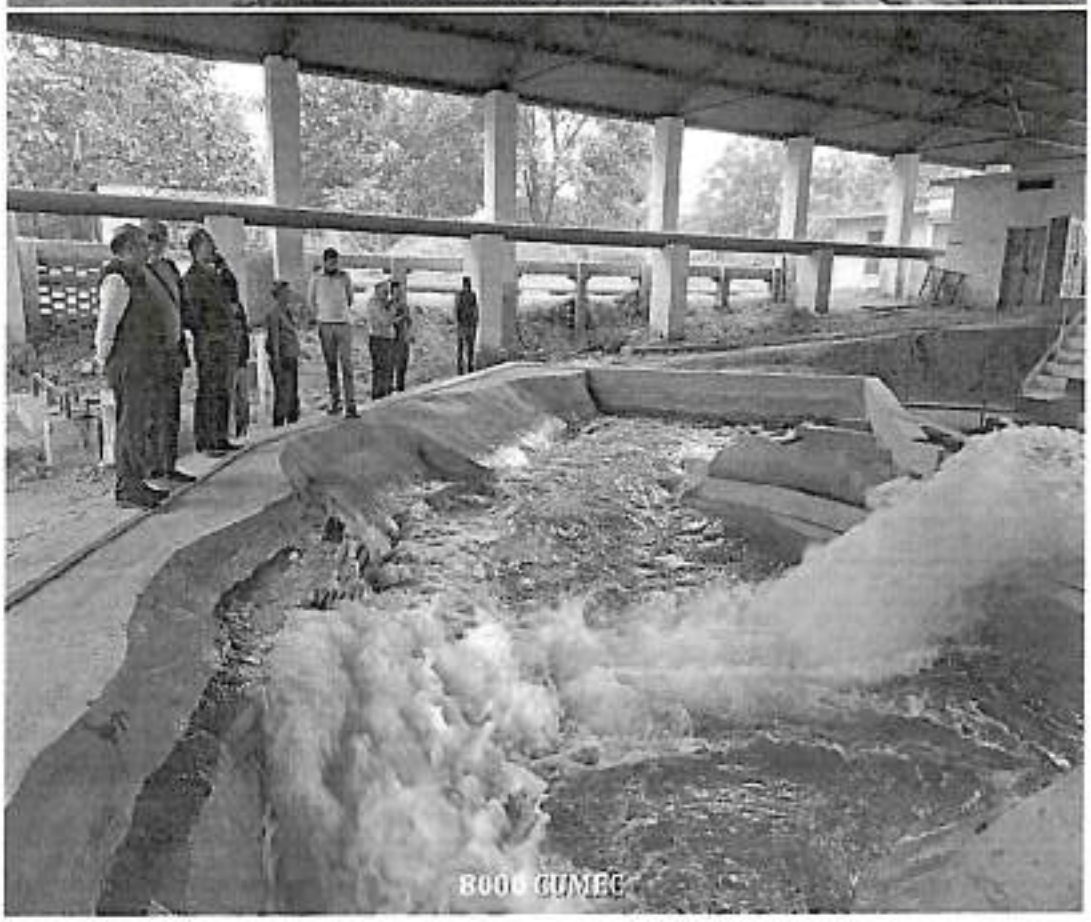
(Mr. P.B. Deolalikar) (Mr. R. Jeyaseelan) (Dr. Y.P. Sharda)

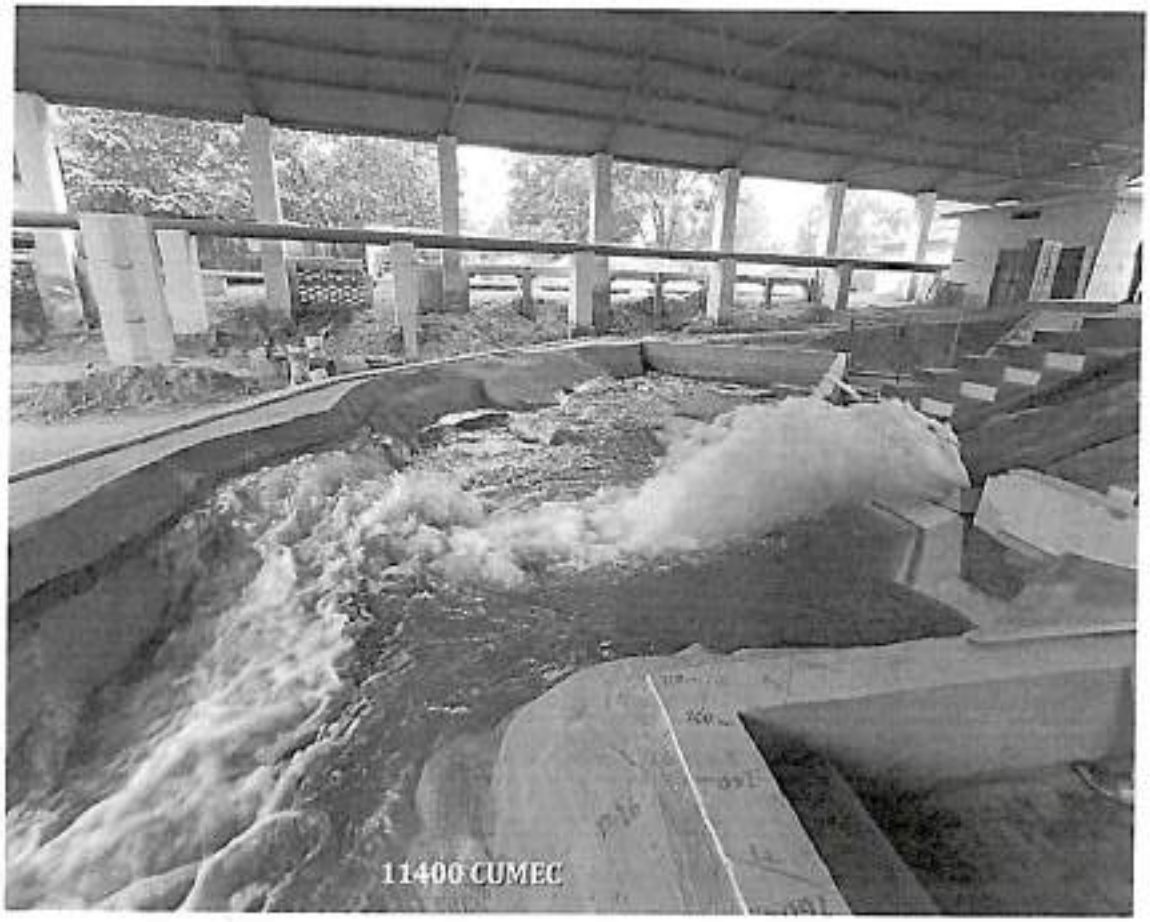
(Mr. V.K. Gupta) (Mr. A.K. Mishra) (Dr. Gopal Dhawan)

PHOTOGRAPHS FOR VARIOUS DISCHARGES




5000 CUMEC


8000 CUMEC


11400 CUMEC

Minutes of the meeting of POE held on 14th & 15th March 2024 at EOC Noida

Regarding Flip Bucket and Plunge Pool of Koldam HPS (4x200MW).

1. PREAMBLE

A meeting of POE was held on 14th & 15th March 2024 at EOC Noida. Following members of Panel of Experts (PoE) were present:

Sh. R Jeyaseelan

Sh. V.K.Gupta

Sh A K Mishra

Dr Y P Sharda

Dr. P. Deolalikar

Dr Gopal Dhawan (could not attend due to his pre-occupation)

List of NTPC officials who participated in the meeting is placed at Annexure- I.

2. Meeting Deliberations

Brief about the agenda points, discussion and POE recommendations thereon are detailed pointwise hereunder:

2.1 Agenda Point-1: Model Study by IRI, Bahadrabad.

NTPC apprised the POE that model study at IRI in line with POE recommendations has been completed and final report has been submitted by IRI in Feb 2024. Main outcome of the report along with model study photographs & scour contours was presented to POE members. Main points as brought out in the report are as under,

- With rigid bed, Velocities of the order of 10 m/s to 18 m/s were observed from P-10 to P-14 points on right bank of river. Also, at P-3 point on right side wrap around cladding, velocities of 6 m/s to 7 m/s were observed at 2000 m3/sec discharge. With erodible bed, the high velocities of the order of 6 m/s to 10 m/s were recorded along right bank of river from P-9 to P-15 at 11400 m3/s, and velocity of 6.6 m/sec were observed at point P3.
- Depth of scour estimated from model studies reached up to El 472 m for 11400 m3/sec discharge at a distance of about 200m from Flip bucket toe and about 180m & 250m from left and right claddings respectively. The maximum scour depth level observed at Point P-3 along right-side wrap around cladding was 480.0 m and along left side wrap around cladding, it was 485 m.

- Very high velocities associated with turbulence and wave action have been observed towards the right bank of the river due to which it is susceptible for heavy erosion at toe. IRI suggested that adequate protection be evolved based on site conditions.
- It was observed that for higher discharges (SPF) the powerhouse retaining wall at EL 527 m was getting overtopped by 1 to 3 m with wave actions.
- Report also states that due to various limitations, sedimentation/ scour results observed from model studies are qualitative in nature rather than quantitative outputs. The actual scouring could be lesser than observed in the model. Also, the boundary effect cannot be ignored in present case as vertical cuttings has been used, which may not be the case at site, to find out maximum scoured level.

In view of the above conclusions of the study, NTPC proposed that the depth of Secant Piling proposed in the Plunge Pool & along the wraparound wall i.e., 20m may be provided.

NTPC also informed that as per the detailed design carried out by EDF, the water levels at TRC corresponding to SPF & PMF are 521.6 & 526.10m respectively. (Ref IH-KOL-NTP1-DEL-00024 B: FINAL Design Intent Memorandum- General Civil Works, Volume-1 Book-1). Regarding water levels near Powerhouse, as per the Model Study conducted by IRI, water level for SPF condition at Point P6 i.e., just at TRC location are 529m & 528m for Rigid Bed & Erodible bed respectively (further these levels would rise due to wave action).

After detailed deliberations on the above, POE recommended the following:

a) Flow velocities on right bank of the river may be taken of the order of 10-12 m/sec. Scour depth in this reach has been reported extending to EL 480m. Considering above details, required protection measures need to be developed by NTPC.

b) Return flow velocities at Right & Left Wrap Around Cladding may be taken of the order of 5 to 7m/sec & about 4 m/sec respectively.

c) Deepest Scour level along Left & Right-side wraparound walls may be taken as EL 485m & 480m respectively.

d) Considering the above, length of the pile shall be fixed such as it gets socketed in rock (i.e. below scour level) by minimum 5m. Further, higher grade concrete would be preferred considering the velocities as observed in the model.

e) Secant pile wall lateral stability shall be checked considering the situation that all material above the socketing level on plunge pool side is eroded. Accordingly, required modification (like anchoring the wall at top (pile cap) with the help of anchors etc) in drawing may be done by NTPC.

f) As per model study report, water level at Powerhouse at SPF overtopped the powerhouse protection wall (EL 527m). The same needs to be reconfirmed with IRI. Studies corresponding to PMF also to be carried out to decide powerhouse protection measures.

g) NTPC is also advised to check the impact of higher tail water level and its fluctuations due to Plunge pool operation on d/s slope of the dam.

2.2 Agenda Point-2: Seismic Tomography study by NHPC

NTPC apprised that the geophysical cross-hole seismic tomography study has been completed by M/s NHPC. The first phase of the study was completed in Jan 2023 & Phase-II could be completed by Feb 2024. M/s NHPC submitted the comprehensive draft report in March 2024. Following conclusion points along with report were presented to POE:

- The depth of inferred contact between weak & good rock has been marked on the geological cross sections provided by the project.
- The report also indicates that contact between weak & good rock is at shallow depth on Right bank and gradually goes deeper towards the left bank.
- For the observed Seismic P-wave velocities for different rock types and quality, two parameters viz. Uniaxial Compressive Strength (UCS) and Deformation Modulus (E) have been evaluated.

From the study, it is inferred that:

The depth of weak zone is about 20m from the cladding surface.

Rock mass properties for basic dyke were recommended by PoE considering low value of GSI (=28) for 3D analysis as such NTPC submits to PoE for consideration of using higher value of GSI (=40) for good rock.

Recommendations:

POE noted and agreed to the same.

2.3 Agenda Point-3: Status of 3D analysis by NIRM

NTPC apprised the POE that after communicating the rock mass properties as finalised during previous POE meeting to M/s NIRM, many round of discussions have been held by NTPC with NIRM for better understanding of the model. Still there are difficulties in convergence of the model.

As per the last discussion held on 05.03.2024 with NIRM, model is not converging due to very low rock-mass properties of sheared phyllite.

Recommendations:

Considering the recommendations under para (2) above, NIRM may be asked to run the model and conclude the study. Further, the impact of consolidation grouting carried out in sheared phyllite may also be considered.

2.4 Agenda Point-4: Behaviour of Flip Bucket / Plunge Pool during non-monsoon period.

(a) Tell tales readings.
(b) Vinchons / Load cell readings
(c) Visual observations – seepage in Flip Bucket gallery, movement of joints upstream of joint at Chute & Flip Bucket

NTPC presented the observations on above.

Recommendations:

POE noted the same and advises NTPC that difference between initial and final displacements need to be presented for any fruitful deliberations.

2.5 Agenda Point-5: Wraparound wall

NTPC apprised the POE that the strengthening measures as recommended by PoE and discussed during previous meetings have been updated based on scour depth as obtained from the Model studies. The depth of Piling has been kept accordingly.

Further, as discussed, the wraparound wall has been kept separate from secant piles by providing a joint between Pile cap and foundation of wraparound wall. Accordingly, one row of 900mm secant piling has been provided and Anchors have also been provided in the foundation block of wraparound cladding.

Recommendations:

i. As advised earlier, wraparound cladding wall profile shall be kept as considered in the physical model studies.
ii. The depth of secant piles be provided such that the pile gets socketed in rock at least by 5m.

iii. Secant piles need to be checked for lateral stability and measures to be deviced accordingly.

iv. As discussed & advised earlier in order to provide support, horizontal offset be provided in wraparound cladding wall and secant pile cap be in front of horizontal offset to facilitate construction as well as provision of lateral support to the secant piles.

2.6 Agenda Point-6: Protection of anchor head (from corrosion & dynamic forces of water) of cable anchors which are submerged under water as well as above water.

NTPC proposed that cable Anchor heads may be encased locally with suitable size concrete block with surface reinforcement.

Recommendations:

PoE agreed the same.

2.7 Other points:

ATR on Sh. R Jeyaseelan's observations dated 27th Nov. '23 & 31.01.2024 shall be discussed in the next meeting.

Sh. R Jeyaseelan | Sh. V.K.Gupta | Sh A K Mishra

Dr Y P Sharda | Dr. P. Deolalikar

Annexure- I

List of NTPC officials who participated in the meeting.

Sh. Madhukar Aggarwal, GENERAL MANAGER (HYDRO- ENGG), Koldam

Sh. Rajendra Kumar Joshi, GENERAL MANAGER (PROJECT CONST

Sh. Ved Prakash, ADDL.GENERAL MANAGER (PM), HRHQ

Dr. Anubhav, ADDL.GENERAL MANAGER (HYDRO- ENGG), TVHEPP

Sh. Rajneesh Pathania, ADDL.GENERAL MANAGER (CIVIL CONST)

Sh. Rakesh Rathee, DGM (FLD. ENGG.)

Sh. Jagat Singh Yadav, DGM (HYDRO- ENGG), HRHQ Noida

Sh. Virendra Kumar Singh, DGM (HYDRO- GEO)

Sh. Abhinav Sukhija, SR. MANAGER (P&S)

Sh. Rakesh Sharma, SR. MANAGER (REGIONAL ENGG)

Minutes of Meeting of POE held online on 17th April 2024

Regarding Flip Bucket and Plunge Pool of Koldam HPS (4x200MW).

1. PREAMBLE

An online meeting of POE was held on 17th April 2024. Following members of Panel of Experts (PoE) were present:

Dr Gopal Dhawan

Sh. V K Gupta

Sh. A K Mishra

Dr. Y P Sharda

Shri R Jayaseelan could not attend due to his pre-occupation.

2. NTPC Presentation

NTPC presented the present status of works related to Plunge pool and Plan to carry out works in current working season. A comparison of condition of Plunge pool after dewatering in 2023 and 2024 was presented through photographs of Plunge pool taken during June 2023 and April 2024 respectively . NTPC informed that the deepest level after dewatering in Plunge pool in 2023 could be achieved only down to about 488m whereas during this season the bottom level in Plunge pool could be further excavated down to about 481.5m. Columns of jet grouting carried out during last season are visible at that level. It was further informed that NTPC is going ahead with all the works /activities related to strengthening measures in Plunge Pool as already recommended by PoE during previous meetings.

Further, NTPC informed that NIRM has carried out the 3D analysis and some portion in central & right-side cladding between El 489 m & El 501m indicate area of distress even after considering all remedial measures and NIRM suggested further ground improvement in the form of jet grouting/ consolidation grouting in this area. NIRM has further carried out analysis presuming that after jet grouting in this area the ground will achieve strength parameters equivalent to M5 concrete. Analysis with revised inputs indicate safe slopes in the distressed area flagged above. After discussion with NTPC, NIRM, has evolved that jet grouting may be carried out in the sloping portion between El 489m & 501m or consolidation grouting at 1.5m c/c spacing may be carried out to achieve strength parameters equivalent to M5 concrete in this area. The same was discussed during PoE meeting.

NTPC also informed that an attempt was made to carry out analysis to check stability of Piling envisaged to be provided along wraparound cladding walls wherein piling are

found to be stable by providing some fixity at the top i.e. pile cap level. In this regard, NTPC submitted that the reinforcement in Pile cap and foundation slab of wraparound cladding wall may be kept continuous to provide this fixity.

3. Deliberations & Recommendations:

After detailed deliberations on the above, POE recommended the following:

i. Joints in vertical direction at about 20m interval (depending on the geometry of wraparound cladding wall) may be provided in wrap around cladding walls.
ii. As advised earlier, cores may be taken from jet grouting columns carried out last season for checking the strength.
iii. Grout holes being drilled through concrete cladding may be filled with non-shrink concrete (in concrete portion of holes) after completion of grouting through the hole.
iv. 1m thick concrete cladding may be provided from El 489m to 501m (in central and right cladding) after completing activities of grouting & cable anchor.
v. Jet grouting may be carried out at El 489.5m platform. Simultaneously, some samples of sheared phyllites may be taken from surface and after crushing mixed with cement (with and without accelerator) and tested to check the efficacy of setting time & strength of the samples to estimate achievable strength of sheared phyllite in foundation after grouting.
vi. Jet grouting be carried out with care avoiding any upward pressure on existing concrete cladding. The experience of jet grouting may be shared with PoE after grouting of 3 to 5 holes.
vii. Data of tests at Sl. No V & VI may be shared with POE for review and arriving at alternative solution like injection grouting.
viii. Reinforcement being provided in Pile cap and foundation slab of wraparound cladding wall may be kept continuous.
ix. Site proposal of doing some jet grouting in slushy area to carry out activity of piling in that reach is acceptable provided this work does not disturb the overall work completion schedule.
x. Plum concrete may be provided behind wraparound cladding walls.
xi. PoE again emphasised need to complete all planned plunge pool works (as advised earlier including as stated above) before onset of monsoon & NTPC assured PoE for the same.

Sh. V.K. Gupta

Dr Gopal Dhawan

Sh. A K Mishra

Dr Y P Sharda

Minutes of the meeting of POE held (MS-TEAMS) on 14th June 2024

Regarding Spillway and Plunge Pool of Koldam HPS (4x200MW).

1. **Preamble**

A virtual meeting on MS-Teams was held with POE on 14th June 2024. Following members of Panel of Experts (PoE) attended the meeting.

Sh. R Jayaseelan

Sh. V.K.Gupta

Dr Gopal Dhawan

Sh. A K Mishra

Dr Y P Sharda

List of NTPC officials participated in meeting is placed at Annexure- I.

2. **Meeting Deliberations**

The NTPC informed that the spillway was operated three times @ discharge of 1500 cumec for around 3-4 hrs in each operation between 25th May 2024 and 28th May 2024 due to increase in river inflow caused by snow melting on account of increase in temperatures in the catchment of Satluj River. This seriously impacted NTPC's endeavour to complete the works as per recommendations of PoE. NTPC Koldam gave a presentation to appraise the status of works which could be executed during this season before 26.05.2024, the day when spillway had to be operated unscheduled.

Following was presented:

a) The works which were scheduled to be done vis-à-vis actually could be executed related to Cavity/Crack Filling with Concrete, treatment of spillway joints, cable anchors on cladding, consolidation grouting, secant pilings, ground improvement by jet grouting, wrap around wall concreting and concrete apron.

Works scheduled and achieved are given in the Table below:

Sl	Major Activities	Progress Achieved till 25.05.2024/Scheduled	Actual Date
1	Concreting in Crack/Cavity Filling	4831 /9000 cum	11.01.24 to 25.05.24
2	Concreting in Wrap Around Wall	18729 /38000 cum	26.02.24 to 25.05.24
3	Concreting for Secant Piling	1654/3840 cum	08.04.24 to 25.05.24
4	Concreting at Toe of Plunge Pool	2767 /6105 cum	23.04.24 to 25.05.24
5	Secant Piling	133/300no.	06.04.24 to 25.05.24
6	Ground Improvement- Jet Grouting Col. No.	86 /300	18.04.24 to 25.05.24
7	Consolidation Grouting	6012 /8752 m	27.09.23 to 22.05.24

[illegible]	Cable Anchors	[illegible] cable anchors installed	15.04.24 to 24.05.24
[illegible]	Dewatering of Plunge Pool	Completed	25.03.24 to 15.04.24
11	Dyke Work	[illegible]	23.10.23 to 15.03.24
[illegible]	Jet Grouting in Dyke seepage cut off – No.	307/307	21.11.23 to 29.05.24

b) POE members noted with concern that truncated working season had adversely affected execution of works as per recommendations of PoE. Main support measure of cable anchors could not be done. The PoE further mentioned that all the recommended measures are required to be completed.

c) NTPC informed that no damage / crack / movement / settlement has been observed in the spillway and plunge pool when spillway was operated between 26th and 28th May 2024 at 1500 cumec for 3 to 4 hrs in each operation.

d) Considering the work as already carried out by site (refer para "a" above), the Project authorities submitted a way forward for execution of balance works for protection of Left and Right side of slopes of plunge pool as under:

(i) Construction of approach road and undertake secant piling and

(ii) Concrete cladding above water level only.

The above way forward was suggested keeping in view the procedural requirements of contract for the execution of the complete recommended works before next monsoon season. Site proposed to keep observing the plunge pool and associated structures for next one season as the toe has been protected as mentioned above along with monitoring of joints/ cracks as per existing monitoring plan. However, if any movements are observed in future, then dewatering shall be done for completing the balance recommended works.

Further, it was submitted by site that, for better hydraulics in the plunge pool, the left-hand side hill (as shown in Annexure III) may be profiled by systematic excavation and slope protection. It was also suggested by site that suitable spur structure may also be constructed on the left bank of river at right side of plunge pool.

It was also submitted by site that it could be very difficult to carry out balance recommended concreting works which is estimated to be around 1 lakh cum within a working window of 2-3 months.

3. POE Recommendations:

POE deliberated the status, way forward and difficulties submitted by the site regarding carrying out of balance works and recommended as follows: -

a. The PoE did not agree with the way forward proposed by the project at 2(C) above. The PoE stated that works which were suggested already in the previous recommendations are to be completed by dewatering the plunge pool. This becomes necessary since it has been observed when first

dewatering was done, that heavy scouring and dislodgement of the cladding blocks have taken place below the water surface. It had led to development of cracks/openings above water level, in the structure and rock slopes. Moreover, in spite of some works done in the first season, it has been seen, upon dewatering in this season, that heavy scour and further dislodgement of cladding blocks have occurred and further cracking/opening has taken place on the sides. Treatment of damages below water surface is of prime importance to stabilise them first to minimise its impact above the water level. Protection measures suggested for right bank of the river may also be completed

b. Last para of 2(d) stating that concreting works of the magnitude expected cannot be done in the limited period needs to be looked into in detail.

The PoE expressed its faith in the project team that with previous experience of handing dewatering, they will be able to complete the balance works in totality during the next season. PoE stated that spillway of Kol Dam is the lifeline of this project. Hence, contractual difficulties, if any, are to be resolved well in time and necessary works are to be performed without taking any chance with the safety of the structure.

c. Physical hydraulic Model studies are required to be undertaken for profiling of plunge pool left bank junction with river, and during model studies improvement in plunge pool flow condition with provision of spur, if any, can also be examined. Plunge pool left side slopes will have to be profiled by systematic excavation along with suitable slope protection measures, based on the results of hydraulic model studies.

d. PoE also brought out the following issues:

The damages observed so far are with spill flows of only about a fifth of the design flood (PMF in this case). Hydraulic model study has been conducted up to SPF. It is necessary to assess the conditions/exigencies that could arise if design flood occurs, by extrapolation of the results obtained from the model studies in respect of the extent and zones of deep scour and very high return velocities below the water surface that could occur. The level of overall protection works required need to be rechecked and the additional works, if any, planned accordingly.

It was suggested to prepare Technical Memos on the following:

- Overall scour that could be anticipated, its zones, extent of occurrence and its impact on the stability of hill slopes all around.
- Design checks for slope stability and anticipated erosive damages due to high velocity return flows, to ensure overall safety of the plunge pool.
- Water levels with oscillations generated at the power house Tail Race outlet for safety against any possibility of flooding of the PH.
- Impact, if any, on the downstream slope of the toe of the rockfill dam due to high water levels generated with oscillations.

Above points shall also be deliberated in next meeting of PoE alongwith various other points as raised by Sh Jeyaseelan through his earlier communications.

4. NTPC has approached the Central Water Commission for Consultancy Services for solving the issues faced in the spillway Concrete Chute Structure and the Plunge Pool. Input from CWC could be value addition and will be very useful. NTPC agreed to keep the Panel of Experts informed of the developments.

Sh. R Jeyaseelan

Sh. V.K. Gupta

Dr. Gopal Dhawan

Sh. A K Mishra

Dr Y P Sharda

Annexure -B

CENTRAL WATER COMMISSION

DAM SAFETY ORGANISATION

REPORT OF DAM SAFETY INSPECTION OF KOLDAM HYDRO POWER PROJECT OF NTPC

REPORT ON REVIEW OF DAM SAFETY ASPECTS OF KOLDAM HYDRO POWER PROJECT, HIMACHAL PRADESH (27th and 28th, June 2022)

1. PREAMBLE

NTPC requested Central Water Commission (CWC) for review of dam safety aspects of their first hydro power project "Koldam". Accordingly, an inspection team consisting of the following officers of CWC visited the Koldam project on during 27th to 28th June, 2022:

1. Sh. Anil Jain	: Director, Embankment (N&W) Directorate
2. Sh. Rahul Kumar Singh	: Director, Gates (NW&S) Directorate
3. Sh. Rakesh Gautam	: Deputy Director, Dam Safety Monitoring Directorate
4. Ms. Shachi Jain	: Deputy Director, Instrumentation Directorate

2. INSPECTION PROGRAMME

The team reached Kol dam project location in the afternoon of 27th June, 2022. On the same day, there was a meeting with the Head of the Project and other officials of NTPC wherein presentation was made by officials encompassing the its history, investigations, execution and construction, various dam safety measures being taken by the project authorities, instrumentation readings and analysis and other operation & maintenance related issues followed by brief discussions (mainly regarding dams and appurtenant structures).

On 28th June, 2022, the team along with the project officials carried out comprehensive inspection of the dam starting from project visitors gallery, dam crest, upstream and downstream slopes, spillway, decanting/desilting chamber of the power house, hydro-mechanical equipments, gallery U-2, reservoir rim area, instrumentation and a short visit was also undertaken to the power house. CWC team was also apprised about the conditions of various instruments installed in the dam, galleries and abutments and the schedule followed for taking instrumentation readings, presentation of data and its analysis. In the evening, there was a meeting again with the project Head and other officials of NTPC. The list of officials present during the inspection is given as ***Annexure-I***. Photographs of the pertinent portions of dam and appurtenant structures are presented in this report as Plates at ***Annexure-II***.

CWC team was apprised about various dam safety inspections carried out by the Project authorities on a regular basis and was provided with sample reports (on demand) of the Kol dam during the inspection. The interpretation report although not comprehensive, but was informative about the condition of the dam to some extent.

3. PROJECT BRIEF

Kol dam is the first hydro power project undertaken by NTPC which is located in the Bilaspur district of Himachal Pradesh state on the river Satluj, at about 6 Km u/s of existing Dehar Power House of Bhakra Beas management Board (BBMB). As reported by the project officials, the construction of the project started in 2004 and completed in 2013. The project was inaugurated in October, 2016. Koldam Hydro Power Project consists of a 167m high and 500 m long earth and rock fill dam with a central clay core and a chute spillway with flip bucket. The dam toe power house has 4 x200MW Francis turbines. A chute spillway with six radial gates has been provided on the left bank to pass a Probable Maximum Flood of 16,500 cumecs. A network of galleries has been provided in the abutments to provide for access for grouting of rock mass and draining out of seepage water. Total 17 galleries have been provided with a length of 3.2 Km in addition to gallery in the body of spillway. Galleries 1 to 12 are grouting galleries while the remaining galleries 13 to 17 are drainage galleries. A decanting/desilting chamber is provided just u/s of the power intake for allowing water having sediment particles less than 0.25 mm only into the penstocks. Salient features of the Project is placed as ***Annexure-III***.

4. OBSERVATIONS AND RECOMMENDATIONS

Dam and Reservoir

In general the Upstream and downstream slopes of the dam were found to be well maintained. Reservoir level during the inspection was EL. 637.7858 m.

During the inspection of Gallery no. 2, substantial seepage was observed from the top in the inclined gallery no 6 adjoining to gallery no.2. However, the drainage gallery and the foundation gallery could not be visited by the team, however, team witness the visuals from the gallery camera. Some small amount of flooding was observed from the visuals. Appropriate rehabilitation measures may be carried out to reduce the quantity of seepage water and make the drainage galleries relatively in dry condition. Further, the quality of seepage water from the formed drains as well as foundation drains appears to be clean. It was advised to regularly test/ analyze for contents of fines/salts and take appropriate remedial actions if warranted. It is further emphasized that separate measurement of dam body seepage, both quantitative and qualitative, from the abutment seepage is important so as to ensure the health of dam core and filter material.

Most of the foundation drains on the floor of foundation gallery were discharging water except a few. The clogged drains shall be reamed and cleaned for serving their intended purpose. Besides recording of pore pressure measurements, the quantum of flows from the foundation drains is being observed regularly. It was informed that quantity of seepage water

(about 2000 lpd) is under the limit set during the design. The seepage record was being measured to mark increasing or decreasing trend with time.

It was observed that sufficient lighting installations were in place covering entire length of drainage and grouting galleries. However, electrical arrangements over a part of the gallery no.2 were non-functional. All electrical installations shall be made working and may be encased in water tight conduits.

The reservoir rim was inspected from a boat and some slide zones were observed. It was informed by the project authorities that most of the slides have become stable. It is advisable that reservoir rim shall be monitored regularly for detection of any slope movement and potential slides in the vulnerable areas due to road construction activity or any other activity.

Spillway

It was observed that there is a lot of erosion/scour in the plunge pool area of the chute spillway on account of which, there is substantial movement in the flipping bucket of the chute. The project authorities informed that to address this problem rehabilitation measures including grouting. Micro piling (on the LHS) etc on the recommendation of various experts have been done earlier but there was no significant improvement in the condition. However, after 100 ton; 60 m deep cable anchoring and deep grouting, carried out last year, there was reduction in the rate of displacement last year. Further, on the right side the erosion/cutting has been stabilised/protected by placing tetra pods.

It was informed that as per the recommendation of the panel of experts, the project authorities are planning to dewater the plunge pool area to thoroughly investigate the health of the toe and pool and various protection measures like secant pile, grouting and concreting (cast-in-situ) below 485 are to be implemented thereafter accordingly as per requirement.

Team observed that so far maximum release from the spillway is of the order of 1000 cumec. It was informed that Left bank area of the plunge pool is almost stabilized now. However, the team suggested that some protection measures may be implemented on the left side as well, as the same may be vulnerable in case of high flood discharge from spillway. It was also suggested that minimum required waterway, as per physical modal study may be ensured to avoid extensive erosion.

Hydromechanical Equipments

The general condition of the radial gates, hoists and sealing arrangement of the chute spillway were found to be satisfactory. Project authorities informed that Gate No.2 stuck at 2.0 to 2.5 m of opening. The same is attributed to the misalignment of wall plate/side seal seat due to faulty construction or local spalling of concrete in the pier. It was further informed that the work of chipping of the defective portion of first/second stage concrete is

soon to be taken up and re-concreting of the same will be carried out after proper alignment of wall plate and side seal seat. The conditions of stop logs, their storage, their operating crane etc. were also inspected visually and found generally in order. Project authorities have not reported any issue in the four number of bonneted power intake gates operated by hydraulic hoist in dam chambers. However, small seepage observed in the breast wall of the power intakes chambers and the same was under repair by grouting.

Radial and vertical lift gates constructed for initial controlled filling of dam in diversion tunnel no.2 (DT-2) are showing heavy leakage. These gates have been plugged partially. However, due to heavy leakage and loss of water, project authorities has planned to plug the DT-2 completely as no future use is intended for these gates /Diversion Tunnel. Complete plugging of the Diversion Tunnel No 2 shall be carried out at the earliest to stop further water loss thru this tunnel.

Instrumentation

A wide range of instruments have been provided in the dam complex for monitoring its behavior as intimated by the project authority. The instruments namely Piezometers (Vibrating wire), joint meter, normal plumb line, inverted plumb line, strong motion accelerograph, measurement beams, cell settlement system, V-Notch, automatic water level recorder were observed to be installed in the dam and its appurtenances. Some instruments in the gallery No. 2 were test checked for their working conditions and it was found that inverted plumb line was not working as the same is under the process of automation and will start working soon.

It was further informed that overall about 83% of the instruments are in working conditions and readings for all are being collected on regular basis. Readings for most of the instrumentation are coming in DAS at the Control centre built beside the abutment near dam top and the manual observations are being recorded on a weekly basis. All the data is being stored in excel format sample of which have been shared by the project authorities with the team.

Data of all the instruments installed in various components of the dam complex are being monitored regularly and the interpretation reports are being prepared by the project authorities on quarterly basis. In addition the pre monsoon and post monsoon inspections are also being carried out and sample reports (one each) were shared and discussed with the team during the visit.

A network of targets have been fixed on the downstream side face of dam and precise observation of deformation are being carried out using total Station for monitoring the overall performance of the dam. A total settlement of 60 cm of dam from initial readings (MB18- MB25 on U/S) has been reported till March 2022 as per the sample interpretation report (Jan-2022 to Mar 2022) shared by the project authority.

The inspection checklist as per the Appendix B of the *Guidelines for Safety Inspection of Dams* has been prepared on the basis of field observations and information provided by the project authorities and the same is enclosed at ***Annexure IV***.

5. OTHER ISSUES & RECOMMENDATIONS

1. The issue of arresting movement and erosion near plunge pool area should be taken on priority. For which detailed geotechnical investigation programme need to be framed to establish possible scour of the foundation material.
2. The measures to arrest the heavy seepage in the diversion tunnel DT-2 from the plug gated, roof etc should be taken up on the priority. It was informed to the team that efforts for the same are undergoing and the team witnessed project authority has managed to keep seeping water in right side of the tunnel in order to start the work on the other side.
3. The small seepage observed in the breast wall of the power intakes should be arrested before the monsoon.
4. The full lifting of the radial gate no 2 should be ensured immediately by taking necessary civil and mechanical works.
5. It is advised that NTPC may establish a dedicated Dam Safety Unit manned by properly trained personnel at the field level with responsibility for perpetual periodical surveillance, and for carrying out routine inspections and monitoring of the operation and maintenance of the dam.
6. The Action Taken Report of the previous inspection which has not been submitted yet may be submitted at the earliest. Extent of compliance of the recommendations of this inspection shall be brought into the records for next inspection.
7. The copy of the inspection reports (pre and post monsoon) shall be sent to the Dam Safety Monitoring Directorate of CWC on regular basis. Also, annual report on the Dam instrumentation shall be prepared by the dam authorities and a copy of the same to be sent to the Instrumentation Directorate, CWC.

6. ACKNOWLEDGMENTS

The Team expresses its sincere thanks to the management of NTPC for entrusting it with the important task of dam safety inspections of the prestigious Koldam project. The team places on record its gratitude to each and every project official associated with this inspection for their cooperation and hospitality extended by them to the CWC Team.

Annexure-I

List of NTPC officers associated during Dam Safety Inspection Koldam

	Name	Designation
1	Nandan Singh Thakur	Head of Project, Koldam
2	Lav Tandon	GM (O&M)
3	Surinder Kumar Garg	DGM (C&I/P&S)
4	Rakesh Rathee	DGM (FES)
5	Virendra Kumar Singh	DGM (Geology)
6	Durgesh Kumar Joshi	DGM (Civil)
7	Akhilesh Chandra Joshi	DGM (FQA)
8	Jagat Singh Yadav	DGM (Engg.), HRHQ
9	Amit Goyal	Sr. Manager (MTP)
10	Manjeet Negi	Sr. Manager (Operation)
11	Abhishek Dhiman	Sr. Managet (MMD)
12	Abhinav Sukhija	Sr. Manager (P&S)
13	Lucky Junas	Sr. Manager (C&I)

Annexure-II

PLATES

Bird's eye view of Kol Dam

Decanting chamber

Tail race channel

View of Gallery No. 2

Dam and Reservoir

Cable anchoring and grouting near plunge pool

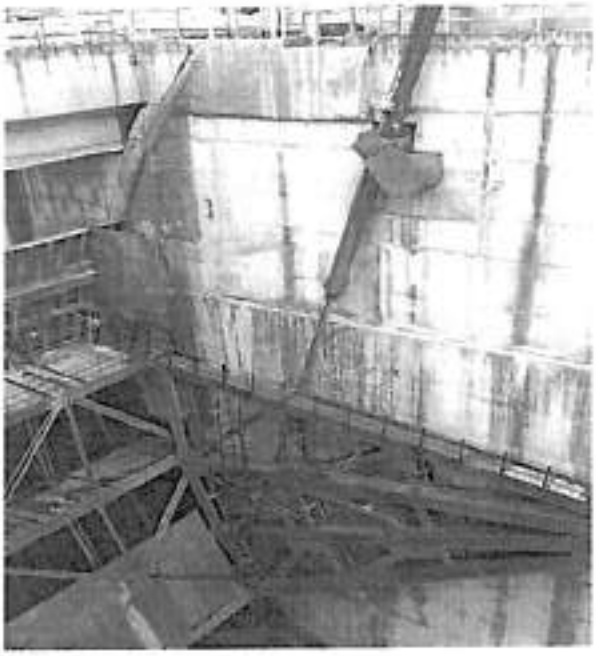
Wide crack in the side walls of the chute due to settlement in the toe area of the plunge pool

Stabilization by tetrapods on the right side of the plunge pool

Erosion/scour in the plunge pool area (LHS)

Spillway and Plunge pool

Radial gate



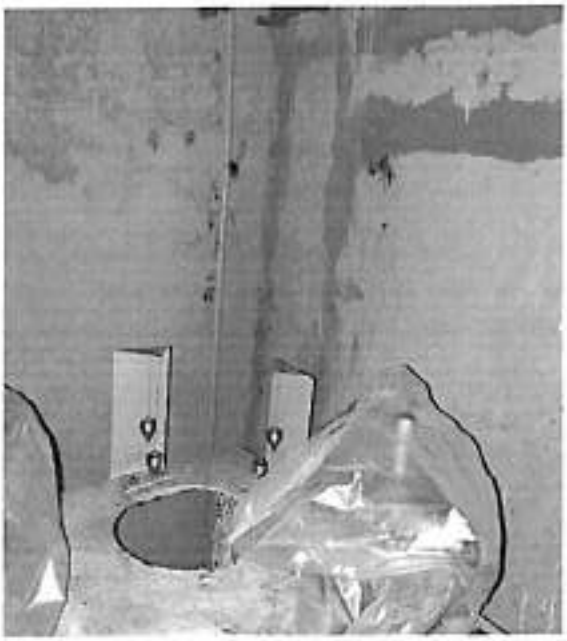
Wall Plate

Intake Gate

Diversion Tunnel 2

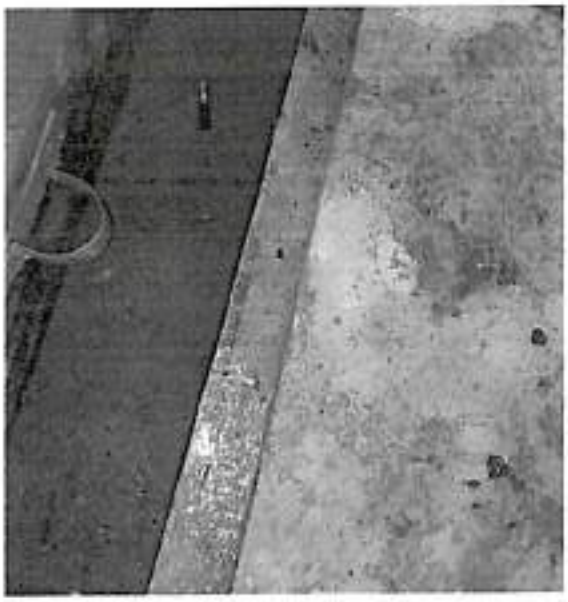
Hydromechanical Equipments

Jointmeter (Vinchen apparatus)



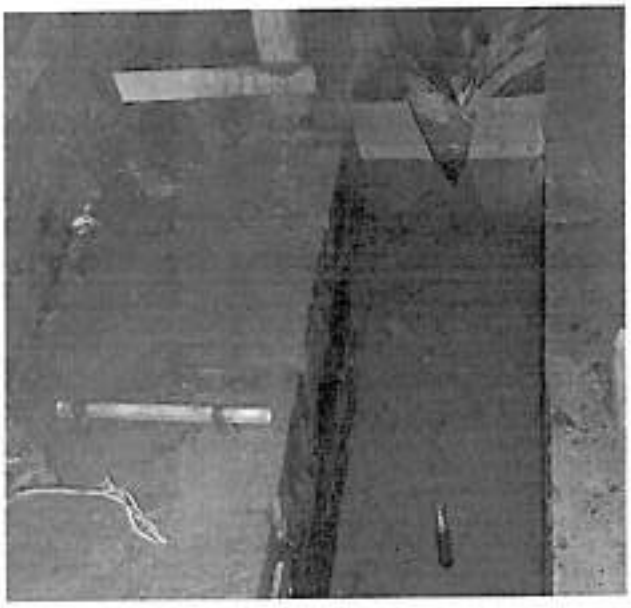
Inverted Plumb Line (Non functional)

Pore Pressure Measurement



Automatic Water Level Measurement in Drain

Instrumentation Installations in Spillway Gallery No.2



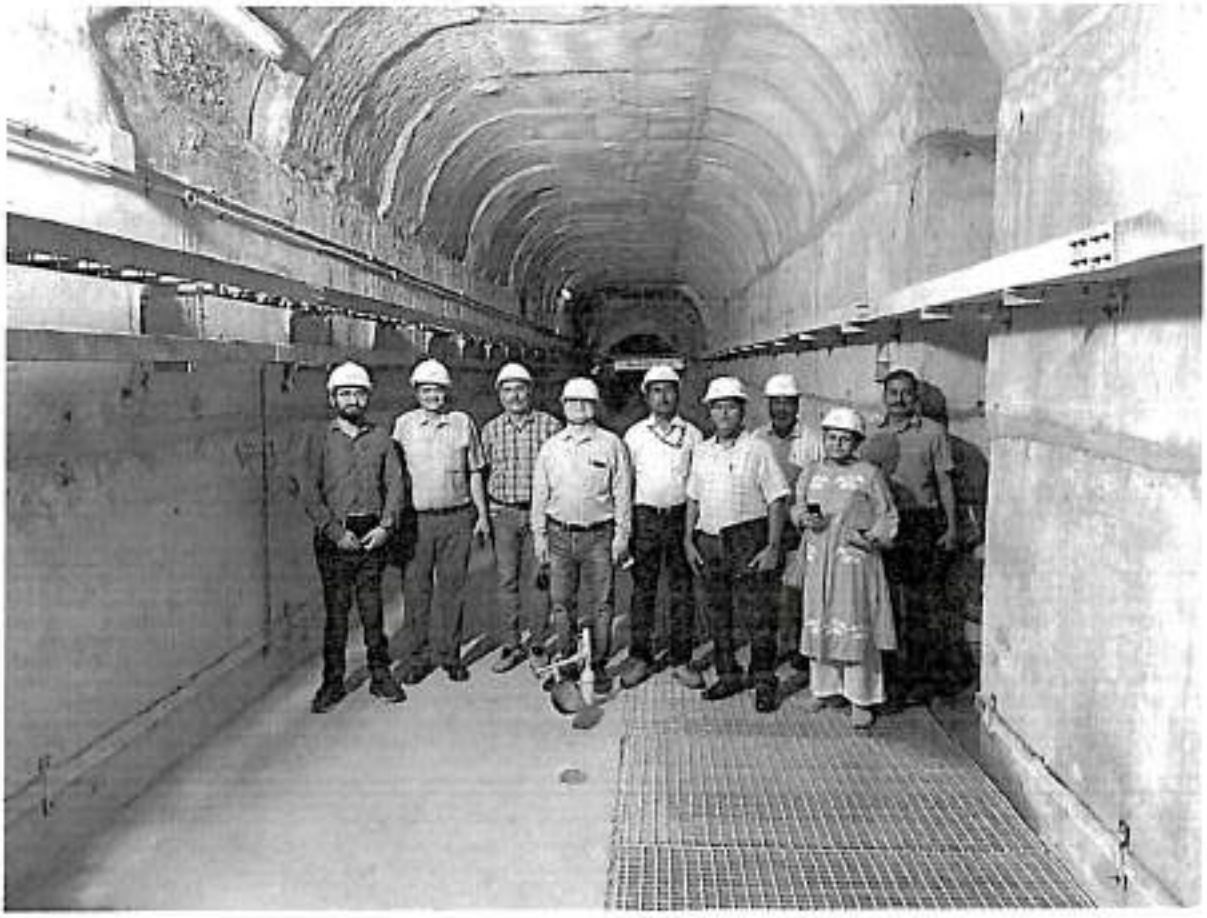
Flow Measurement in Spillway Gallery No.2

Strong Motion Accelerograph near the Right Abutment on the top of Dam

Cell Settlement System in the Dam Body on the Downstream Side

Automatic Water Level Recorder

Instrumentation Installations



INSPECTION OF KOLDAM HYDRO POWER PROJECT, HIMACHAL PRADESH BY CWC TEAM ALONG WITH PROJECT OFFICIALS (28th, JUNE 2022)

Annexure III

Salient Features

KOLDAM HYDRO POWER PROJECT			
(a)	State		Himachal Pradesh
(b)	District		Bilaspur
(c)	Latitude & Longitude at Dam		Latitude N 31° 23' 30"Longitude E 76° 52' 12"
(d)	Township Elevation		865 m (MSL)
(e)	Nearest rail head		Kiratpur
(f)	Nearest Airport / Approach		Kullu (Bhuntar) / NH 21
(g)	Location		On River Satluj about 4 kms upstream of Slapper Bridge on NH-21, Bilaspur(H.P)
(h)	Capacity		800 MW (4 X 200 MW)
(i)	Generation		3054 Million Units (90 % dependable year)
(j)	Power evacuation		400 KV Integrated Transmission System
(k)	Beneficiary of power		29.75 % of total generation to H.P (12 % free of cost, 15 % on bus bar tariff & 2.75 % as grid allocation) and rest of power to SEBs of Northern grid.
(l)	Land Acquired		About 1485 Hectares
i	**Hydrology and Climate**		
	Catchment		53770 Sq.Kms.
	Maximum annual rainfall in catchment		2450mm
	Minimum annual rainfall in catchment		570mm
	Design flood for		
(a)	Spillway probable Maximum Flood		16,500 m^3/s
(b)	Design Flood for river diversion during construction (1 in 200 years return period)		6,500 m^3/s
(c)	Standard Project Flood		11,400 m^3/s
(d)	Available discharge (without storage) in 90% dependable year		102 m^3/s
(g)	Max. temperature		45°C
(h)	Min.temperature		2°C
ii	**Diversion structure**		
(a)	Diversion tunnel		2 Nos
(b)	Diameter & Shape		Finished Dia 14m Horse Shoe Shape (Excavated Dia 16.4m)

(c)	Length of tunnels		T-1 = 901m	
			T-2 = 934m	
(d)	No & Type of Gates		4 Nos Vertical	
(e)	Inlet level (EL.)		510 m	
(f)	Outlet level (EL.)		503 m	
(g)	Av. Slope		T-1 = 0.78%	
			T-2 = 0.75%	
(h)	Discharge Capacity		6500 Cumecs	
(i)	Maximum Velocity		20m/sec	
iii	**Dam**			
(a)	Type		Rock and gravel fill with impervious central clay core	
(b)	Crest of Dam		648m	
(c)	River Bed		502m	
(d)	Lowest Foundation Level		481m	
(e)	Height above deepest foundation		167m	
(f)	Crest length (m)		493.11	
(g)	Base Width (U/S to D/S with Cofferdams), m		690.134	
(h)	Crest width		14m	
(i)	Slopes		Up- stream slopes	
			up to El 610.00 = 1.8(H) : 1(V)	
			Above El 610.00 = Varies as 2.16(H) to 2.23(H) : 1(V)	
			Down-stream slopes	
			up to El 615.00 = 1.5(H) : 1(V)	
			Above El 615.00 = Varies as 1.62(H) to 1.68(H) : 1(V)	
(j)	Dam filling Materials & quantities			
			Main Dam	U/S Coffer Dam
	· Clay (M1)		21.72 Lac Cum	1.16Lac Cum
	· Filter(M2)		4.76 Lac Cum	-
	· Coffer Dam Filter(M3)		-	0.22 Lac cum
	· Filter(M4)		3.51 Lac Cum	0.50 Lac Cum
	· Gravel(M5)		20.40 Lac Cum	7.30 Lac Cum
	· Gravel(M6)		3.45 Lac Cum	-
	· Transition(M7)		5.42 Lac Cum	-
	· Rock fill(M8)		21.36 Lac Cum	-
	· Rock fill(M9)		30.75 Lac Cum	3.45 Lac Cum
	· Rip-Rap(M10)		2.03 Lac Cum	-
	Total		**113.40 Lac Cum**	**12.63 Lac Cum**
(k)	Coffer Dams			
	Type		Gravel fill with impervious clay core	
	Height and Crest Elevation		Upstream Coffer Dam - 73m, El. 558m (Included in main Dam)	

			Downstream Coffer Dam - 28.5m, El. 518.5m
(l)	Roads in main Dam		up-stream, 14m wide replaced with 1.0m RipRap
			down- stream,7m wide Bitumen Top, gradient 10%
(m)	Galleries		
	Finished Diameter		3.0 m (for Grouting Galleries)
			3.6 m (for Drainage Galleries)
	Left Bank Grouting Galleries		1- length = 248.10m, section = horse shoe, slope=0.2%
			2- length = 329.50m, section = horse shoe, slope=0.2%
			3- length = 97.50m, section = circuler, slope=100%
			4- length = 65.02m, section = horse shoe, slope=0.2%
			5- length = 102.80m, section = circuler, slope=100%
	Base Grouting Gallery		6- length = 161.30m, section = horse shoe, slope=0.2%
	Right Bank Grouting Galleries		7- length = 97.45m, section = circuler, slope=100%
			8- length = 61.42m, section = horse shoe, slope=0.2%
			9- length = 84.95m, section = circuler, slope=100%
			10-length = 85.20m, section = circuler, slope=100%
			11-length = 423.85m,section = horse shoe,slope=0.2%
			12-length = 471.30m,section = horse shoe,slope=0.2%
	Drainage Galleries		13-length = 377.70m,section = horse shoe,slope=2.75%
			14-length = 251.70m,section = horse shoe,slope=0.35%
			15-length = 186.40m, section = horse shoe,slope=0.5%
			16-length = 52m, section = horse shoe, slope=0.2%
			17-length = 80m, section = horse shoe, slope=3 %
iv	**Spillway**		
(a)	Type		Chute, Gated Crest
(b)	Crest level		EL. 625m
(c)	Total width of crest (Water Way excluding Peir & Guide wall Width)		102.6m
(d)	No. of gate bays		Six each of 17.1m wide.
(e)	Length of chute		460.52m
(f)	Type of gates		Radial (17.1 m wide x 17.74m high)
(g)	Right/ Left guide wall Length		403.551m ; Height Varies from 8.5-12m
(h)	Pier Width		6.0 m
(i)	Wier (Ogee)		33m (L) x 6m(w)
			19.737m(L) x varies (w)
v	Desilting Arrangement/Decanting Chamber		
(a)	Type		Submerged in the body of the reservoir.

(b)	Particle size exclusion		Preventing for particles 0.25mm size and above for entry
(c)	Perepheral Length along C/L of Piers(m)		357.054
(d)	No & Size of Trash Rack		14 Nos (12.98m Wide X 16.125 m High)
vi	**Reservoir**		
(a)	Top EL of Dam		El. 648m
(b)	Maximum reservoir level (MWL) corresponding to PMF		El. 646m
(c)	Full reservoir level (FRL)		El. 642m
(d)	Minimum draw down level (MDDL)		El. 636m
(e)	Gross Capacity at FRL		57,600 ha-m (576 MCM)
(f)	Dead storage capacity at MDDL		48,600 ha-m (486MCM)
(g)	Live Storage		9000 ha-m (90MCM)
(h)	Maximum reservoir depth		140m
(i)	Area of Reservoir		13.20 sq. km
vii	**Power Intake**		
(a)	No and size of Bays		4 nos. of 6.45 m x 6.45 m
(b)	No of Gates		4
(c)	Size & Type of Gates		6.45m x 6.45m Vertical slide gates
viii	**Penstock Tunnels**		
(a)	No. of Penstock tunnels		4 Nos Circular steel lined
(b)	Maximum discharge through each Penstock tunnel		196.0 m3/s
(c)	Finished Diameter of Penstock tunnels		6.45m
(d)	Max. velocity through Penstock		6.0 m/s
(e)	Total Length of 4 Penstock tunnels		1765 meter
(f)	Penstock Valve		Butterfly
ix	**Power Plant House**		
(a)	Type		Surface
(b)	Power house size		170.2 m x 68.69m x 50.5m
(c)	No. of Units		4
(d)	Type of turbines		Francis, vertical shaft
(e)	Installed capacity		800 MW (4x200 MW)
(f)	Rated unit Capacity		200 MW
(g)	Firm Power at 100% load factor		101.9 MW
(h)	Maximum gross head		140.0m
(i)	Minimum gross head (Flood Condition)		121m
(j)	Maximum Net Head		137.7m

(k)	Minimum Net head (Flood Condition)		119.1m
(l)	Design Head		134.75m
(m)	Maximum flow through each unit		196.0 cumecs
(n)	Synchronous Speed		166.6 RPM
(o)	Generator		
	-Type		Synchronous, Vertical Shaft
	- Power factor, generator voltage		0.9, 13.8 kV
(p)	Size of machine hall		94.50m x 27m x 50.5 m
x	**Tailrace Channel**		
(a)	Type		Open Channel
(b)	Length		100m
(c)	Minimum tail water level		El. 502m
(d)	Maximum tail water level		El. 525m (at PMF)
xi	**Switchyard**		
(a)	Type of Switchyard		AIS (Air Insulated Switchyard)
(b)	Number of bays in the switchyard		16
(c)	Transmission Voltage		400 KV
(d)	No. of Towers		13
(e)	Evacuation System		Through 400 KV Line coming from Nathpa- Jhakri
(f)	Location		Open
xii	**Power Benefit**		
(a)	Firm Capacity		
	1) 90% dependable year		101.9MW Continous
	2) 50% dependabel year		137.0MW continous
(b)	Energy Generation		
	1) 90% dependable year		3054 GWh
	2) 50% dependable year		3369 GWh
(c)	Design Annual Energy		2990.34GWh

Annexure IV

SCHEDULED DAM SAFETY INSPECTION FORM[1]

Part 1a - Inspection Details:

Dam Name:	**Kol Dam**	**Project ID Code (PIC):**	**HP32VH0014**
Dam Type:	**Rock and gravel fill with impervious central clay core**	**Dam Purpose:**	**Hydropower**
Dam Owner:	**National Thermal Power Corporation (NTPC)**	**Hazard Classification:**	**NA**
Dam Operator:	**NTPC**	**Type of Inspection:**	**Safety Inspection**
Commissioning Date:	**March 2015**	**Inspection by:**	**CWC Team**
City/State/PIN:	**Himachal Pradesh**	**Date of Inspection:**	**28th June 2022**
District:	**Bilaspur**	**Reservoir water level in metre on the date of inspection:**	**637.7858 m**
Latitude:	**N 31° 23' 30"**	**Storage Capacity (MCM):**	**(i) Gross 57,600 ha-m (576 MCM)** **(ii) Live 9,000 ha-m (90MCM)**
Longitude:	**E 76° 52' 12"**	**Weather Conditions:**	**Hot, humid and cloudy**
Important Controlling Level	**a) TBL RL El. 648m** **b) MWL RL El. 646m** **c) FRL RL El. 642m** **d) Spillway Crest RL El. 625m** **e) MDDL RL El. 636m**		

[1] This annexure is derived from the published ***Guideline for Safety Inspections of Dam***, Appendix-B "Scheduled Dam Safety Inspection, Instructions and Forms, Pages B-1 to B-12.

Annexure IV

f) Lowest River bed RL El. 502m
g) Deepest foundation level RL El. 481m

Part 1b - Inspection Remarks:
Please provide any additional information or comments not covered by Part 1a form above.

Annexure IV

Part 2a - Inspection Checklist:

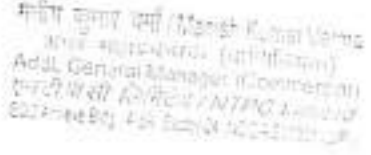
Sl. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory /Poor/Fair/ Satisfactory)
		Y	N	NA		
A-Reservoir						
A-1.1	**General Condition**					
1.1.1	Is the reservoir water level unusually high or low?		√			**Satisfactory**
1.1.2	Are there signs of decline in water quality?		√			
1.1.3	Are there signs of recent sediment deposition?		√			
1.1.4	Is floating debris present?	√				
1.1.5	Any indications of major active or inactive landslide area in the reservoir rim If so, indicate their locations and extent.		√		Reservoir Rim stability Report attached as Annex A	
1.1.6	Are there people or livestock in and around reservoir?		√			
1.1.7	Any other issues?		√			
B-Dam and Dam Reach (Embankment)						
B-1.1	**General Condition**					
1.1.1	Any major alterations or changes to the dam since the last inspection?		√			**Satisfactory**
1.1.2	Is there any new nearby development in the downstream floodplain?		√			
1.1.3	Any misalignment of poles, fencing or walls due to dam movement?		√			
B-1.2	**Upstream Slope**					
1.2.1	Any signs of bulging or concavity (depressions)? If so, indicate their locations and extent. (Check up the cross-sections with tape and level at random locations, at least two)		√			**Satisfactory**

Annexure IV

Sl. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory /Poor/Fair/ Satisfactory)
		Y	N	NA		
1.2.2	Does the section of the dam and upstream slope appear structurally sound and stable?	√				
1.2.3	Presence of longitudinal or transverse cracks?		√			
1.2.4	Whether any signs of distress to stability of slopes noticed at any time in any part of the dam? If so, give brief details of the incidents and location, the method of treatment adopted and its effectiveness. Indicate the general condition of upstream pitching.		√			
1.2.5	Any degradation to slope protection (rip-rap)?		√			
1.2.6	Is there any profuse growth of bushes or weeds over any portion of the dam? If so, indicate the locations.		√			
1.2.7	Does the upstream slope shows existence of crab holes or holes made by rodents or burrowing animals or ant hills? If so, indicate the locations.		√			
1.2.8	Any other issues?		√			
B-1.3	**Crest of Dam**					
1.3.1	Is the crest profile at proper elevation? (To be test checked at random locations by taking level)		√			**Satisfactory**
1.3.2	Does it show any signs of excessive and/or uneven settlement? If so, indicate such locations and extent of settlement. (Surface settlement points must be installed for observing this aspect)		√			
1.3.3	Is the surface of the crest free from undulations and local depressions or heaving?	√				
1.3.4	Does it provide an all-weather road surface?	√				

Annexure IV

Sl. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory /Poor/Fair/ Satisfactory)
		Y	N	NA		
1.3.5	Any degradation to access road (sealed/unsealed)?		√			
1.3.6	Does it develop any visible cracks in transverse or longitudinal directions? If so, attach a map showing their locations and extent. Depth of cracks must be ascertained by taking open trenches extending below the bottom of cracks.		√			
1.3.7	What is the condition of the edges of crest? Have got eroded and cut up resulting in reduced effective width?		√			
1.3.8	Is the crest free from local slips throughout its length on either sides?	√				
1.3.9	Do the headers, guard stones and parapet wall provided at the edges of the crest appear in proper profile and plumb?	√				
1.3.10	Any degradation to upstream parapet or downstream curb wall?		√			
1.3.11	Evidence of livestock on dam crest?		√			
1.3.12	Trees or profuse growth of weeds/bushes at any location?		√			
1.3.13	Proper lighting arrangement at dam top?	√			Inspection was done during day light	
1.3.14	Any other issues?		√			
B-1.4	**Downstream Slope**					
1.4.1	Any signs of bulging or concavity (depressions)?		√			**Satisfactory**
1.4.2	Are there any wet or slushy patches or any concentrated leaks, springs or trickles observed on the downstream slopes or the toe? If so, indicate their locations and extent. Please look out for patches of extensive vegetation growth and examine them carefully and record the findings.		√			
1.4.3	Presence of longitudinal or transverse cracks?		√			
1.4.4	Any signs of distress to the stability of slopes?		√			



Annexure IV

Sl. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory /Poor/Fair/ Satisfactory)
		Y	N	NA		
1.4.5	Are rain cuts/erosion channels present at any location?		√			
1.4.6	Are all the rain cuts and erosion channels properly treated and made good? Please indicate location of recurring damages, if any.	√				
1.4.7	Is there any profuse growth of bushes or weeds over any portion of the dam? If so, indicate the locations.		√			
1.4.8	Does the downstream slope shows existence of crab holes or holes made by rodents or burrowing animals or ant hills? If so, indicate the locations.		√			
1.4.9	Any other degradation to slope protection (turfing)? Indicate the general condition of downstream pitching/ turfing and rock toe.		√		General condition of downstream pitching/ turfing and rock toe is good	
1.4.10	Is the downstream area clear of debris and free draining?	√				
1.4.11	Any other issues?		√			
B-1.5	**Downstream Drainage**					
1.5.1	Are there any signs of water logging, slushy conditions or growth of aquatic weeds on the downstream of the dam? To be checked upto 300 m downstream of toe		√			**Satisfactory**
1.5.2	Are there any standing pools of water in the downstream of dam? If so, give their locations and extent. To be checked upto 300 m downstream of toe		√			
1.5.3	Are there any boils observed in the vicinity of the downstream toe of the dam? If so, give locations.		√			
1.5.4	Is the downstream area sufficiently clear and free draining?	√				
1.5.5	What is the depth of ground water table on the downstream as evident from the existing wells in the vicinity of the dam				Piezometers readings attached as Annex B	

Annexure IV

Sl. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory /Poor/Fair/ Satisfactory)
		Y	N	NA		
	To be checked upto 300 m downstream of toe. Does the water table show any marked variation in accordance with the variations in reservoir water level?					
1.5.6	Are all the exposed drains working satisfactorily?	√				
1.5.7	Toe drains and cross drains. i. Are the portions of longitudinal toe drain and exposed cross drains beyond the downstream toe of the dam in regular section and freely draining? ii. Is the pitching to these drains intact? iii. Is there any weed growth in these drains? iv. Indicate other defects noticed in the drains, if any.	√ √	 √ √		Information provided	
1.5.8	Outfall Drain: (a) Is the outfall drain in proper shape and grade and freely draining? (b) Is the outfall drain properly cleaned and maintained? Does the outfall drain show any stagnant pools of water or weed growth?	√ √	 √		Information provided	
B-1.6	**Surface Drainage of Downstream Slope**					
1.6.1	Is the condition of the downstream slope drainage arrangements, if provided, satisfactory?	√				**Satisfactory**
1.6.2	Is the paving to these drains intact?	√				
1.6.3	Are all the drains properly maintained and free of vegetation growth and debris?	√				
1.6.4	Does the slope have a tendency to develop severe rain cuts at any location?		√			
1.6.5	Enumerate any other defects noticed in the surface drainage of		√			

Annexure IV

Sl. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory /Poor/Fair/ Satisfactory)
		Y	N	NA		
	downstream slope.					
B-1.7	**Seepage Measurement**					
1.7.1	Is the quantity of seepage being daily or periodically measured and recorded? Please check the registers and record observations.	√				Fair
1.7.2	Does it show any abnormal rise or fall? If so, does it have any relation to a certain reservoir level elevation?		√		The seepage in the foundation gallery is high owing to flooding.	
1.7.3	Does the seepage show a turbid colour at any stage? Was such a phenomenon observed at any stage at any location in the past?		√			
1.7.4	What is the measured rate of seepage flow with date and reservoir level; i. On the day of present inspection(31.05.2022) ii. Maximum since last June (04.05.2022) iii. Minimum since last June (17.05.2022)				 6655 L/Min.(639.3m) 6843 L/Min.(641.2m) 6577 L/Min.(638.8m)	
1.7.5	Is the portion upstream and downstream of measuring points of seepage easily accessible with proper steps and paths and free of vegetation growth?		√			
1.7.6	Are the measuring points properly located, constructed and maintained so as to give accurate and reliable measurements of seepage in accordance with the relevant IS Codes?	√				
1.7.7	Is the method of taking seepage measurements satisfactory?	√				
B-1.8	**Breaching Section (if provided)**					
1.8.1	Is the breaching section easily accessible?			√		
1.8.2	Is the condition of the breaching section satisfactory?			√		
1.8.3	Is the note of instructions as to when and how to operate the breaching section available on record?			√		
1.8.4	For reconstruction after the breach are the following items			√		

Annexure IV

Sl. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory /Poor/Fair/ Satisfactory)
		Y	N	NA		
	decided in advance? a) Quarry for embankment material b) Suitable routes of access Is the maintenance staff fully aware of the instructions related to operation of the beaching section and for reconstruction after the breach					
1.8.5	Ascertain and indicate the latest event of operation of breaching section and its performance.			√		
1.8.6	Evidence of recent degradation?			√		
1.8.7	Any other issues?			√		
B-1.9	**Junction of Earth work with Masonry/Concrete dam sections and outlets**					
1.9.1	Is there any existence of leaks, springs or wet spots in the earth work in the vicinity of the junctions between earth work and masonry works? If so, what is the approximate rate and colour of the leakage? Does it turn turbid at any time? Please ascertain from enquiries and record the findings.		√			Satisfactory
1.9.2	Is there any tendency for separations, cracking, settlement or upheaval of the earth work in the vicinity of masonry or concrete? If so, indicate the locations and the exact nature of deficiency.		√			
1.9.3	Is there any tendency for surface erosion or slope instability at the junction?		√			
1.9.4	If the outlet conduit is located in the earth dam section, is the entire length of the conduit in perfect order and profile and free from offsets, open joints, cracks and leakage? Examine the conduit carefully from the downstream or from			√		

Annexure IV

Sl. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory /Poor/Fair/ Satisfactory)
		Y	N	NA		
	inside, if possible, and indicate the deficiencies observed, if any.					
1.9.5	Any other issues?			√		
B-1.10	**Relief Wells**					
1.10.1	Are the relief wells in good working condition and functioning well?			√		
1.10.2	Are the relief properly surged and cleaned periodically?			√		
1.10.3	Please indicate the dates of last surging and cleaning and the next surging due.			√		
1.10.4	Are the necessary plant and equipment for cleaning the relief wells, available with the office?			√		
1.10.5	Is the record of periodical measurements of discharge from each relief well maintained? If so, indicate total discharge and maximum discharge observed from a single well on the date of inspection.			√		
B-1.11	**Abutment Contacts**					
1.11.1	Any presence of leaks, springs or wet spots near the abutment?		√			**Satisfactory**
1.11.2	Any presence of cracking, settlement or upheaval of earthwork?		√			
1.11.3	Any evidence of erosion or slope instability?		√			
1.11.4	Trees or profuse growth of weeds/bushes?		√			
1.11.5	Any degradation to up/downstream slope protection (rip-rap, turfing)?		√			
1.11.6	Any other issues?		√			
C-1	**Dam and Dam Block/Reach (Concrete/Masonry)**					
C-1.1	**General Condition**					
1.1.1	Any major alterations or changes to the dam since the last inspection?			√		

Annexure IV

Sl. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory /Poor/Fair/ Satisfactory)
		Y	N	NA		
1.1.2	Is there any new nearby development in the downstream floodplain?			√		
1.1.3	Any misalignment of poles, fencing or walls due to dam movement?			√		
C-1.2	**Upstream Face**					
1.2.1	Evidence of surface defects (honeycombing, staining, stratification)?			√		
1.2.2	Concrete/masonry deterioration (spalling, leaching, disintegration)?			√		
1.2.3	Is cracking present (structural, thermal, along joints)?			√		
1.2.4	Evidence of differential settlement (displaced/offset/open joints)?			√		
1.2.5	Presence of vegetation (growth in joints between blocks)?			√		
1.2.6	Evidence of any other damage to joints and/or water stops?			√		
1.2.7	Any other issues?			√		
C-1.3	**Crest of Dam**					
1.3.1	Evidence of differential settlement (displaced/offset/open joints)?			√		
1.3.2	Presence of cracking (structural, thermal, along joints)?			√		
1.3.3	Profuse growth of weeds/grass/plants at any location?			√		
1.3.4	Any degradation to access road?			√		
1.3.5	Any degradation to upstream parapet or downstream curb wall?			√		
1.3.6	Any other issues?			√		
C-1.4	**Downstream Face**					
1.4.1	Evidence of surface defects (honey-combing, staining, stratification)?			√		
1.4.2	Concrete/masonry deterioration (spalling, leaching, disintegration)?			√		

Annexure IV

Sl. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory /Poor/Fair/ Satisfactory)
		Y	N	NA		
1.4.3	Presence of cracking (structural, thermal, along joints)?			√		
1.4.4	Evidence of differential settlement (displaced/offset/open joints)?			√		
1.4.5	Presence of vegetation (growth in joints between blocks)?			√		
1.4.6	Evidence of any other damage to joints and/or water stops?			√		
1.4.7	Excessive seepage/sweating at any location on downstream face?			√		
1.4.8	Significant leakage at any location on downstream face?			√		
1.4.9	Any other issues?			√		
C-1.5	**Abutment Contacts**					
1.5.1	Any presence of leaks, springs or wet spots in vicinity of abutment?			√		
1.5.2	Any presence of cracking or settlement?			√		
1.5.3	Profuse growth of weeds/grass/plants at any location?			√		
1.5.4	Any other issues?			√		
D	**Gallery/Shaft and Drainage (Concrete/Masonry)**					
D-1.1	**General Condition**					
1.1.1	Slushy condition or water logging immediately downstream of dam?		√			**Fair**
1.1.2	Any evidence of boiling in vicinity of dam toe?		√			
D-1.2	**Gallery/Shaft Condition**					
1.2.1	Any problems accessing or inspecting gallery/shaft (obstruction)?		√			**Fair**
1.2.2	Any safety issues (inadequate handrails, lighting or ventilation)?		√			
1.2.3	Problems of inadequate drainage (slippery stairs, water logging of gallery, clogged porous or foundation drains)?	√			Excessive seepage/flooding in the foundation/drainage gallery	
1.2.4	Evidence of differential settlement (displaced/offset/open joints)?		√			
1.2.5	Excessive seepage/sweating at any location along gallery/shaft?	√				
1.2.6	Significant or excessive leakage at any location along	√			Drainage and foundation galleries	

Annexure IV

Sl. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory /Poor/Fair/ Satisfactory)
		Y	N	NA		
	gallery/shaft / porous drain? If yes, provide location(s).					
1.2.7	Are proper arrangements made for the measurement of seepage into the gallery? Is the seepage measured separately from- 1. Porous pipes? 2. Foundation drains? And 3. Monolith Joints? Are the above arrangements satisfactory?	√				
1.2.8	Has there been substantial progressive reduction in the seepage through the foundations? Is it due to choking of the drain holes? If so, indicate number of holes choked.		√			
1.2.9	Are all the foundation and porous holes periodically cleaned with reaming tool and air water jetting? Indicate the last date of such cleaning and extent of variation observed in the seepage discharge before and after the cleaning.			√	Informed by the PA	
1.2.10	Is the seepage water and the deposit, if any, from the seepage being regularly examined for chemical composition? If so, indicate the result and the probable source of dissolved salts, if any.	√			Yes, regularly examined in chemistry lab	
1.2.11	Are any seepage water springs observed in the downstream area any where? If so, indicate the locations and state the physical nature of this seepage. Look out for such seepage spots particularly near the dykes, fault zone etc. Ascertain if chemical testings are made of water samples from such springs for dissolved salts.		√			
1.2.12	Is there any leachate deposition? If yes provide location	√			Some Leachate deposition in parts of the spillway gallery	
1.2.13	Any other issues?		√			

Annexure IV

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		Y	N	NA		
D-1.3	**Drain Condition**					
1.3.1	Is the flow in the drain unusually high or low?		√		The drain inspected was in fairly good condition	Fair
1.3.2	Presence of calcium or other deposits in drain?		√			
1.3.3	Is dewatering pumping station fully operational?	√				
1.3.4	Any problem inspecting pump?		√		Informed by PA	
1.3.5	Any obstruction preventing or impairing smooth operation?		√			
1.3.6	Any deterioration of pump and associated equipment?		√			
1.3.7	Is sump well clean and maintained?		√			
1.3.8	Is V-notch before sump well clean and maintained?	√				
1.3.9	Any other evidence of the drain being blocked/having reduced section?		√			
1.3.10	Is the flow in the drain noticeably sporadic/irregular?		√			
1.3.11	Does the drainage water have unusual color (leachate)?		√			
1.3.12	Any other issues?		√			
D-1.4	**Body Wall (Masonry/Concrete) of 'NOF' Dam and Spillway**					
1.4.1	What is the total seepage into gallery from the porous pipes in the dam at lake full condition? How does it compare with the seepage when the reservoir was first filled? (For the corresponding water level)			√		
1.4.2	If there has been substantial reduction in this seepage? Ascertain and indicate the probable reasons therefore.			√		
1.4.3	Has there been a tendency for gradual reduction of drainage through pipes and progressive appearance of sweating on the downstream face of the dam?			√		
1.4.4	Has there been considerable leaching from the seepage water and deposition of lime near the seepage exit spots?			√		

मनोज कुमार वर्मा/Manoj Kumar Verma
अति महाप्रबंधक (परियोजना)
Addl. General Manager (Comm.)

मनोज कुमार वर्मा/Manoj Kumar Verma
अति महाप्रबंधक (परियोजना)
Addl. General Manager (Comm.)

Annexure IV

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		Y	N	NA		
1.4.5	Are the samples of the seepage water and reservoir water being regularly tested for reactive and corrosive properties?			√		
1.4.6	Is there excessive seepage, sweating at any locations on the downstream face of the dam? (Examine the monolith or construction joints for such seepage and leaching and indicate the findings)			√		
1.4.7	Is there any swelling or cracking observed on the downstream face especially near the points of concentration of stresses like the toe or locations of abrupt change in geometry of the face of the opening? If so, indicate the details of observations.			√		
1.4.8	Is the pointing on upstream face of the dam in good condition? If not, indicate the nature and extent of deficiency.			√		
1.4.9	Are the registers and graphs showing the periodical measurements of seepage discharge from the porous drains in the gallery and from the downstream face at various lake levels maintained at site?			√		
D 1.5	**Waste Weir Bar and Tail Channel**					
1.5.1	Is the Concrete/masonry spillway bar in good condition? Is there any leakage through the masonry or from the foundation? If so, what remedial measures are proposed/taken for minimizing the leakage? Is the record of leakage measurement maintained? What is the quantity of Seepage/Leakage on the date of inspection?			√		
1.5.2	Is the coping over the spillway bar in good condition?			√		
1.5.3	Does the upstream and downstream face of waste weir bar need pointing?			√		
1.5.4	Is there any scouring on downstream side of the bar and/or EDA?			√		

Annexure IV

Sl. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory /Poor/Fair/ Satisfactory)
		Y	N	NA		
	If so what remedial measures are proposed/taken?					
1.5.5	Are there any damages or undermining to guide walls, divide wall and other appurtenants? If so, what remedial measures are proposed/taken?			√		
D 1.6	**Structural performance of the 'NOF' and 'OF' Portions of Dam Foundations**					
1.6.1	Are there any signs of structural distress noticed in the dam spillway and foundations in the form of-					**Fair**
	i. Excessive deflection with respect to permissible deflection at the time of design		√			
	ii. Tendency of gradual sliding		√			
	iii. Cracking and upheaval or settlement in any part of the body wall or foundations,		√			
	iv. Excessive uplift,		√			
	v. Excessive seepage and leaching through the body of the dam and the foundation.		√			
1.6.2	Conspicuous weathering of materials or components in any portion of the body wall or the foundations.			√		
E	**Spillway and Energy Dissipation Structure**					
E 1.1	**Spillway**					
1.1.1	Any problems inspecting spillway (obstructed access, damaged catwalk)?		√			**Fair**
1.1.2	Any obstructions in or immediately downstream of the spillway?		√			
1.1.3	Evidence of abrasion, cavitation or scour on glacis (e.g. exposed reinforcement)?		√			
1.1.4	Presence of displaced, offset or open joints?					
1.1.5	Presence of cracking (structural, thermal, along joints)?		√			

मनीष कुमार वर्मा / Manish Kumar Verma

Annexure IV

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		Y	N	NA		
1.1.6	Evidence of surface defects (honeycombing, staining, stratification)?		√			
1.1.7	Concrete/masonry deterioration (spalling, leaching, disintegration)?	√			Some amount of spalling observed in the pier concrete adjoining Gate No.2	
1.1.8	Presence of vegetation (growth in joints between blocks)?		√			
1.1.9	Evidence of any other damage to joints and/or waterstops?		√			
1.1.10	Excessive seepage/sweating at any location on spillway glacis?		√			
1.1.11	Significant leakage at any location on spillway glacis?		√			
1.1.12	Any other issues?		√			
E-1.2	**Energy Dissipation Structure**					
1.2.1	Any problems inspecting energy dissipation structure?		√			Fair
1.2.2	Any obstructions in or immediately downstream of dissipation structure?		√			
1.2.3	Evidence of abrasion, cavitation or scour on dissipation structure?	√			Erosion/ scouring in the toe of the chute adjoining the plunge pool	
1.2.4	Presence of displaced, offset or open joints?	√			Open joint between flipping bucket and chute. Being monitored regularly	
1.2.5	Presence of cracking (structural, thermal, along joints)?	√				
1.2.6	Evidence of surface defects (honeycombing, staining, stratification)?		√			
1.2.7	Concrete/masonry deterioration (spalling, leaching, disintegration)?		√			
1.2.8	Presence of vegetation (growth in joints between blocks)?		√			
1.2.9	Evidence of any other damage to joints?		√			
1.2.10	Any problems with under-drainage (blockage of open drain holes)?		√			

मनीष कुमार वर्मा/Manish Kumar Verma

Annexure IV

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		Y	N	NA		
1.2.11	Can the tail pond be drained easily for inspection of the stilling basin or bucket? If not, what are the alternatives available for dewatering? Please ascertain and indicate the last event of inspection of stilling basin (or bucket).			√		
1.2.12	From the examination of the levels and contour plans and reference marks in tail channel; ascertain if there is progressive erosion and retrogression in the tail channel. If so, indicate the extent and location of such erosion with reference to the various components of dam, spillway, outlet, power house etc.		√		Erosion/ scouring in the toe of the chute in the plunge pool	
1.2.13	Is the concrete surface of the stilling basin and apron (or bucket) in good condition? Are there any indications of pitting, cracking, spalling or wearing of the surface of bedding concrete? If so, please give details of the nature and extent of the damage.	√			Open joint between flipping bucket and chute Being monitored regularly	
1.2.13	Is there any indication of abrasion and cavitation damage (pitting of concrete) especially at friction blocks , chute blocks and slotted roller teeth, the surface near the lower tangent point and the end sill? If so, please give the details of nature and extent of damage.			√		
1.2.14	Is the under drainage of the stilling basin (or bucket) satisfactory? Are all the open drain holes clear and functioning well?			√		
1.2.15	Any other issues?		√			
F	**Intake/Outlet and Water Conveyance Structure**					
F-1.1	**Intake/Outlet Structure**					
1.1.1	Any problems inspecting intake/outlet structure (obstructed / unsafe access)?			√		
1.1.2	Any obstructions in, upstream or downstream of intake/outlet			√		

Addl. General Manager (Commercial)
एनटीपीसी लिमिटेड / NTPC Limited

Annexure IV

Sl. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory /Poor/Fair/ Satisfactory)
		Y	N	NA		
	structure?					
1.1.3	Evidence of abrasion, cavitation or scour on intake/outlet structure?			√		
1.1.4	Any evidence of structural distress (displaced/offset/open joints, cracking)?			√		
1.1.5	Any evidence of surface defects and/or concrete/masonry deterioration?			√		
1.1.6	Any other issues?			√		
F-1.2	**Water Conveyance Structure**					
1.2.1	Any problems inspecting intake/outlet structure (obstructed/ unsafe access)?			√		
1.2.2	Any obstructions in, upstream or downstream of water conveyance structure?			√		
1.2.3	Evidence of abrasion, cavitation or scour on structure?			√		
1.2.4	Any evidence of structural distress (displaced/offset/open joints, cracking)?			√		
1.2.5	Any evidence of surface defects and/or material deterioration?			√		
1.2.6	Any evidence of seepage or leakage from water conveyance structure?			√		
1.2.7	Any other issues?			√		
G-1	**Hydro-Mechanical Component and Pump**					
G-1.1	**Spillway Gates (Radial gates, Vertical lift gates, Automatic gates)**					
1.1.1	Any problems inspecting gate/Stop-logs (obstructed/unsafe access)?		√			Fair
1.1.2	Is the condition of the steel surface and the surface paint deteriorated?	√			Yes, planned for painting intimated by PA	

Prof. Prof. (Dr.) Manish Kumar Verma
Addl. General Manager (Comm.)

Annexure IV

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		Y	N	NA		
1.1.3	Are any connection bolts of rubber seals loosened or damaged? If so, indicate the details of defects.		√		No such thing observed in the visible portions	
1.1.4	What is the general condition of rubber seals? Do any of the rubber seals show signs of weathering, hardening, cracking or tearing and damage?		√		Seals have been replaced/ repaired recently (2019-20)	
1.1.5	Are the rubber seals of side and bottom touching uniformly all along the sealing surface?	√				
1.1.6	Do the rollers (wherever applicable) touch the track plates uniformly? Are the rollers well lubricated?	√			Guide rollers of Gate no 02 , 03 & 06 have been checked and serviced Bushes of Some guide rollers of Gate#2 & 6 have been replaced with new one.	
1.1.7	Are the embeded parts of spillway gates, emergency gates and stop-logs in sound condition and free from corrosion, uneven wear, cracking, chipping and dents? If not, state the nature of defects or deficiencies and observation, if any, regarding such defects.	√			Erosions in concrete structure have been observed due to which water leakage was observed from the concrete near the side plate area in Gate #2 & 4	
1.1.8	Check the following for structural soundness of all members and welded, bolted and riveted connections, uneven wear, uneven bearing, cracking, chipping and dents and indicate the findings: (1) Gate leaf and stiffeners (2) End arms (3) Trunnion girders / Yoke girder (Corbel provided) (4) Stop logs (5) Lifting beams (6) Gantry cranes (7) Tracks				All are in good condition	

Annexure IV

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		Y	N	NA		
	(8) Trunnion bracket (9) Chains/ wire ropes (10) Bridge structure					
1.1.9	Are the trunnion bearings of radial gates properly lubricated?	√			Self lubricating bearing	
1.1.10	Is there any damage or wear caused to the seal plates? If so, indicate the nature of damage noticed.		√			
1.1.11	Are any of the mechanical or structural components and fastners or seals subjected to excessive wear? If so, please give details. Is there any tendency for recurring damage to any particular component? If so, please give details.		√			
1.1.12	Is sufficient stock of spares which need frequent replacement maintained at the site?	√			Spares/ consumables which are frequently used like filters, hydraulic oil VG- 46/ 32, Grease etc. is maintained	
1.1.13	Any issues with storage of equipment (emergency stop logs, lifting beam and gate leaves)?		√			
1.1.14	Any deterioration, corrosion? scaling? pitting? or cracking? of equipment (connecting bolts, welds?)		√			
1.1.15	Any obstructions preventing or impairing smooth operation?	√			Spillway Gate#2 is openable up to 2.5 meter only. Rest all gates are fully operational.	
1.1.16	Any problems with the rollers (not touching tracks, inadequate lubrification)?			√		
1.1.17	Any debris, etc., in the gate grooves?		√			
1.1.18	Any damages to Radial Gate trunion pins? gate arms? lubrication? etc.?		√			
1.1.19	Any damage to embedded parts above waterline? access structure?		√			

Annexure IV

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		Y	N	NA		
1.1.20	Any damage to concrete grooves?			√	Water leakage from concrete structure (pier) of spillway Gate#2 towards Gate#1 side and Gate#4	
1.1.21	Is the staff posted at the site for maintenance and operation of gates, hoists, equipments and electrical installations, well experienced, fully trained and conversant with the job requirements and responsibilities?	√				
1.1.22	Are the following documents maintained at the respective location of all the units? (1) Maintenance schedules specifying each operation, its frequency and 'due' and' done' dates. (2) Operating instructions with 'dos' and 'don't' for all operational units.	√				
1.1.23	Are the trunnion hub and the brackets well maintained?	√				
1.1.24	Are the trunnions likely to get submerged during actual working of the spillway? if so, ascertain the causes for the same and specify. Please enquire for occurrence of such events, if any.		√			
1.1.25	Are all the nuts of connecting bolts and anchorages properly tightened?	√				
1..1.26	Any other issues?		√		There is a problem in installation of Stop Logs in Power Intake Gate#3 due to crack/ gap between guide rails of stop log grooves	
G-1.2	**Hoists, Cranes and Operating Mechanisms**					
1.2.1	Are the hoists working satisfactorily?	√				**Fair**
1.2.2	Any problems inspecting hoist/crane/operating mechanism?		√		Gantry Crane not available Power supply/ VFD Problem	
1.2.3	Is sufficient stock of spares which need frequent replacement	√				

Annexure IV

Sl. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory /Poor/Fair/ Satisfactory)
		Y	N	NA		
	maintained at the site?					
1.2.4	Is the full length of the chains or wire rope of the hoist in sound condition and free from broken strands?	√				
1.2.5	Is the electrical wiring in sound condition?	√				
1.2.6	Is the alternative power system for gate operation working properly?	√				
1.2.7	Is the alternate hand operation system of hoist working			√		
1.2.8	Any deterioration of equipment (connecting bolts, welds, surface, paint work?)		√			
1.2.9	Any wear or damage to wire cables and other moving parts?		√			
1.2.10	Any obstructions preventing or impairing smooth operation?		√			
1.2.11	Any health and safety concerns (e.g. lack of "danger" sign during maintenance)?		√			
1.2.12	Any other issues?		√			
G 1.3.	**Spillway Bridge, Hoist Bridge, Trunnion Level Bridge Catwalks**					
1.3.1	Are the decking, girders and structural supports of spillway bridge, hoist bridge, trunnion level bridge and catwalks structurally sound?	√				**Satisfactory**
1.3.2	Is the chequered platform of the bridge structurally sound and safe?			√		
1.3.3	Is there satisfactory arrangement to prevent unauthorized entry into the control structures and bridges?	√				
1.3.4	Are the structural members and joints sound and free from corrosion?	√				
1.3.5	When were the steel components painted last?	√			2015-16	
1.3.6	Is the surface of steel work and paints satisfactory?	√				

Addl. General Manager (Commercial)
NTPC Limited

Annexure IV

Sl. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory /Poor/Fair/ Satisfactory)
		Y	N	NA		
1.3.7	Is the parapet or railing over the bridges sound, safe and painted?	√				
1.3.8	Is the walkway properly enchored to the piers?	√				
1.3.9	Are the track rails for gantry cranes structurally sound and intact?	√				
G-1.4	**Valves**					
1.4.1	Any problems inspecting valve?		√			**Satisfactory**
1.4.2	Any obstructions preventing or impairing smooth operation?		√			
1.4.3	Any deterioration of valve and associated equipment?		√			
1.4.4	Any other issues?		√			
G-1.5	**Walls: Guide walls/Divide walls/Junction walls/Return walls/Spray walls etc. (Strike out whichever is not applicable)**					
1.5.1	Are all the locations of such wall accessible for inspection, maintenance and repairs?	√				
1.5.2	Is the drainage of back sides of the walls (wherever applicable) from the weep holes satisfactory? If not, indicate the nature of deficiencies.	√				
1.5.3	Is there any tendency for the water to undercut the ends of the walls?	√				
1.5.4	Is there any foundation erosion or scour noticed in the vicinity of such walls? If so, give the details of nature and extent of such damage.				Could not be observed	
1.5.5	Is there any surface erosion/damage caused, to face or body of such walls?				Could not be observed	
1.5.6	Do any of the walls show symptoms of unusual settlement, developments of cracks and tilting? If so, give details of the defects noticed.				Could not be observed	
1.5.7	Is there any damage to guide bunds? If so, give details of the				Could not be observed	

मनीष कुमार वर्मा / Manish Kumar Verma
अपर महाप्रबंधक (वाणिज्यिक)
Addl. General Manager (Commercial)
एनटीपीसी लिमिटेड / NTPC Limited
EOC Annex Bldg, A-8A Sector-24 NOIDA-201301 (U.P.)

Annexure IV

Sl. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory /Poor/Fair/ Satisfactory)
		Y	N	NA		
	damage.					
G-1.6	**EndWeir**					
1.6.1	Is it accessible?			√		
1.6.2	Is there any erosion, pitting or spalling of the concrete or masonry surface? If so, give details			√		
1.6.3	Is there any scour noticed on the immediate downstream of such weir? If so, give details of location and extent of such damage.			√		
G-1.7	**HydraulicPerformanceofEnergy DissipationArrangements**					
1.7.1	Do the flow conditions in the stilling basin (or bucket) have a tendency to draw material into the bucket and cause its churning and abrasion damage to the surface of buckets baffle blocks, apron and end sill? Is the hydraulic performance in agreement with the results of model studies? (wherever applicable) Ascertain the performance from observed tail water rating curves and deficient observation, if any, such as sweep outs and excessive erosion under plunge pools and locations of secondary rollers and retrogression.			√		
G-1.8	**Trash Racks**					
1.8.1	Is the trash rack fixed or movable?				Fixed	Satisfactory
1.8.2	What is the mode of cleaning? Is it manual or by TRCM?				By TRCM	
1.8.3	Is the welding work on Trash Rack in sound health?	√				
1.8.4	Any problems inspecting trash rack?		√			
1.8.5	Problems of excessive debris and/or inadequate cleaning?		√			
1.8.6	Any deterioration of trash rack (rust, corrosion, and damaged		√			

Annexure IV

Sl. No.	Inspection Item	Response[a] Y	N	NA	Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory /Poor/Fair/ Satisfactory)
	blades)?					
1.8.7	Any other issues?		√			
G-1.9	**Trash Rack Cleaning Machines**					
1.9.1	Any problems inspecting trash rack cleaning machine?		√			**Satisfactory**
1.9.2	Missing or inadequate spare parts (particularly requiring regular replacement)?		√			
1.9.3	Any deterioration of equipment (wheel trolleys, gantry structures, operating mechanism, connecting bolts, welds, surface, paint work?)		√			
1.9.4	Any wear or damage to wire cables and other moving parts?		√			
1.9.5	Any obstructions preventing or impairing smooth operation?		√			
1.9.6	Missing or inadequate provision of back-up/standby power supply?		√			
1.9.7	Any health and safety concerns (e.g. lack of "danger" sign during maintenance)?		√			
1.9.8	Any other issues?		√			
G-1.10	**Pumps**					
1.10.1	Any problems inspecting pump?		√		Informed by PA	**Fair**
1.10.2	Any obstructions preventing or impairing smooth operation?		√			
1.10.3	Any deterioration of pump and associated equipment?		√			
1.10.4	Any other issues?		√			
G-1.11	**Approach b r i d g e ,operation platform and cabin (for outlets):**					
1.11.1	Are the decking, girders and structural supports of approach bridge structurally sound?			√		
1.11.2	Is the floor of the operating platform structurally sound and safe?			√		
1.11.3	Is there satisfactory arrangement to prevent unauthorized entry			√		

मनीष कुमार वर्मा / Manish Kumar Verma
Addl. General Manager (Commercial)
NTPC Limited

Annexure IV

Sl. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory /Poor/Fair/ Satisfactory)
		Y	N	NA		
	into the control structures of the outlet?					
1.11.4	Are the structural members and joints sound and free from corrosion?			√		
1.11.5	When were the steel components painted last?			√		
1.11.6	Is the surface of steel work and paint satisfactory?			√		
1.11.7	Is the parapet or railing over the control tower, operating platform and approach bridge sound and safe?			√		
G-1.12	**Outlet**					
1.12.1	Is the air vent periodically cleaned?			√		
1.12.2	Are there any structural damages to the intake well?			√		
1.12.3	Is there any leakage observed through the well proper and the conduit concrete or masonry? If so, give details of its location and extent.			√		
1.12.4	Is there any damage noticed to the conduit concrete, breast wall and gates lots?			√		
1.12.5	Isthebye-pass valve/filling-in-valve (wherever provided) operating satisfactory? (a) Take operation trials of the following as provided andrecord the observations and defects noticed, if any. (1) Service gate(s). (2) Emergency gate(s). (3) Stop-log gate(s). (4) Sluice valves. Note- (i) The operating trial for the emergency gate shall be taken with			√		

Annexure IV

Sl. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory /Poor/Fair/ Satisfactory)
		Y	N	NA		
	service gate in partially open position to test the capability of emergency gate for self-closing under these conditions. The trial for the operation of the emergency gate under balanced condition of water pressure also needs to be taken (ii) To guard against the possibility of outlet gate hoist being operated forcibly after closed position of gate a "Distinctive Mark" should be insisted or check the functioning of the limit switches.					
1.12.6	Are there vibrations and noise noticed in operation of out-let gates at any time? If so, are any periodical observations taken to ascertain their severity?			√		
1.12.7	Is the energy dissipation arrangement working satisfactorily for all the discharges? Is there any structural damage to the energy dissipation structure? If so, give details of nature and extent of damage.			√		
1.12.8	Is the conduit structurally sound and reasonably leak proof? If not, give details of nature and extent of the defects.			√		
1.12.9	Is there any seepage noticed around the conduit as ascertained from the observations of the downstream conditions? If so, is it likely to cause (In case of earth dams) erosion and piping?			√		
G-1.13	**OutletGates**					
1.13.1	Is the surface of gates and the paint deteriorated?			√		
1.13.2	Are the connecting bolts of rubber seals properly tightened or damaged?			√		
1.13.3	Do the rubber seals show signs of weathering and damage and need			√		

Add. General Manager (Commercial)
NTPC Limited

Annexure IV

Sl. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory /Poor/Fair/ Satisfactory)
		Y	N	NA		
	replacements?					
1.13.4	Are the rubber seals of side sand bottom touching the bearing surface uniformly?			√		
1.13.5	Do all the rollers touch the track plates?			√		
1.13.6	Are the rollers well lubricated?			√		
1.13.7	Are the stem rods for lifting the gates perfectly straight?			√		
1.13.8	Is the operation of outlet gates smooth? Are the actual operations of lifting and lowering of the gates and hoist mechanisms adequate and smooth?			√		
1.13.9	Are all the gears and hoist mechanisms well lubricated?			√		
1.13.10	Is the storing arrangement for emergency gate leaves and the stop logs in satisfactory condition?			√		
1.13.11	Are the seal plates/seats in sound condition?			√		
1.13.12	Is the full length of wire rope (wherever applicable) of the hoist in serviceable condition and free from any broken strands?			√		
1.13.13	Are all the nuts of connecting bolt and anchors properly tightened?			√		
1.13.14	Are all the lifting beams in proper working order and in levelled condition. If not ascertain the nature and extent of problems. Do any of the mechanical or structural parts of the gate, fasteners of hoist show signs of excessive wear? If so, please give details.			√		
1.13.15	Is there any tendency for recurring damage to any particular component or components? If so, please give details.			√		
1.13.16	Is sufficient stock of spares, which need frequent replacement, maintained at the site?			√		
G-1.14	**River Outlet/River Sluice**					

Asst. General Manager (Commercial)
NTPC Limited

Annexure IV

Sl. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory /Poor/Fair/ Satisfactory)
		Y	N	NA		
1.14.1	Is the overall condition of river outlet works/river sluices satisfactory? Is the operation of the gate (Service/Emergency/Stop-log) satisfactory as ascertained by taking operating trial? If not, indicate the defects noticed.			√		
1.14.2	Are the trash racks (wherever provided) cleaned before monsoon?			√		
1.14.3	Is there excessive silting on the upstream of the sluice?			√		
1.14.4	When were the gates last opened for desilting, etc.?			√		
1.14.5	Please indicate the approximate quantity of the leakage through the gates, if any.			√		
1.14.6	Is there any seepage or leakage through the conduit surface?			√		
1.14.7	Is there any damage to the upstream and downstream convergence of the conduit?			√		
1.14.8	Is the condition of energy dissipation arrangement satisfactory? If not, indicate nature and extent of damage. Is there any retrogression noticed in the downstream channel? If so, give details of nature and extent of damage.			√		
H-1	**Access Road**					
H-1.1	**General Condition**					
1.1.1	Any problems ensuring security of dam site (including gates and fencing)?		√			**Satisfactory**
1.1.2	Is there a properly constructed and well maintained all weather access road to the dam site?	√				
1.1.3	What is the type of the pavement of the access road and its condition?				Bituminous, good condition	

Annexure IV

Sl. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory /Poor/Fair/ Satisfactory)
		Y	N	NA		
1.1.4	Are there properly constructed and well maintained access road arrangements to the following components for inspection, maintenance and repairs? Top of Dam Spillway Gates and hoisting arrangement Drainage gallery, adits and exits Bridge structure Downstream stilling basin Junction and abutments Outlet control tower Outlet gates Toe of earth dam, downstream drainage arrangements and berms. All saddle dams.	√				
1.1.5	What is the general condition of all the masonry structures on various access roads?			√		
1.1.6	Are all the structures on the access roads adequately safe for allowing passage of plant machinery for emergent repairs?	√				
1.1.7	Any obstructions along or at entrance to access road (temporary or long-term)?		√			
1.1.8	Any slope stability issues (road embankment or adjacent slopes)?		√			
1.1.9	Profuse growth of weeds/grass on or in vicinity of access road?		√			
1.1.10	Any drainage problems (standing water on or adjacent to road)?		√			
1.1.11	Any other degradation to road surface (ruts, potholes, cavities, cracking)?		√			
1.1.12	Any other issues?		√			
I-1	**Instrumentation**					
I-1.1	**General Condition**					
1.1.1	Are all the instruments installed accessible? (Attach separate list). Are all the locations properly lighted, ventilated and adequately protected from possibilities of damage?		√		As per Annexure-C	**Fair**
1.1.2	Any problems inspecting instrument (obstructed/unsafe access)?	√			Drainage galleries and Foundation gallery flooded	
1.1.3	Is the instrument vulnerable to damage or theft (inadequate		√		All are secured and protected	

Add. General Manager (Commercial)

Annexure IV

Sl. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory /Poor/Fair/ Satisfactory)
		Y	N	NA		
	protection)?					
1.1.4	Any problems ensuring correct functioning of instrument (lighting, ventilation)?		√		In a part of Gallery No 2 light was not working for taking readings	
1.1.5	Any evidence of degradation to condition of instrument (rusting, vandalism)?		√			
1.1.6	Are all the instruments in working order? Ascertain the cases of instruments going out of order and indicate.	√			Those sample checked in gallery 2 were found to be working **except inverted plumbline.** 83% working, remaining instruments failed during construction.	
1.1.7	Are all the registers of observations posted up-to-date? Please take test observations and initial the register.	√			Readings compiled and stored in excel from the field notebook same day	
1.1.8	Are all the plotting of the instrumentation data completed up-to-date? Are sufficient stocks of spares, gauges, master gauges, stationary items etc., maintained at the site for uninterrupted data collection?		√		Interpretation report prepared quarterly and shared for the first quarter (upto March 2022) Spares are there in the store as intimated	
1.1.9	Operator or public safety issues?		√			
1.1.10	Any other issues?		√			
I-1.2	**CommunicationFacilities**					
1.2.1	Are following facilities available at dam site? (i) Wireless Telephone / mobile/Fax/Internet	√				**Satisfactory**
1.2.2	Any other issue (please indicate part, location, etc., as necessary)		√			
K-1	**Emergency Preparedness**					
K-1.1.	**Emergency Action Plan**					
1.1.1	Is the Emergency Action Plan (EAP) prepared for the dam as per the national guidelines? If not, the expected date of preparation of guidelines	√			Informed by the PA	**Satisfactory**

Add. General Manager (Commercial)

Annexure IV

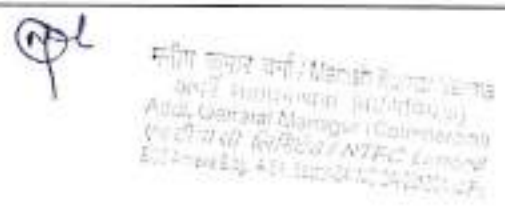
Sl. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory /Poor/Fair/ Satisfactory)
		Y	N	NA		
1.1.2	When EAP was last updated?				Reviewed on 15.12.2021	
1.1.3	If not, are any dam staff unaware or insufficiently conversant with the EAP?		√			
1.1.4	Any concerned authorities unaware or insufficiently conversant with the EAP?		√			
1.1.5	Are communication directories/contact details and other dynamic information are being updated annually?	√				
1.1.6	Any problems accessing or operating the communication/ warning system?		√			
1.1.7	Are inundation maps updated and available to concerned authorities?	√				
1.1.8	Are the concerned authorities informed about the system of emergency reporting procedures and warning?	√				
1.1.9	Are available safety spots on the downstream of the dam identified and made known to the concerned authorities? Are adequate warning devices and facilities provided at the dam?	√				
1.1.10	Are proper arrangements made for security of the dam and preventing cases of unauthorized trespass, vandalism and sabotage to the dam works?	√				
1.1.11	Date of last annual stakeholder consultation meeting along with mock drill exercise conducted	√			21.12.2021	
1.1.12	Does the EAP disseminated to all the concerned stakeholders?	√				
1.1.13	Any other issues?		√			
K-1.2	**Inspection of Records**					
1.2.1	Whether following Dam Safety Documents are prepared and approved by the competent authority?	√				**Satisfactory**

Asst. General Manager (Civil)
NTPC Limited

Annexure IV

Sl. No.	Inspection Item	Response[a]			Observations and recommendations, if any, of the authorized inspecting officer	Condition[b] (Unsatisfactory /Poor/Fair/ Satisfactory)
		Y	N	NA		
	i. As Built Drawings ii. EAP iii. Completion Report iv. Data Book v. O and M manual					
1.2.2	Are the relevant documents reviewed and updated from time to time?	√				
1.2.3	Are all the members of the maintenance staff adequately trained and fully conversant with their responsibilities concerning. (a) Designer's Operation Criteria. (b) Standing Operating Procedures. (c) Maintenance and Vigilance Procedures of the dam. (d) Maintenance and operation of all control equipments. (e) Reservoir Operation Schedules, Gate Operation Schedule (f) Maintenance and Operation of all instruments. (g) Identification of signs of deficient behavior. (h) Reporting Procedures of emergency situations. (i) Emergency repairs	√				

I.-1.1	**Inspection Photographs**	
1.1.1	Information furnished	
[a]Respond either yes (Y), no (N) or not applicable (NA). [b]Condition: Please rate the condition as either Satisfactory, Fair, Poor or Unsatisfactory as described below: 1. Satisfactory - No existing or potential dam safety deficiencies are recognized. Acceptable performance is expected under all loading conditions (static, hydrologic, seismic) in accordance with the applicable regulatory criteria or tolerable risk guidelines.		Satisfactory (except issue of erosion in Plunge



Annexure IV

2.	Fair - No existing dam safety deficiencies are recognized for normal loading conditions. Rare or extreme hydrologic and/or seismic events may result in a dam safety deficiency. Risk may be in the range to take further action.	pool)
3.	Poor - A dam safety deficiency is recognized for loading conditions which may realistically occur. Remedial action is necessary. Poor may also be used when uncertainties exist as to critical analysis parameters which identify a potential dam safety deficiency. Further investigations and studies are necessary.	
4.	Unsatisfactory - A dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution.	

Part 2b – Consolidated Dam Health Status Report:

SN	Observations/Significant Deficiencies Noticed	Remedial Measures Suggested
1.	Issue of erosion/scouring in the plunge pool near the toe and movement/settlement of flipping bucket portion.	The issue of arresting movement and erosion near plunge pool area should be taken on priority. For which detailed geotechnical investigation programme need to be framed to establish possible scour of the foundation material.
2.	The issue of heavy seepage from the diversion tunnel DT-2 was brought out by the project authority.	The measures to arrest the heavy seepage in the diversion tunnel DT-2 from the plug gated, roof etc should be taken up on the priority. It was informed to the team that efforts for the same are undergoing and the team witnessed project authority has managed to keep seeping water in right side of the tunnel in order to start the work on the other side.
3.	The small seepage observed in the breast wall of the power intakes.	The issue may be addressed before the monsoon

Annexure IV

4.	Issue in lifting of Gate No. 2	The full lifting of the radial gate no 2 should be ensured immediately by taking necessary civil and mechanical works.

Overall condition of dam based on above inspection – Satisfactory
Overall Safety Category* of the Dam – III

*Category I– deficiencies which may lead to failure;
Category II – major deficiencies requiring prompt remedial measures;
Category III – minor remedial measures which are rectifiable during the year

Name of Official(s) and Signature(s) :

1. Sh. Anil Jain :
2. Sh. Rahul Kumar Singh :
3. Sh. Rakesh Gautam :
4. Ms. Shachi Jain :

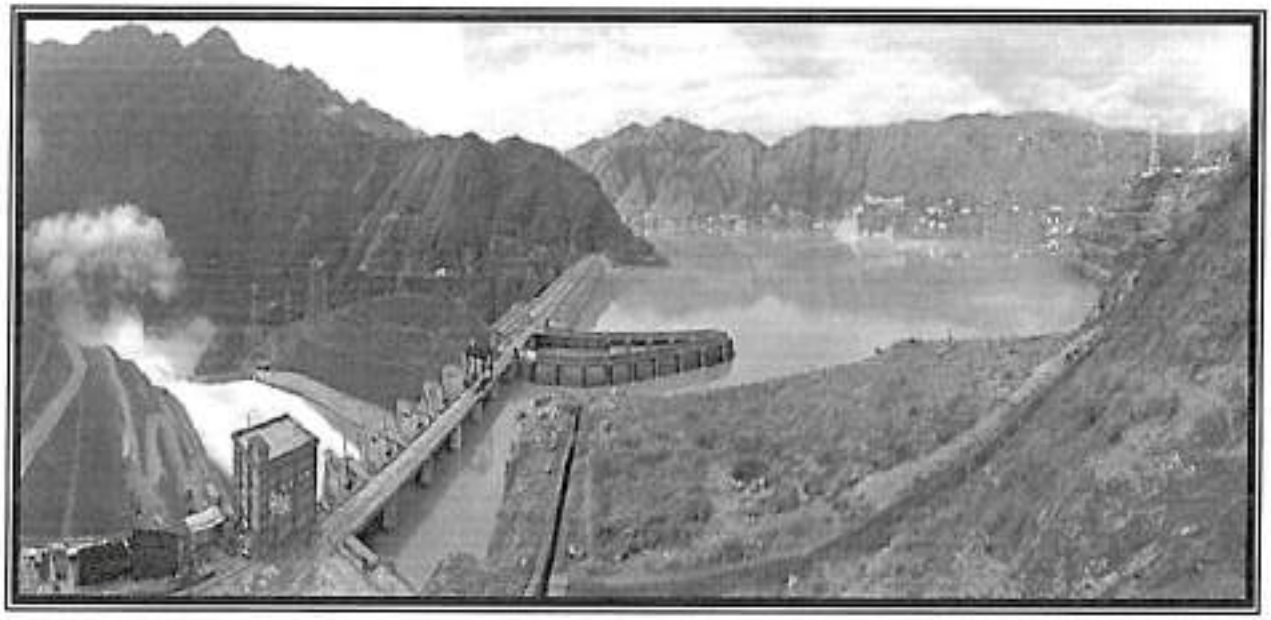
Annex-A

NTPC LTD

KOLDAM HYDRO POWER PROJECT

UPDATED REPORT ON THE RESERVOIR RIM STABILITY STUDY

MAY 2022



SUBMITTED BY:

VIRENDRA KUMAR SINGH (DGM - GEO)

SHIV KUMAR (SR MGR - MECH)

ARVIND (SR MGR - CIVIL)

Reservoir Rim Study Report May 2022

Representatives of Dam safety group inspected Rim area of the reservoir of Koldam HPS on 20.05.2022 for the post monsoon inspection. The reservoir rim area includes Bilaspur, Solan, Shimla and Mandi districts of Himachal Pradesh. Observations of the team on various landslides are as follows:

A) Kasol Road slide at Left bank:

Harnora - Kasol road above the quartzite quarry is at the EL: 670m approximately. During the Quartzite quarry excavation sliding occurred on January 2010. During the pre monsoon inspection on 20.05.2022, it is noticed that there is no further movement in the rock boulder and rock masses. The slide is to be regularly monitored for any further movement.
Presently this slide doesn't pose any threat to nearby Road at EL 720m, private land & dwelling units.
(Photograph enclosed)

B) Chamyon slide at Left bank:

During the Quartzite quarry excavation in the Chamyon area, a large conglomerate boulder found at the top of the quarry. The crest of the hill side cutting restricted at EL: 620.0 approximately as per the approved mining plan. However, after raising the water level, number of cracks observed in the agriculture field near Chamyon. Subsequent to the raising of reservoir, cracks widened and sliding occurred with falling of large boulders.

During the pre monsoon inspection on 20.05.2022, it is noticed that land slide has not enlarged since previous post monsoon inspection in June 2021, but has to be monitored regularly as boulder and rock masses are hanging which may fall, and presently this slide is not a threat for any dwelling unit, agriculture land nearby. (Photograph enclosed)

C) Kyan- Ahhan road slide at Right bank:

Kyan – Ahhan road above the DT inlet area is passed through the old existing sliding zone. This was under inspection since the pre impounding of Koldam reservoir. Longitudinal cracks and transverse cracks were widened gradually and it was fallen into the reservoir on 14.04.2015. Due to this landslide the road between Kyan and Ahhan was cutoff but connectivity is restored and there is no further slide since then.

During the pre monsoon inspection on 20.05.2022, it is observed the open cracks on the top and the slide may exaggerate due to steep slope, the continuous monitoring of zone is required. There is no dwelling unit, agriculture land nearby, but road is passing through the slide. (Photograph enclosed)

D) Slide near village Ahaen at Right bank:

RBM deposit along the reservoir has been falling and destabilizes the area. The area in this zone comprises of terrace deposit. During pre monsoon inspection on 20.05.2022, it is noticed that slide is stable since previous post monsoon visit. The slide is to be monitored. Presently this slide is not a threat for any dwelling unit, agriculture land nearby (Photograph attached).

E) Downstream of Village Neri at Left bank:

Three major slides noticed in rock mass on left bank, during inspection on Nov 2016, In post monsoon inspection in June 2018, it was observed from the landslide behavior that there is further movement in the rock mass. During pre monsoon inspection on 20.05.2022the slide found to be in similar condition. The slide is to be monitored regularly for further slide; however, there is no habitation or agriculture land in this area. (Photograph enclosed).

F) Downstream of Village Neri at Right bank:

At Approximately 3 kms of Downstream of village Neri, major slide observed on the right bank. From the behavior of

slide, it looks that slide occurred along a joint plane and it is a plane failure. During post monsoon inspection on 06.12.2021, the slide shows minor fall of debris and the slide may exaggerate due to steep slope. The movement in the area along the joint plane is being monitored using drone after the recommendation of the GSI. (Photograph enclosed).

G) Slides between village Neri and village Dogri at Left Bank & Right bank:

Two Slides between village Neri and village Dogri on (i) left bank and (ii) right bank of Reservoir. No habitation or agriculture field is located near to the slide and during pre monsoon inspection on 20.05.2022, the slide observed to be stable. (Photograph enclosed)

H) Slide at Village Boi on left Bank

This slide was first observed during inspection on 30.11.2016, during recent pre monsoon inspection on 20.05.2022, the slide found to be in similar condition, it is necessary to monitor the slide for any further sliding as this is recent slide and some movement may occur. (Photograph enclosed).

I) Slides noticed near village Neri at Left & Right Bank

Two new slides were observed during post monsoon inspection in May 2017, during recent pre monsoon inspection on 20.05.2022, one of the slides found to be active and other one is stable and in similar condition, No residential house or agricultural land is located near the slide. (Photograph enclosed).

J) Madraich near the NTPC bridge at Left Bank

As such there is no active slide in this area as of now but the monitoring of this area is started since the one of the resident of this village had complaint about the stability of his house.

PHOTOGRAPHS

A) Kasol Road Slide (Left bank)

JUNE 2021

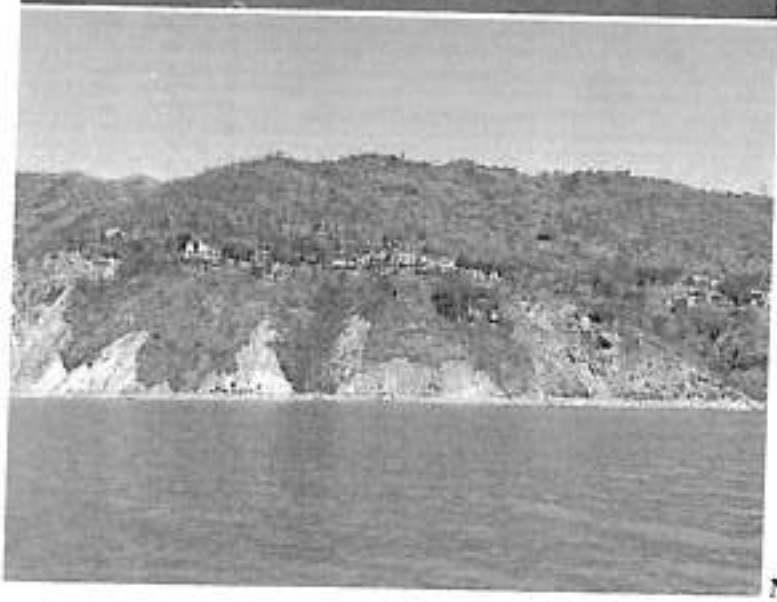
DEC 2021

MAY 2022

B) Chamyon Slide

JUNE 2021

DEC 2021



MAY 2022

C) Kyan- Ahhan road slide

JUNE 2021

DEC 2021

MAY 2022

D) **Slide near village Ahaen**

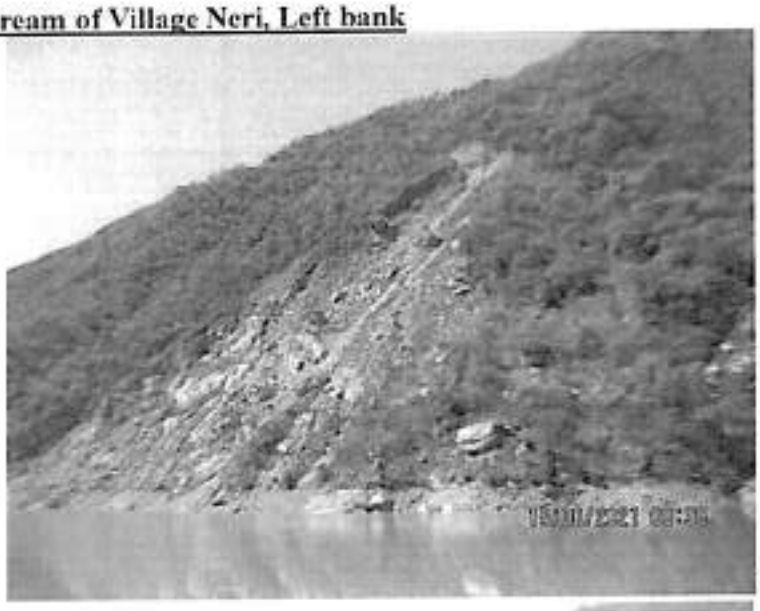
JUNE 2021

DEC 2021

MAY 2022

E) Downstream of Village Neri, Left bank

(I)



JUNE 2021

DEC 2021

MAY 2022

(II)

JUNE 2021

DEC 2021

MAY2022

(III)

JUNE 2021

DEC 2021

MAY 2022

F) Downstream of Village Neri, Right bank

JUNE 2021

DEC 2021

MAY 2022

G) **Slide between village Neri and village Dogri left bank :**

(I)

JUNE 2021

DEC 2021

MAY 2022

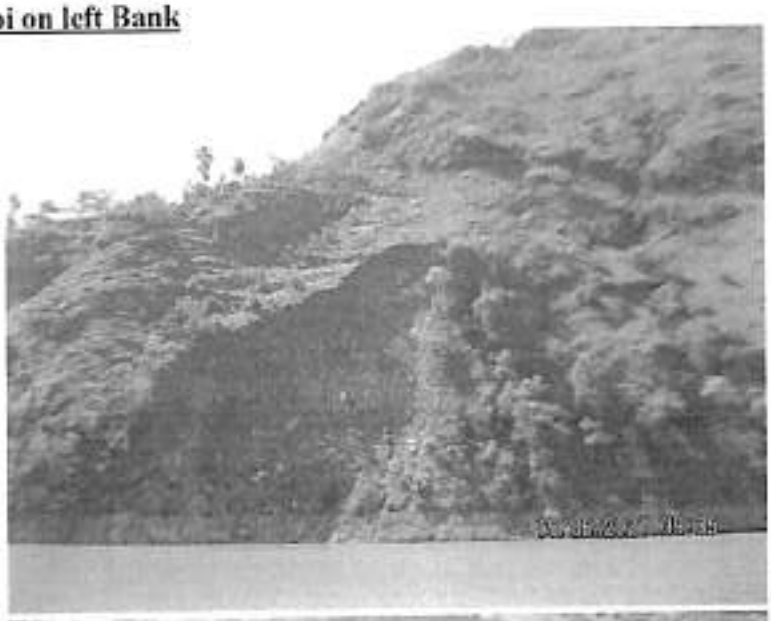
(II)

JUNE 2021

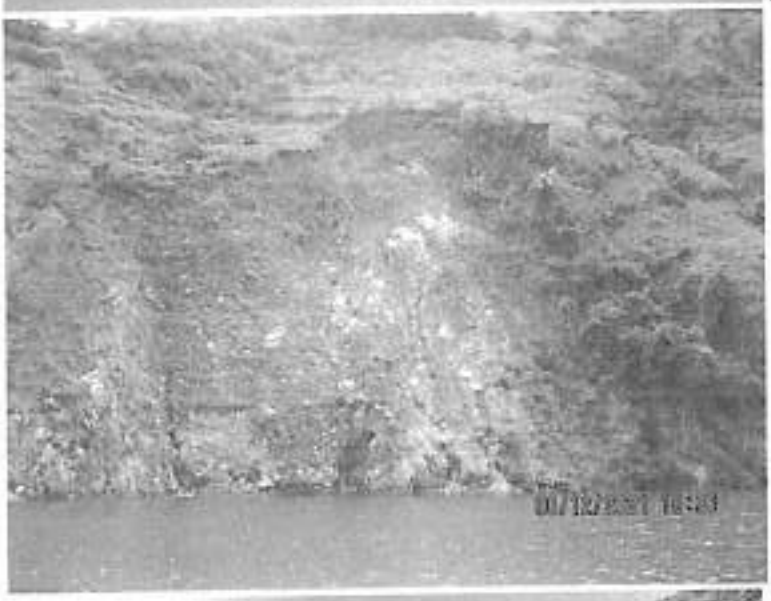
DEC 2021

MAY 2022

H) Slide at Village Boi on left Bank



JUNE 2021



DEC 2021

MAY 2022

I) New Slides noticed near village Neri

(I) Right Bank

JUNE 2021

DEC 2021

MAY 2022

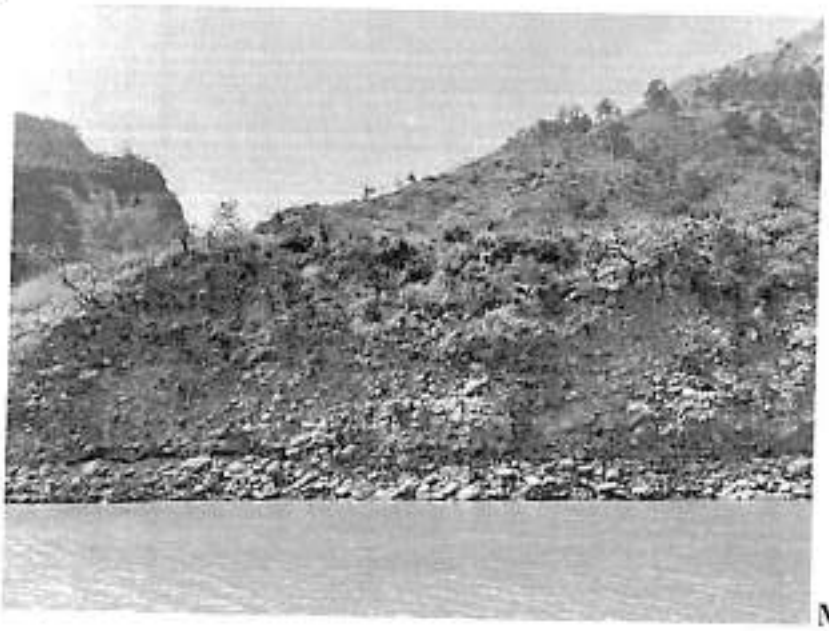
II) Left Bank:

JUNE 2021

DEC 2021

MAY 2022

J) Madraich



May 2022

Comparison of all slide w.r.t GSI report prepared in year 2002

Location	Status in GSI Report	Status as on Sept 2018 in NTPC Report	Status as on Nov 2019 in NTPC Report	Status as on Jun 2020 in NTPC Report	Status as on Sept 2020 in NTPC Report	Status as on June 2021 in NTPC Report	Status as on Dec 2021 in NTPC Report	Status as on May 2022 in NTPC Report
A	Not there at that time	Stable,needs monitoring	Stable,needs monitoring	Stable,needs monitoring	Stable,needs monitoring	Stable,needs monitoring	Stable,needs monitoring	Stable,needs monitoring
B	Not there at that time	Stable,needs monitoring	Stable,needs monitoring	Stable,needs monitoring	Stable,needs monitoring	Stable,needs monitoring	Stable,needs monitoring	Stable,needs monitoring
C	Stable	Active, road work in progress	Active, road work in progress	Active, road work in progress	Active, road work in progress	Active	Active	Active
D	Not there at that time	Stable	Stable	Stable	Stable	Stable	Stable	Stable
E	Out of 5 Slides, only one (No.4) was there	Active, no habitation, needs monitoring	Active, no habitation, needs monitoring	Active, no habitation, needs monitoring	Active, no habitation, needs monitoring	(I)&(II)Stable (III)Active, no habitation, needs monitoring	(I)&(II)Stable (III)Active, needs monitoring	(I)&(II)Stable (III)Active, needs monitoring
F	Not there at that time	Active, needs monitoring	Active, needs monitoring	Active, needs monitoring	Active, needs monitoring	Active, monitoring through Drone	Active, monitoring through Drone	Active, monitoring through Drone
G	Not there at that time	Stable	Stable	Stable	Stable	(I) Stable (II) Active	(I) Stable (II) Active	(I) Stable (II) Active
H	Not there at that time	Stable	Stable	Stable	Stable	Stable	Stable	Stable
I	Not there at that time	Active	Active	I) is Active II) is Stable	I) is Active II) is Stable	I) is Active II) is Stable	I) is Active II) is Stable	I) is Active II) is Stable
J	Not there at that time							Stable (New)

Annex-B

MAIN DAM
PIEZOMETERS:
CCP - Closed Chamber Piezometer (U/S grout curtain)
OCP - Open Chamber Piezometer (D/S grout curtain)
PTP - Porous Tube Piezometer

S No	Instrument Tag Tag	N	E	EL (m)	Remarks	Outputs	Operation n° date Unit	01-Jan-16	02-Jan-16	03-Jan-16	04-Jan-16	05-Jan-16	06-Jan-16	07-Jan-16	08-Jan-16	09-Jan-16
CCP - Closed Chamber Piezometer (U/S																
1	CCP-B1	15823.208	25287.022	509.663		piezometric head	water [EL.]	617.03	616.97	617.01	617.09	617.05	617.00	616.94	616.89	616.76
2	CCP-C1	15783.823	25281.069	469.008	Not Working	piezometric head	water [EL.]									
3	CCP-C2	15783.767	25280.644	473.033	Not Working	piezometric head	water [EL.]									
4	CCP-D1	15724.565	25271.141	442.004		piezometric head	water [EL.]	590.71	590.66	590.61	590.67	590.66	590.64	590.60	590.54	590.44
5	CCP-D2	15724.94	25270.555	445.766		piezometric head	water [EL.]	594.11	594.10	594.03	594.19	594.13	594.00	593.99	593.92	593.93
6	CCP-E1	15665.566	25261.046	441.79		piezometric head	water [EL.]	570.05	570.01	569.94	569.97	569.94	569.91	569.86	569.80	569.69
7	CCP-E2	15665.588	25260.528	445.521		piezometric head	water [EL.]	575.91	576.00	576.09	576.19	576.29	576.39	576.49	576.58	576.67
8	CCP-F1	15606.493	25251.314	441.811		piezometric head	water [EL.]	564.46	564.41	564.37	564.41	564.40	564.39	564.34	564.26	564.17
9	CCP-F2	15606.404	25250.681	445.629		piezometric head	water [EL.]	460.65	460.64	460.64	460.64	460.64	460.64	460.63	460.63	460.61
10	CCP-G1	15546.501	25240.667	492.092		piezometric head	water [EL.]	628.62	628.55	628.51	628.57	628.57	628.56	628.50	628.42	628.30
11	CCP-G2	15546.524	25240.509	496.132		piezometric head	water [EL.]	623.73	623.67	623.63	623.70	623.69	623.66	623.58	623.51	623.39
OCP - Open Chamber Piezometer (D/S																
1	OCP-B1	15822.975	25288.607	528.03		piezometric head	water [EL.]		575.03	575.03	575.03	575.03	575.03	575.03	575.03	
2	OCP-C1	15783.593	25282.177	487.778		piezometric head	water [EL.]		489.78	489.78	489.78	489.78	489.78	489.78	489.78	
3	OCP-C2	15783.327	25282.586	487.915		piezometric head	water [EL.]		523.92	523.92	523.92	524.92	523.92	523.92	523.92	
4	OCP-C3	15783.388	25282.621	488.383		piezometric head	water [EL.]		492.38	492.38	492.38	492.38	492.38	492.38	492.38	
5	OCP-D1	15742.409	25271.822	460.795		piezometric head	water [EL.]		521.80	521.80	522.80	522.80	522.80	521.80	521.80	
6	OCP-D2	15724.285	25272.553	460.791		piezometric head	water [EL.]		541.79	541.79	541.79	541.79	541.79	541.79	541.79	
7	OCP-D3	15724.151	25277.868	461.124		piezometric head	water [EL.]		541.12	541.12	541.12	541.12	541.12	541.12	541.12	
8	OCP-E1	15665.566	25262.148	460.584		piezometric head	water [EL.]		509.58	508.58	509.58	509.58	509.58	509.58	509.58	
9	OCP-E2	15665.209	25262.722	460.684		piezometric head	water [EL.]		522.68	522.68	522.68	522.68	521.68	522.68	522.68	
10	OCP-E3	15665.305	25263.056	461.477		piezometric head	water [EL.]		492.08	491.08	492.08	492.08	492.08	492.08	492.08	
11	OCP-F1	15606.219	25252.028	460.494		piezometric head	water [EL.]		535.49	534.49	534.49	534.49	535.49	535.49	534.49	
12	OCP-F2	15606.259	25252.88	460.499		piezometric head	water [EL.]									
13	OCP-F3	15606.267	25252.9	460.793	Not Installed	piezometric head	water [EL.]									
14	OCP-G1	15545.942	25241.991	510.723		piezometric head	water [EL.]		Dry	Dry	Dry	Dry	Dry	Dry	Dry	
15	OCP-G2	15545.939	25242.451	511.07		piezometric head	water [EL.]		530.07	531.07	530.07	530.07	531.07	531.07	530.07	
16	OCP-G3	15545.666	25242.465	511.365		piezometric head	water [EL.]		545.37	544.37	546.37	546.37	546.37	546.37	546.37	
Vibrating Wire Piezometers installed along																
1	VPF-PJ1	15629.12	25305.19	483.65		piezometric head	water [EL.]	519.53	519.54	519.49	519.51	519.49	519.49	519.50	519.49	519.44
2	VPF-PJ2	15621.888	25348.64	490.635		piezometric head	water [EL.]	512.62	512.63	512.58	512.60	512.58	512.58	512.59	512.58	512.53
3	VPF-PJ3	15687.071	25313.838	491.3	Not Working	piezometric head	water [EL.]									
4	VPF-PK1	15686.433	25315.89	480		piezometric head	water [EL.]	505.69	505.82	505.84	505.85	505.80	505.93	506.03	506.14	505.73
PTP - Porous Tube Piezometer																
5	PTP-J1	15629.12	25305.19	483.65	Not Working	piezometric head	water [EL.]									
6	PTP-J2	15621.888	25348.64	490.635	Not Working	piezometric head	water [EL.]									
7	PTP-J3	15614.501	25395.976	491.64	Not Working	piezometric head	water [EL.]									
8	[illegible]	[illegible]	[illegible]	480	Not Working	piezometric head	water [EL.]									
9	PTP-JJ1	15593.262	25521.27	525.289		piezometric head	water [EL.]	510.93		510.93	510.92	510.91	510.91	510.92	510.91	510.91
10	PTP-KK2	15651.327	25524.402	530.91		piezometric head	water [EL.]	510.64		510.63	510.62	510.62	510.62	510.62	510.61	510.61

Addl. General Manager (Commercial)

Annex-C

Status of Monitoring Instruments

Table – 1 (Earth and Rock fill Dam)

Monitoring	Instrument	Location	Instrument Name	Status	Date of last reading of Non-working instruments	Progress
Water level in upstream of Kol Dam	Staff gauge (up to El. 560m)	On upstream coffer dam centre line (Between Section C-C&D-D)	Staff gauge	Installed	Submerged	
	Staff gauge (from El. 560m to El. 648m)	On Main dam upstream near left abutment of dam (Between Section A-A & B-B)	Staff gauge	Installed	Available	
	Water level sensor	On Left Abutment area	Hydrostatic type Radar Type available	Installed	Working	
	Water level sensor	On decanting chamber wall	Radar type	Installed	Working	
Water level in downstream of Kol Dam	Water level sensor	On top of Tail race channel	Radar type	Installed	Working	
Ground water level below dam foundation	Piezometers (VPU's)	3 in Section A-A at El. ± 585m	VPU-A1,A2 , A3	Installed	Working	
		6 in Section B-B at El. ± 531.34m	VPU-B1,B2,B3, B4,B5,B6	Installed except VPU B3.	VPU B1, B2 not working (27 September 2013) B5 NOT WORKING	Checked up to last approachable point, No signal Found (resistance indicates shorting of Cable cores)
		8 in Section C-C at El. ± 504.8m	VPU-C1,C2,C3, C4,C5,C6,C 7, C8	Installed except VPU C8.	VPU C6 not working (28.09.16) C8 NOT WROKING	Checked up to last approachable point, No signal found.
		11 in Section D-D at El. ± 474m	VPU-D1, D2, D3, D4, D5, D6, D7, D8 , D9, D10, D11	Installed.	VPU D1,D2 not working (30 August 2013, VPU-D6, D10 not working (30 May 2012), VPU-D7 not working (31 Oct 2016), VPU-D8 not working (28 Nov 2016), VPU-D9 not working (29 July 2015)	Checked upto last approachable point , only temp signal found in VPU-D1 and no other signals found.
		11 in Section E-E at El. ± 474m	VPU-E1,E2,E3, E4,E5,E6,E7 ,E8,E9,E10,	Installed	E10 not working (06 March 2017),E11 not working (29 Feb	Checked up to last approachable point, E11 temp signal found.

			E11		2012).E1, not working (30.03.2016)	
		8 in Section F-F at El. ± 473.8m	VPU-F1,F2,F3,F4 F5,F6,F7,F8	Installed	VPU-F1,F4,F6 not working (27-Sept-2013)	VPU-F1 Checked upto last approachable point no signals found. VPU-F4 & F6 cables not found at SB Location.
		3 in Section G-G at El. ± 525.93m 1 in Section G-G at El. ± 525.68m (G1) 1 in Section G-G at El. ± 514.90m (G5)	VPU-G2,G3,G4 VPU-G1 VPU-G5	Installed	VPU G4 not working (2-Jun-2014), VPU-G2 not working (29-Mar-2015)	Fluctuating signals found, core of sensor cable showing continuity with shield wire (earth), cannot be rectified.
		3 in Section H-H at El. ± 578.28m	VPU-H1,H2,H3	Installed	Working	
	Piezometers (CCP's)	Upstream of grout curtain inside grouting galleries 1 in Section B-B (Gallery # 5)	CCP-B1	Installed	Working	
		2 in Section C-C (Gallery # 5)	CCP-C1,C2	Installed	CCP- C1, not working (21.04.2014), CCP-C2 ,not working (24.10.2014)	
		2 in Section D-D (Gallery # 6)	CCP-D1,D2	Installed	Working	
		2 in Section E-E (Gallery # 6)	CCP-E1,E2	Installed	Working	
		2 in Section F-F (Gallery # 6)	CCP-F1,F2	Installed	Working	
		2 in Section G-G (Gallery # 7)	CCP-G1,G2	Installed	Working	
	Piezometers (OCP's)	Downstream of grout curtain inside grouting galleries 1 in Section B-B (Gallery # 5)	OCP-B1	Installed	Working	
		3 in Section C-C (Gallery # 5)	OCP-C1,C2,C3	Installed	Working	
		3 in Section D-D (Gallery # 6)	OCP-D1,D2,D3	Installed	Working	
		3 in Section E-E (Gallery # 6)	OCP-E1,E2,E3	Installed	Working	
		3 in Section F-F (Gallery # 6)	OCP-F1,F2,F3	Installed except OCP-F3.	F1 Working, OCP F2 not available.	

		3 in Section G-G (Gallery # 7)	OCP-G1,G2,G3	Installed	Working	
Pore pressure in clay core of dam	Vibrating wire Piezometers	3 in Section A-A at core foundation contact 2 in Section A-A at El.± 620m	VPF-A1,A2, A3 VPF-A5,A6	Installed	Working	
		3 in Section B-B at core foundation contact 4 in Section B-B at El.± 560m 4 in Section B-B at El.± 590m 2 in Section B-B at El.± 620m	VPF-B1,B2 ,B3 VPF-UB1, B5, B6,B7 VPF-UB2, B8,B9,B10 VPF-B11, B12	Installed .	VPF-UB2, B8,B9,B10 not working (30-Aug-2013)	All non-working sensors checked. No signals found upto last approachable point and no resistance in between core of cables.
		4 in Section C-C at core foundation contact 5 in Section C-C at El.± 530m 5 in Section C-C at El.± 560m 4 in Section C-C at El.± 590m 2 in Section C-C at El.± 620m	VPF-C1,C2 ,C3,C4 VPF-C6,C7, C8,C9&UC 0 VPF-C10, C11 , C12, C13 & UC1 VPF-C14, C15 ,C16 & UC2 VPF- C17, C18	Installed except UC0.	VPF-C14,C15,C16 & UC2 not working (30-Aug-2013).	All non-working sensors checked. No signals found upto last approachable point and no resistance in between core of cables.
		5 in Section D-D at core foundation contact 5 in Section D-D at El.± 500m 6 in Section D-D at El.± 530m 5 in Section D-D at El.± 560m 4 in Section D-D at El.± 590m 2 in Section D-D at El.± 620m	VPF-D1, D2,D3,D4,D 5 VPF-D7,D8 ,D9,D10 ,D11 VPF-D12, D13,D14,D1 5,D16 & UD0 VPF-D17, D18,D19,D2 0 & UD1 VPF-D21, D22,D23 & UD2 VPF-D24, D25	Installed except UD0.	VPF-D18, D21,D22, D23& UD2 not working (30-Aug-13)	All other non-working sensors checked. No signals found upto last approachable point and no resistance in between core of cables.

		6 in Section E-E at core foundation contact 5 in Section E-E at El.± 500m 6 in Section E-E at El.± 530m 5 in Section E-E at El.± 560m 4 in Section E-E at El.± 590m 2 in Section E-E at El.± 620m	VPF-E1,E2 ,E3,E4,E5,E 6 VPF-E8,E9, E10,E11, E12 VPF-E13, E14 ,E15, E16,E17 & UE0 VPF-E20, E21,E22, E23 & UE1 VPF-E24, E25,E26 &UE2 VPF-E29, E30	Installed except UE0	E9 not working (30.07.2013) VPF-UE1(29. 10.13) ,VPF-E1,E8(30.07.13), VPF-E21,23(30.08.13) , VPF-E14(19.09.14)	VPF-E14 Found not working , Checked upto last approachable point no signal found.
		5 in Section F-F at core foundation contact 5 in Section F-F at El.± 500m 6 in Section F-F at El.± 530m 5 in Section F-F at El.± 560m 4 in Section F-F at El.± 590m 2 in Section F-F at El.± 620m	VPF-F1,F2 ,F3,F4,F5 VPF-F7,F8 ,F9,F10, F11 VPF-F12, F13 ,F14, F15,F16 & UF0 VPF-F17, F18,F19, F20 & UF1 VPF-F21, F22,F23 & UF2 VPF-F24,F25	Installed expect UF0.	VPF-F13 not working (27-Sep-13)	Checked upto last approachable point no signal found.
		4 in Section G-G at core foundation contact 5 in Section G-G at El.± 560m 4 in Section G-G at El.± 590m 2 in Section G-G at El.± 620m	VPF-G1,G2 ,G3,G4 VPF-G6,G7 ,G8,G9 & UG1 VPF-G10, G11,G12 & UG2 VPF- G14, G15	Installed	VPF-G1 Not working(16-March-2015). VPF-G2 not working(11-April-2015)	VPF-G1 & G2 Found not working Checked no signal found.
		3 in Section H-H at core foundation contact 2 in Section H-H at El.± 620m	VPF- H1,H2 ,H3 VPF-H5,H6	Installed	Working	

		17 Additional piezometers	VPF-AD1, AD2 ,AD3, AD4,AD6,AD7,AD8, AD9,AD10, AD11,AD12 , D13,AD14, AD15,AD16 ,AD17, VPF-D1 ADD	Installed except AD5.	AD-2, 6,7,8 not working (27-Sep-13). AD11,13,16 not working (30-Aug-13) AD 10 not working (30-Mar-14). AD-9, not working (08.04.2016)	VPF-AD2 Found not working. Checked, no signal found. VPF-AD6,7,8,9,10,11 are checked upto last approachable point. VPF-AD13 & AD16 are checked at SB end , no signal found.
Pore pressures in d/s fine filter of dam		1 in Section A-A at filter foundation contact	VPF- A4	Installed	Not Working (30-Aug-13)	Checked at SB end ,no signal found.
		1 in Section B-B at filter foundation contact	VPF-B4	Installed	Working	
		1 in Section C-C at filter foundation contact	VPF-C5	Installed	Working	
		1 in Section D-D at filter foundation contact	VPF-D6	Installed	Working	
		1 in Section E-E at filter foundation contact	VPF-E7	Installed	Working	
		1 in Section F-F at filter foundation contact	VPF-F6	Installed	Working	
		1 in Section G-G at filter foundation contact	VPF-G5	Installed	Working	
		1 in Section H-H at filter foundation contact	VPF-H4	Installed	Working	
Pore pressure in Rock fill of dam	Vibrating wire Piezometers	4 Nos. At Foundation level below downstream shell in Mat. 7	VPF-PJ1, PJ2,PJ3 &PK1	Installed.	PJ3 is not working 28-Sep-2007	
	Porous Tube Piezometers	4 in downstream shell	PTP-J1,J2,J3 &K1 New PTP-JJ1,PTP-KK2	New PTP-JJ1,PTP-KK2 working	PTP-J1, J2, J3 & K1 not working. Rectification failed for PTP-J1,J2,J3 &K1. New PTP's Installed in Nov-13	

Displacement of dam in X,Y,Z direction	Monitoring Beams	At Crest on Upstream MB18 to MB25	MB18 to MB25	Installed	Available	
		At Crest on Downstream MB26 to MB33	MB26 to MB33	Installed	Available	
		At El. 620.00 on Upstream MB11 to MB17	MB11 to MB17	Installed	Submerged	
		At El. 590.00 on Upstream MB6 to MB10	MB6 to MB10	Installed	Submerged	
		At El. 530.00 on Upstream MB1 to MB5	MB1 to MB5	Installed	Submerged	
		At El. 620.00 on Downstream MB34 to MB40	MB34 to MB40	Installed	Available	
		At El. 590.00 Downstream MB41 to MB45	MB41 to MB45	Installed	Available	
		At El. 560.00 Downstream MB46 to MB49	MB46 to MB49	Installed	Available	
		At El. 530.00 Downstream MB50 to MB52	MB50 to MB52	Installed	Available	
Horizontal deformation	Fill extensometer	Upstream shell 4 sensors at El. 590 in Section B-B	FE-B1/1, B1/2, B1/3, B1/4	Installed.	FE-B1/1 & B1/2, not working (10.05.16) . FE-B1/4, fluctuating	FE-B1/1 & B1/2 No signal output. FE-B1/4 Fluctuating .
		2 sensors at El. 620 in Section B-B	FE- B2/1 ,B2/2	Installed	FE- B2/1, fluctuating	
		4 sensors at El. 590 in Section D-D	FE-D1/1 ,D1/2,D1/3, D1/4	Installed	FE-D 1/1 not working (20.04.15), FE-D1/2 fluctuating	FE-D1/1 no signal found . FE-D1/2 Fluctuating .
		2 sensors at El. 620 in Section D-D	FE-D2/1 ,D2/2	Installed	FE-D2/1 , fluctuating.	FE-D2/1 Fluctuating
		2 sensors at El. 620 in Section F-F	FE-F1/1, F1/2	Installed	FE-F1/2 fluctuating.	FE-F1/2 fluctuating.
		Downstream shell 1 sensors at El. 620 in Section C-C	FE-C1/1	Installed	Working	
		7 sensors at El. 530 in Section E-E	FE-E1/1, E1/2,E1/3, E1/4,E1/5,E 1/6,E1/7	Installed	FE E1/1, E1/2, E1/3, E1/4 & E1/7 Fluctuating signal.	FE E1/1, E1/2, E1/3, E1/4 & E1/7 Fluctuating.
		4 sensors at El. 590 in Section E-	FE-E2/1, E2/2,E2/3,	Installed	FE-E2/1 & E2/4 fluctuating	FE-E2/1 & E2/4 Fluctuating .

		E	E2/4			
		2 sensors at El. 620 in Section E-E	FE-E3/1, E3/2	Installed	Working	
		3 sensors at El. 590 in Section G-G	FE-G1/1, G1/2,G1/3	Installed	FE-G1/3Fluctuating signal observed.	FE-G1/3 Fluctuating .
		2 sensors at El. 620 in Section G-G	FE-G2/1 ,G2/2	Installed	FE-G2/2 Fluctuating	FE-G2/2 Fluctuating
Vertical Deformation	Vibrating Wire Cell settlement system	Upstream shell. filter 1 sensor at El.590 in Section B-B	VWS-B1	Installed	Not-Working	Checked No signal found.
		1 sensor at El. 620 in Section B-B	VWS-B2	Installed	Not-Working	Checked No signal found.
		3 sensor at El. 590 in Section D-D	VWS-D1,D2,D3	Installed	Not-Working	Checked No signal found
		2 sensor at El. 620 in Section D-D	VWS-D4, D5	Installed	Not-Working	Checked No signal found.
		1 sensor at El. 590 in Section F-F	VWS-F1	Installed	Not-Working	Checked No signal found
		1 sensor at El. 620 in Section F-F	VWS-F2	Installed	Not-Working	Checked No signal found
	Cell settlement system	Downstream shell 1 sensor at El. 620 in Section C-C	CSS-C1	Installed	Working	
		2 sensor at El. 530 in Section E-E	CSS-E1,E2	Installed	CSS-E1, Not Working	Checked , No Output.
		3 sensor at El. 590 in Section E-E	CSS-E3,E4 ,E5	Installed	CSS-E5 Not working (05.09.2016)	Checked , No Output.
		2 sensor at El. 620 in Section E-E	CSS-E6,E7	Installed	Working	
		1 sensor at El. 590 in Section G-G	CSS-G1	Installed	Working	
		1 sensor at El. 620 in Section G-G	CSS-G2	Installed	Working	
Deformation of foundation	5-Point MPBX	2 Sensor at EL. 620m RB and LB	MPBX-M5R ,M5L	Installed	Working	

Table – 2 (Spillway and Power Intake)

Water level in upstream of Spillway	Staff gauge	Left Bank On Pier	Staff gauge	Installed	Available	
	Water level sensor	On left abutment of spillway	Radar type	Not Installed		Shifted to Decanting chamber/Power Intake area.
Water level at Power Intake	Water level sensor	On Central Pier of Power intake	Hydrostatic	Installed	Removed	
Pore pressure in spillway modules	Piezometers (PC's)	2 in Module 2 at foundation contact	PC-1,2	Installed	PC-2 , Not working	
		2 in Module 4 at foundation contact	PC-5,6	Installed	Working	
Ground water level below spillway foundation	Open Chamber Vertical Piezometers (VP's)	Upstream of drainage holes inside spillway gallery				
		1 in Module 2	OCP-VP1	Installed	Working	
		1 in Module 4	OCP-VP2	Installed	Working	
		1 in Module 6	OCP-VP3	Installed	Working	
	Closed Chamber Inclined Piezometers @20° (AIP's)	Downstream of drainage holes inside spillway gallery				
		1 in Module 1	CCP-AIP1	Installed	Working	
		1 in Module 3	CCP-AIP2	Installed	Working	
		1 in Module 5	CCP-AIP3	Installed	Working	
	Open Chamber Inclined Piezometers @40° (IP's)	Downstream of drainage holes inside spillway gallery				
		1 in Module 2	OCP-IP1	Installed	Working	
		1 in Module 4	OCP-IP2	Installed	Working	
		1 in Module 6	OCP-IP3	Installed	Working	
Pore pressure in spillway modules	Pore Pressure Cell (PC's)	2 in Module 2 at El.±610m	PC-3,4	Installed	PC- 4 not-working since 4-Jan-14	PC 3 working & readings available.
		2 in Module 4 at El.±610m	PC-7,8	Installed	Working	
Displacement between modules	Triaxial Joint Meter (JM's)					
		3 at Junction of Module 1 & Power Intake, El.±599m	JM-1,2,3	Installed.	JM-1X ,1Z not-working (31Aug 2013). JM-2Z Not-working (31-aug-13). JM-3Y and JM-3Z not working	Checked signals can't be retrieved of previously not working sensors. Also JM-3Y and JM-3Z are not working when

						checked at SB.
Displacement between modules	Triaxial Joint Meter (JM's)	3 at Junction of Module 3 & 4, El.±599m	JM-7,8,9	Installed.	JM-7X, 7Y&7Z not working (15 Dec 15) & JM-8Z (4-jan-14) not working.	Checked, signals can't be retrieved.
		3 at Junction of Module 6 & Left abutment, El.±599m	JM-13,14,15	Installed.	JM-13Y &13Z (08-jan-14),15Y(31-aug-13),15Z (28-feb-12) Not-working.	Checked, signals can't be retrieved.
		3 at Junction of Module 2 & 3, El.±612m	JM-4,5,6	Installed	JM-4Z, not working (22.03.16)	
		3 at Junction of Module 4 & 5, El.±612m	JM-10,11,12	Installed.	JM-12Y (28-feb-12) not working. JM-10Z,not working (28.05.16)	Checked, signals can't be retrieved
	Vinchon Apparatus (VI's)	In spillway gallery 6 at Junction of all modules	VI-2 to VI-7	Installed	Available	
		1 at Junction of Module 1 and Power Intake	VI-8	Not-Installed	Not-Installed	
		1 at Junction of Module 6 and Left Abutment	VI-1	Installed.	Available	
		6 on Left Guide Wall along Spillway chute	VI-LB1 to VI-LB6	Installed	LB1, not available (08.03.2016).	Rectification Work in Progress.
		6 on Right Guide Wall along Spillway chute	VI-RB1 to VI-RB6	Installed	Available	
Movement of spillway	Direct Pendulum (DP's)	1 in Module 1	DP-1	Installed	Available	
Movement of spillway		1 in module 2	DP-2	Installed	Available	
		1 in Module 4	DP-3	Not installed. (Deleted)		
		1 in Module 6	DP-4	Installed	Available damaged	
	Inverted Pendulum (IDP's)	1 in Module 3	IDP-1	Installed	Available	
Horizontal Deformation	Water Tubes	WT1,2,3,4,5,6,7,8,9-L,9-R, 10-L,10-R,11,12		Installed	WT1, 2, 3,5,6,9-L,10-R are damaged.	
Vertical Deformation of foundation	5-point MPBX	1 on left abutment Inside Rock El.±621m	M5L	Installed	M5L-24m (28-feb-12), 20m and10m (1-oct-13) sensor not working.	

Vertical Deformation of foundation	3- point MPBX	1 at Junction of Power Intake and Spillway	M3R	Installed	Working	
	3- point MPBX	1 in Module 3 at foundation level vertical	M3L	Installed	M3L-8m sensor not working. 31-Aug- 2013	
Temperature of concrete	Thermometer (T)	8 in Module 3	T1,T2,T3,T4 ,T5, T6,T13,T14	Installed	Working	
		8 in Module 5	T7,T8,T9,T10,T11 T12,T15,T16	Installed	T-11 not working	
Strain and Stresses in Concrete	Group of 5 strain meter and 1 stress meter	2 in Module 2	SG-1,2	Installed.	Working	
		3 in Module 3	SG-5,6,7	Installed	Working	
		2 in Module 4	SG-3,4	Installed	Working	
		2 in Module 5	SG-9,10	Installed	Working	
		1 in Module 6	SG-8	Installed	Working	
	Group of 5 strain meter with 'No Stress' Strain meter	2 in Module 2	NSG-1,2	Installed.	Working	
		2 in Module 3	NSG-5,6	Installed	Working	
		2 in Module 4	NSG-3,4	Installed	Working	
		1 in Module 5	NSG-8	Installed	Working	
		1 in Module 6	NSG-7	Installed	Working	

Table – 3 (Other Instruments)

Seepage in Galleries	Measuring Weirs	Gallery #1 on left bank (SM1)	SM1	Installed.	Operational	
		Gallery No# 2, SM2, SM3, SM4 & SM5)	SM2, SM3, SM4 & SM5	Installed	Operational	
		Gallery #14 on left bank (SM6)	SM6	Installed	Operational	
		Gallery #6 on left bank (SM7)	SM7	Not-Installed	Not-Installed	
		Gallery #11 on right bank (SM 10)	SM10	Installed.	Operational	
		Gallery #13 on right bank (SM8)	SM8	Installed .	Operational	
		Gallery #16 on right bank (SM9)	SM9	Installed .	Operational	
		Gallery #17 on right bank (SM11)	SM11	Installed .	Approach not Accessible	
Pore pressure downstream of plugs in DT	Open Chamber Piezometers	2 in DT-1	OCP-RT1,LT1	Not Installed.	Not Installed	
		2 in DT-2	OCP-RT2,LT2	Installed		

Pore Pressure in Surrounding area	Porous Tube Piezometers	8 in D/s area outside Dam & Spillway structures.	WA-PTP1 to WA-PTP 8	Installed	WA-PTP2 and WA-PTP5 not available.	
Strong Motion Accelerograph	Tri axial strong motion recording sensors	1 sensor at dam crest (near centre line)	SMA-1	Installed	Available.	
		1 sensor at El. 648 on right bank outside Gallery #11	SMA-2	Installed	Available.	
		1 sensor at El. 620 on left bank of spillway	SMA-3	Installed	Available.	
Web Based Online Monitoring Server (VDV)		Spillway Control Room Building	Web-based VDV software	Installed	Online	

Annexure – C

Annexure-~~B~~

AGREEMENT

BETWEEN

Government of Himachal Pradesh

AND

NTPC LIMITED

AND

Himachal Pradesh State Electricity Board

FOR THE EXECUTION OF

KOL DAM (4×200 MW)

HYDROELECTRIC POWER PROJECT

IN

HIMACHAL PRADESH

DELHI DATED : 26/02/2000

THIS agreement is made on this Twenty Sixth (26th) day of February in the year Two thousand, amongst :-

The Governor of Himachal Pradesh, through Mr. Ajay Tyagi, Secretary to the Government of Himachal Pradesh, Department of Multipurpose Projects and Power, having its office at Civil Secretariat, Shimla-171002 (here-in-after referred to as "GOHP" which expression, unless repugnant to the context or meaning thereof, shall include its successor(s), or permitted assigns), of the *FIRST PART*

AND

NATIONAL THERMAL POWER CORPORATION LTD., a company incorporated under the Companies Act, 1956, having its registered office at NTPC Bhawan, Scope Complex, 7 Institutional Area, Lodhi Road, New Delhi-110003, through Mr. Rajendra Singh, Chairman & Managing Director, NTPC duly authorised by NTPC (hereinafter referred to as 'CORPORATION" which expression, unless repugnant to the context of meaning thereof, shall include its successors or permitted assigns), of the SECOND PART,

AND

HIMACHAL PRADESH STATE ELECTRICITY BOARD (HPSEB) incorporated under Electricity (Supply) Act, 1948 having its head office at Vidyut Bhawan Shimla 171004, through Mr. M.L. Gupta, Chief Engineer (PSP&R) duly authorised by HPSEB (hereinafter referred to as "BOARD" which expression, unless repugnant to the context or meaning thereof, shall include its successor(s) or permitted assigns) of the THIRD PART.

WHEREAS, KOL DAM HYDROELECTRIC PROJECT (here in after refered to as *"PROJECT"*) on river Sutluj in District Bilaspur, in the State of Himachal Pradesh, owned by GOHP, with a design capacity of approximately 800 MW (4x200 MW), is proposed to be taken up for implementation by the CORPORATION;

Manish Kumar Verma
Addl. General Manager

AND WHEREAS the Techno-economic clearance for the Project was accorded by Central Electricity Authority (CEA) during August 1988, Environment clearance accorded in August, 1989 and Forest clearance accorded in June, 1990;

AND WHEREAS the Ministry of Power, Govt. of India (GoI) has permitted the CORPORATION to enter into the field of Hydro Electric Power generation.

AND WHEREAS the GOHP intend to get the Project implemented through the CORPORATION;

AND WHEREAS CORPORATION agrees to *Build, Own, Operate and Maintain* (BOOM) the Kol Dam Hydro Electric Project (800 MW approx) on river Satluj, in District Bilaspur in the state of Himachal Pradesh .

NOW THEREFORE, FOR AND IN CONSIDERATION OF PREMISES AND MUTUAL COVENANTS SET FORTH HEREIN THE PARTIES HEREBY AGREE AS FOLLOWS:

1.0 PROJECT EXECUTION :

1.1 The GOHP agrees that the CORPORATION shall implement Kol Dam Hydro Electric Project (4x 200 MW) located at Distt. Bilaspur (H.P.). The Salient features of the project as contained in Detailed Project Report (DPR) of 1988 are at *ANNEXURE - I*. The Project completion schedule will be mutually discussed and finalized.

1.2 It is specifically agreed that the said project will include all assets, properties, rights, leaseholds, powers, authorities and privileges and all property movable, immovable including lands, buildings, offices, stores, plants, machinery and equipment, installations, instruments, office furniture, stationery and office equipment, vehicles, staff quarters, workers colonies, together with amenities and installations pertaining thereto and other rights and interests in or arising out of such properties and assets as were immediately before the date of transfer, in the ownership, possession, power and control of GOHP or their authorised agencies such as BOARD, whether within the project area or outside, within the state of H.P. or outside and all books of Accounts, registers and other documents of whatever nature relating thereto but will not include cash in hand, cash at bank, investments, book debts or rights, liabilities and obligations respecting any other contract and shall be transferred on "as is where is basis" to CORPORATION, free from all encumbrances, liabilities and charges etc. by executing Registered Transfer Deed by GOHP in favour of the CORPORATION.

1.3.1 All the statutory clearances, concurrences, approvals and sanctions issued by GOHP for the Project shall be transferred to the CORPORATION within 60 days of the date of signing of the Agreement.

1.3.2 For transfer of statutory clearances/approvals obtained by the GOHP from the GOI authorities for the project to the CORPORATION, the GOHP shall give the necessary No Objection Certificate (NOC) within 30 days of the signing of this Agreement. GOHP will provide all the necessary assistance for expeditious clearance/approval from Govt. of India in this regard.

1.4 Responsibility for development of Master Plan of water resources for the Satluj basin, as stipulated in the environment clearance accorded to Project in August, 1989, shall be with GOHP / BOARD. The CORPORATION shall provide to GOHP/BOARD necessary data as may be required in this regard.

1.5 All reports, data and documents related to the project such as Feasibility Report, Detailed project Report (DPR), Design, Drawings, all investigations and studies, reports, catchment area treatment/R&R plans etc. already carried out by the BOARD, shall be handed over promptly to the CORPORATION. GOHP /BOARD shall also issue necessary communications to various organizations as and when requested by CORPORATION.

1.6 Responsibility of formulating and implementation of the compensatory afforestation plan in 2000 Hectares of degraded forest land as stipulated in the forest clearance accorded vide letter dated June 1990 or as approved by MOEF will rest with the state forest department of GOHP. The cost towards implementation of the plan will be borne by the CORPORATION. The money will be deposited on mutually agreed terms and conditions. This cost shall be capitalised and form a part of Tariff.

1.7 Responsibility of afforestation in 2000 Hectares of land in a 100m corridor around the reservoir as stipulated in the environmental clearance accorded vide letter dated August '89 or as approved by MOEF will also rest with the State forest dept. of GOHP. The cost towards the afforestation will be borne by the CORPORATION. This cost shall be capitalised and form a part of Tariff.

1.8 The CORPORATION shall arrange all the necessary finances for the implementation of the said Project. The ownership of the Project shall vest with CORPORATION.

मनीष कुमार वर्मा / Manish Kumar Verma
अपर महाप्रबंधक (वाणिज्यिक)
Addl. General Manager (Commercial)
एन टी पी सी लिमिटेड / NTPC Limited
EOC Annex Bld. [illegible]

1.9 TRANSFER VALUE

1.9.1 Transfer value shall be the amount of actual expenditure incurred by the BOARD on Survey & Investigation, preparation and approval of DPR, obtaining clearances and other works of the Project, upto the date of signing of this Agreement, duly audited by Govt. auditors and certified by the Accountant General (Himachal Pradesh). This amount will form a part of the capital cost of the project.

1.9.2 The transfer value (as per Clause 1.9.1) shall be bifurcated into two parts. The first part shall comprise the transfer value of Assets in respect of which title is reqired to be transferred to the CORPORATION through sale deed. The other part shall comprise the remaining amount of the transfer value, which shall be treated as transfer value for the services.

The BOARD shall transfer the works/assets of the Project to the CORPORATION within 30 days of signing of this Agreement. The transfer value of Assets, as above, shall be paid by the CORPORATION to the BOARD on the date of transfer of the title of the assets in favour of the CORPORATION.

The transfer value of services shall be paid by the CORPORATION to the BOARD within 30 days of signing of this Agreement subject ot handing over of the site to the CORPORATION.

1.9.3 In case the CORPORATION does not pay the transfer value on the scheduled dates as above, the CORPORATION shall pay to the BOARD, in addition to the transfer value, simple interest @ 16% P.A. from the date of signing of the Agreement, upto date of actual payment.

1.9.4 The outstanding dues and surcharge (undisputed) on account of sale of power by the CORPORATION to the BOARD, as on the date of signing of this Agreement, shall be adjusted against the transfer value.

1.9.5. CORPORATION shall submit a revised DPR to CEA after revised cost of the Project is worked out.

1.10 If project work does not start within thirty (30) months after Investment Approval based on updated DPR/Revised Techno-economic Clearance if required, then the GOHP shall have right to terminate this AGREEMENT after serving ninety days written notice to the CORPORATION. For this purpose, the start of Project work shall mean start of the award of the main packages of the Project.

1.11 GOHP will have the right to carry out the Survey and Investigation / explore the feasibility, and execute any river valley scheme upstream and downstream of the Project, without detriment to the Project including its operation, generation etc., as determined by CEA. The CORPORATION shall not have any claim over generation from any other project (s)existing and being envisaged upstream / downstream of the project.

2.0 LAND :

As per the DPR of 1988 which was cleared by CEA, the estimated land requirement is as under:

Forest Land under the Govt.	-	**955 Hectares.**
Agricultural & Private Land.	-	**750 Hectares.**

The actual land required for the Project as per revised approved DPR will be acquired in the following manner:

2.1 GOHP. Land :

At the request of the CORPORATION, GOHP shall transfer to CORPORATION on ownership basis the GOHP land required for the permanent structure/works and for permanent colonies as is necessary for the construction, operation and maintenance of the Project , at the rates, as may be determined by the GOHP, at the time of transfer of land.

2.2 Agricultural & Private Land:

At the request of the CORPORATION, GOHP shall acquire for the CORPORATION under the Land Acquisition Act, 1894 such agricultural & private lands within the State of Himachal Pradesh as may be required by the CORPORATION for the construction, operation and maintenance of the Project. The CORPORATION will bear the expenses for such acquisition of land.

2.3 Temporary Requirement of Land:

2.3.1 The GOHP shall also arrange for the short term lease of the GOHP land required for temporary colonies and temporary structures for the construction of the Project for 10 years from the date of occupation in the first instance, which may be renewed by the GOHP at its discretion till such period as may be required by the CORPORATION on such terms and conditions and rate or lease rent as may be determined by GOHP.

2.3.2 For the temporary requirement of land as described in clause 2.3.1 above, the lease amount shall also be at one time agreed rates for the entire period of 10 years.

2.4 LAND FOR OFFICE:

GOHP agrees to provide land for construction of office and other infrastructure facilities in Shimla and other locations as required. The CORPORATION shall bear the cost of such land.

2.5 All the expenditure for the above transaction shall form a part of the capital cost of the project for purposes of fixing the tariff.

3.0 RESETTLEMENT & REHABILITATION ISSUES :

3.1 The CORPORATION shall implement the Resettlement & Rehabilitation Plan (R&R Plan) as detailed in Annexure-II. GOHP shall extend all necessary assistance & inputs in implementing the R&R Plan. The GOHP shall monitor the implementation of R&R Plan.

3.2 All R&R Plan cost shall be incurred by CORPORATION and shall form part of capital cost for the purpose of Tariff.

4.0 SHARING OF BENEFITS :

4.1 Twelve percent (12%) of the net energy generated from the project after excluding auxiliary consumption and transformation losses (net energy) shall be given to GOHP/BOARD, free of cost, at bus bar located in switch yard of the project, which will be the take off point for power evacuation.

4.2 15% of actual energy generated excluding auxiliary consumption and transformation losses (net energy) will be provided on daily basis by the CORPORATION to the Board at bus bar tariff. This will be in addition to 12% free power to the STATE and its normal allocation on the basis of Central Plan Assistance during the last five years and consumption of electricity in the last five years, two factors being given equal weightage.

4.3 The Project will be operated as a Regional Power Station and the power generated from the Station excluding 12% free power as per clause 4.1. and power as per clause 4.2 above will be shared by the constituents of the Northern Region as per allocation decided/notified by GOI from time to time.

5.0 EVACUATION OF POWER :

5.1 Power from the project shall be evacuated through the transmission system of Power Grid Corporation of India Ltd., A wholly owned GOI Company incorporated under the Companies Act, 1956 and having its Registered Office at B-9, Katwaria Sarai, New Delhi-110 016, hereinafter called "Power Grid" and / or other agencies, directly and / or by displacement, for which CORPORATION shall cause through GOI the Power Grid to provide suitable integrated transmission system, matching with the commissioning of the Project, for the evacuation of power from this Project. This shall be done in consultation with GOI / CORPORATION / CEA / BOARD / OTHER BENEFICIARIES

5.2 The transmission charges, transmission losses and all other charges pertaining to transmission , if any, for evacuation / availing of power from the Project shall be payable directly by BOARD to Power Grid / Other transmitting agencies and the CORPORATION shall not be responsible, in any manner, in this regard.

5.3 The CORPORATION shall provide space for one bay at the project switchyard for drawal of GOHP share of power from the project directly on a separate transmission system at a later date, subject to approval of CEA. However, financial liability for establishing the bay as and when required by GOHP shall be borne by GOHP/ BOARD.

6.0 POWER PURCHASE AGREEMENT (PPA) AND TARIFF :

6.1 The CORPORATION and the BOARD shall enter into a Power Purchase Agreement (PPA) for sale/purchase of power pursuant to Clause 4.2 within three months of signing of this Agreement. For this purpose, the CORPORATION shall provide a copy of the draft PPA within one month from the date of signing of this agreement.

6.2 The Tariff and terms and conditions for power to be supplied by CORPORATION from Project as per Clauses 4.2 and 4.3 above shall be as per notification(s) to be issued as per decision of the Central Electricity Regulatory Commission (herein after referred to as CERC), from time to time, under Electricity Regulatory Commissions Act, 1998 (latest amendments) and/or any other Act/Regulations related to hydro-power development, as may be enacted by GOI in place of this provision. Subject to approval of CERC, the PPA shall incorporate the Following :

6.2.1 The Debt : Equity shall be in the ratio of 70:30. All capital expenditure towards the project shall stand allocated in the same proportion for tariff purpose.

Addl. General Manager (Commercial)

6.2.2 For the purpose of tariff, the capital cost shall include all the expenditure incurred / to be incurred for the project including cost of Rehabilitation & Resettlement (R&R), cost of the Catchment Area Treatment(CAT), and Compensatory Afforestation package etc.

6.2.3 Return on equity would be 16% as notified by GOI.

6.2.4 The rate of interest and repayment schedule for loans actually arranged by CORPORATION for the project will be based on the actual terms on which these loans are availed.

6.2.5 Incentive shall be paid as an additional return on equity as may be notified by GOI/ CERC from time to time and will be calculated on the basis of above Debt / Equity ratio, at the following rates :

Availability	Rate of Incentive
Above normative Annual availability of 85%	*0.6% of equity for every one percent increase in annual availability above Normative Annual Availability of 85%*

6.2.6 The disincentive below normative availability level of 85% shall be by way of proportionate reduction in capacity charges.

6.2.7 Any pro rata reduction in generation on account of non-payment of dues by BOARD resulting in spillage of water for shall be taken for the purpose of deemed generatio. Modalities shall be mutually finalised at the stage of PPA.

6.2.8 Any Water charges, royalty, levies, taxes, duties and cess etc. on generation of power from this Project will be a pass through in the tariff.

6.2.9 The rate of incentive for Secondary energy shall be equal to the per unit cost of Primary energy. Primary energy means the quantum of energy generated upto design energy on an annual basis in the station.

6.2.10 The payment in respect of the power purchased by the BOARD from the project shall be secured in favour of the CORPORATION as per the general practice in respect of the payments by the BOARD for purchase of power from other power stations of the CORPORATION.

6.3 If the PPA entered in to by the CORPORATION with any other beneficiaries from the Project contains provisions which are more favourable to the BOARD in totality, the CORPORATION shall, at the request of the BOARD extend the benefit of such concessions/ benefits to the BOARD also by suitably amending the PPA signed with the BOARD. Conversely if any other beneficiary state agrees for better terms favorable to the CORPORATION, Board will also accept the same by suitably amending the PPA signed by the CORPORATION.

7.0 OTHER COMMERCIAL ISSUES :

7.1 Payments in respect of power supplied by CORPORATION shall be secured by the following arrangement.

7.2 The BOARD shall open and maintain irrevocable, revolving Letter of Credit (LC) equivalent to the total value of the monthly power supplied from the Project. The amount of such LC shall be reviewed each quarter and its amount shall be enhanced / reduced accordingly.

7.3 The payment through LC for the power supplied from Project, will be backed by the State Government Guarantee and by an appropriate Escrow Arrangement to be entered into between BOARD and CORPORATION.

7.4 GOHP will issue guarantee regarding compliance with the financial obligations by BOARD as per the PPA with the CORPORATION, in respect of power supplied to them from this Project. This guarantee will also provide for a Tripartite Agreement to be entered into between GOHP, CORPORATION and the Reserve Bank of India (RBI) for making payments to CORPORATION from the State's RBI accounts, in case CORPORATION does not otherwise receive payment of its dues within stipulated time.

7.5 In case of default by BOARD in meeting any of the above payment safeguards as indicated in para 7.2 and 7.3 above, the CORPORATION shall have the right to restrict, regulate or re-allocate the power supply from the project.

8.0 PERSONNEL:

8.1 Unskilled staff, to the extent required to be recruited for the Project, will be recruited from among the Land Oustees/other residents of Himachal Pradesh depending on suitability and job availability.

8.2 Any requirement for recruiting any personnel in the SKILLED WORKMEN category, shall be filled out of the Land oustees/other residents of Himachal Pradesh subject to their fulfilling the criteria for employment under respective category as decided by the CORPORATION. The first preference in this regard shall be given to the land oustees. In case of non-availability out of the Land Oustees such recruitment will be through local employment exchange / regional employment exchange of the State.

8.3 The CORPORATION will be deploying approximately 100 executives for this Project. CORPORATION agrees to take 30 executives at the level of AE / AEE / EE/Sr.E.E./ Addl. S.E from BOARD. For this purpose, BOARD shall give a panel of four persons for every one vacancy for selection by CORPORATION. The CORPORATION will select and empanel suitable candidates from the above list at each level as per the notified vacancies. The job offer will be issued

to these empanelled candidates on the basis of merit, till the required number of executives join or the panel is exhausted. These executives on joining the CORPORATION will be on toll and terms & conditions of CORPORATION and will not be allowed to keep lien/deputation with GOHP/BOARD.

8.3.1 In case any one or all of these executives do not join the CORPORATION within the stipulated period as will be indicated in their respective appointment letter(s) issued by the CORPORATION, such offer for appointment will be treated as cancelled and the CORPORATION wil deem to have fulfilled its obligation to fill up the particular vacancy / vacancies from among the HPSEB nominees, as elaborated above.

9.0 DISPUTES AND ARBITRATION :

9.1 All disputes and / or difference arising out of this AGREEMENT shall on the first instance be settled amicably. In the event such amicable settlement is not reached then such unresolved disputes shall be settled through arbitration as provided herein.

9.2 Any dispute or difference whatsoever arising between the parties to the agreement, out of or relating to the consideration, meaning, scope, operation or effect of this contract or the validity of the breach thereof shall be settled in accordance with the provisions of the Arbitration and Conciliation Act, 1996.

9.3 The arbitration shall be conducted at Shimla or mutually agreed place.

9.4 During the period of abitration there shall be no suspension of the Agreement.

9.5 The cost of arbitration shall be shared equally by both the parties.

9.6 The agreement shall be governed by Indian laws and the competent courts shall have exclusive Jurisdiction.

10.0 MISCELLANEOUS :

10.1 The CORPORATION shall comply with all the obligations contained in environment clearance accorded by MOEF on 29/8/89.

10.2 The recreational and navigational rights in the river, water channels, reservoir, lake etc. shall be vested in the GOHP, subject to only such restrictions as may be necessary for the operational requirements and safety of the Project. Fishing right shall be vested with GOHP. However, GOHP will give first preference to land oustees and second preference to the fishermenwho are already engaged in this profession in the affected area

10.3 Subject to security and operational factors, the CORPORATION shall permit free use by the GOHP and the general public, of all service roads, constructed and maintained by it for the Project. Other facilities like post office, school, dispensary (school and dispensary facilities will be available on payment) etc. shall also be made available to the general public as per policies of the CORPORATION.

10.4 Should any existing facilities such as irrigation, water supply, road, electricity, communication system, path etc. be adversely affected but due to execution of the Project, remedial measure shall be taken by the CORPORATION at the cost of the Project, before the existing facilities are disturbed. The extent of such measures shall be discussed by the CORPORATION with GOHP and mutually agreed, from time to time. The cost of such measures shall be added to the capital cost for tariff.

10.5 The CORPORATION shall pay to the Forest Department of GOHP the price of trees coming in the submergence area, as are required to be felled or are damaged in the execution of the Project, at the prevailing Govt rates. The felling and removing of the trees within 60 days of intimation by the CORPORATION shall be the responsibility of GOHP. The net proceeds of sale of such trees will be made over to the CORPORATION. Net cost of the trees after accounting for the net proceeds is to be capitalised for Tariff. This will be in addition to provisions under clauses 1.6 & 1.9 above.

10.6 GOHP shall permit and authorise CORPORATION to collect and use boulders, stones, shingles, sand, limestones and other materials required for construction and maintenance of the Project, on payment of royalty/charges as per GOHP rules in force from time to time, subject to prior approval of the Central Govt., if required, under the provisions of Forest (Conservation) Act, 1980.

10.7 In case any object of archaeological importance is found by the CORPORATION or by any office employees / contractor during the implementation of the project, the CORPORATION shall arrange to hand over the same to the Government of India free of cost.

Provided that in case any precious or semi precious material / mineral is found located from the land acquired for or transferred or leased out to the CORPORATION for the Project, the CORPORATION shall report the fact to the GOHP immediately and shall keep that area intact till the final decision is taken by the GOHP.

10.8 It shall be the responsibility of GOHP to make proper arrangements to maintain general peace, law and order inside and around the project area. However CISF will be deployed for security within Project area by CORPORATION.

10.9 The CORPORATION may only, for the purpose of arranging or re-arranging Finance for the Project, assign or otherwise transfer its rights and benefits or any portion of its rights and benefits but not its obligations under this agreement to any other person or entity.

10.10 Any and all correspondence / demands made or notices to be sent or required to be made under this Agreement shall be in writing in English language, signed by the party giving such notice (claim or demand) and shall be delivered personally or by facsimile transmission coupled with by sending original or by registered mail or by e-mail, to other parties at its addresses set forth herein below or at such other addresses as such other party may subsequently notify.

All notices shall be deemed to have been given when delivered, which include facsimile as stated below :

ADDRESSES

GOHP
secretary (Power)
Govt. of H.P.
Shimla-171 002
0177-221895

CORPORATION
Chairman & Managing Director
NTPC, Scope Complex
7-Institutional Area
Lodhi Road, New Delhi-110 003
011-4360044
011-4363050

BOARD
Chairman
H.P. State Eletricity Board
Vidyut Bhawan,
Shimla-171 004
0177-213563
0177-251934

10.11 This AGREEMENT shall come into force for all purposes and intents upon its signing and shall remain valid unless terminated earlier as per clause no. 1.10 above. The terms and conditions of this agreement may be varied with mutual consent in writing by both parties.

IN WITNESS THEREOF, THE PARTIES HERETO HAVE CAUSED THESE PRESENT TO BE SIGNED, SEALED AND DELIVERED BY THEIR DULY AUTHORISED REPRESENTATIVES ON THE DAY, MONTH AND YEAR FIRST ABOVE WRITTEN.

FOR AND ON BEHALF OF	FOR AND ON BEHALF OF	FOR AND ON BEHALF OF
(Ajay Tyagi) Secretary (Power) Govt. of Himachal Pradesh	(Chandra Singh) Chairman & Managing Director NATIONAL THERMAL POWER CORPORATION	(M.L. Gupta) Chief Engineer HIMACHAL PRADESH STATE ELECTRICITY BOARD
WITNESS : 1. (R.C. Sharma) 2.	1. B. LAKSHMIPATHY DGM(E-C) NTPC 2.	1. 2.

Annexure-I

SALIENT FEATURES OF KOL DAM HYDRO ELECTRIC PROJECT BASED ON THE EXISTING DPR OF 1988

S.N.	ITEMS	DESCRIPTION
1.	Location	On Sathuj river about 6km upstream Of Dehar Power Plant
2.	Nearest Town	Bilaspur
3.	Proposed Installed Capacity (MW)	4 x 200 = 800 MW
4.	Type of Scheme	Run of River
5.	Estimated Annual Generation	3073 MU (90% dependable year)
6.	Proposed Power Evacuation System	400 KV integrated transmission system.
7.	Beneficiary of power	Northern grid and Himachal Pradesh
8	Dam details Type Height	Rock and gravel fill gravity dam 161 M
9.	Power House type Turbine Design head	Surface Francis vertical shaft 140 M
10.	Land Requirement (Tentative) Forest Land under the Govt. Agricultural & Private Land.	955 Hectares. 750 Hectares.
11.	Afforestation (Tentative)	2000 Ha land identified to compensate for 955 Ha Forest land coming under submergence.

	CLEARENCES
1.	TEC of CEA accorded in 1988
2.	Environmental clearance accorded in 1989
3.	Forest clearance accorded in 1990
4.	There is no interstate dispute / litigation.

Date : 26-02-2000
At : DELHI

Annexure-II

Scheme for the Rehabilitation and Resettlment of the Oustees of Kol Dam Hydro Electric Project.

0.0 For the acquisition of Kol Dam Hydro Electric Project, besides Government land, private land is also to be acquired by the Government for handing over to the Project Authority. Due to the acquisition of private land, many families will be affected and some of them will become houseless and landless. To protect the interests of the Oustees, adequate arrangements for the Rehabilitation and Resettlement have to be made.

Whereas Rule B-A of the Himachal Pradesh Nautor Land Rules, 1968 provides for framing of a special scheme for the Resettlement and Rehabilitation of persons who are displaced as a result of anything done in any public purpose.

Therefore, the Government of Himachal Pradesh and NTPC hereby make the following scheme for Resettlement and Rehabilitation of the persons displaced on account of acquisition of their lands and other immovable properties under the Land Acquisition Act, 1894 (a of 1894) for the construction of Kol Dam Hydro electric Project affecting people of Mandi, Shimla, Solan and Bilaspur Districts

PART-I

1.0 This scheme may be called the Resettlement and Rehabilitation of the Oustees of Kol Dam Hydro electric Project (grant of land and other benefits) Scheme, 1999.

1.1 It shall extend to the whole of area affected or likely to affected as a result of construction of Kol Dam Hydro Electric Project covering parts of Mandi, Shimla, Solan and Bilaspur Districts

1.2 In this scheme, unless there is anything repugnant in the subject of context.

(a) "Ouster" means a Land Owner who has been deprived of his house or land or both on account of acquisition proceedings/private negotiations in connection with the construction of Kol Dam Project and entitled to compensation of lieu thereof and includes his successors in interest.

(b) "Family" means husband/wife, who is entered as owner/co-owner of land in the Revenue Record, their children including step or adopted children and includes his/her parents and those brothers and sisters who are living jointly with him/her as per entries of Panchayat Parivar Register as on the date of Notification under Section-4 of the Land Acquisition Act, 1894. Provided that only the Panchayat Parivar Register entry, as it stood on the date of Notification under Section-4 of the Land Acquisition Act, 1894 shall be taken into account for the purpose of 'Separate Family' for Rehabilitation benefit i.e. consideration for employment etc.

(c) The word 'regular employment' means employment on regular basis in accordance with qualification.

(d) "Holding "means the land holding possessed by the family of an Ouster immediately after acquisition of his property.

(e) The words and expression used in this scheme but not defined herein, shall have the same meanings as assigned to them in the Himachal Pradesh Nautor Land Rules 1968.

PART-II

2.0 Sanction of rehabilitation grant, infrastructural grant or facilities and grant to the families rendered houseless.

2.1.1 Resettlement Grant

Each ouster family which will be rendered houseless on acount of acquisition of land / house for the KOL DAM Project shall be entitled to:

a. A compensation of Rs. 60,000/- in the form of houseless grant, and

b. Infastructural facility in the ouster colony which will include developed house site measuring 50' x 40' (one plot for each family), electrification for street lights, line for drinking water suitable, pucca approach road / path and Sulabh Sauchalaya.

Families who do not opt for plot of land (including other infrastructure) will be entitled for Rs. 25,000/- as infrastructure grant in the same line.

2.1.2 A minimum of 25 to 30 families should opt for the plots 50' x 40' in lieu of acquistion of house in the resettlement colony. Only then the infrastructural facilities as specified at part-II earlier will be provided by the Project Authority in the resettlement colony. The following facilities will be considered as a one time capital expenditure. The facilities developed shall, however, be handed over to the State Govt. on completion who will be responsible for its maintenance and its recurring expenditure at their own expenses.

a) Primary School : All capital expenditure for school building, furniture, black boards, other equipments would be provided by executing agency. However, the responsibility of running schools would be that of the State Government. In case, the State Government efforts do not materialise, the schools can be operated with the help of welfare agencies of the State or any other suitable alternative to be decided by the State Govt. at their expenses.

b) Dispensary : All capital expenditure for building, furniture, equipment etc will be provided by the Project Authority. However, the running of dispensary would be the responsibility of State Govt.

e) One village pond, panchayt ghar, one drinking water well for atleast 25 to 30 families, renovation of existing well/hand pump shall be provided in the resettlement colony.

2.2 Rehabilitation Grant

2.2.1 Landless Grant

The families who are rendered landless on account of acquisition of their land shall be eligible for landless grant in the following manner :-

i) Family which having more than 5 Bighas land rendered landless- Rs. 50,000/-.

ii) Family whose land holding was less than 5 Bighas and rendered landless Rs. 45,000/-.

iii) Families who are left with less than one Biswa after acquisition will be treated as landless.

2.2.2 Eligible Family Grant

Eligible families shall be those who do not become landless but their land holding is rendered to less than 5 Bighas on acount of acquisition.

i) Families who are left with land more than one Biswa and upto 2-10-0 Bighas -one time grant of = Rs. 40,000/-

ii) Families who are left with more than 2-10-0 Bighas but less than 5 Bighas - one time grant of = Rs. 35,000/-

The Deputy Commissioneer concerned will be the sanctioning authority for Rehabilitation grant, which shall be provided by the project authorities and placed at the disposal of the concerned Deputy Commissioner, for disbursement to eligible families. All these grants shall be in addition to the compensation paid under Land Acquisition Act.

2.2.3 EXPLANATION

For the purpose of this Scheme:

(a) Houseless family means a family who is rendered houseless as a result of Acquisition of their house under the Land Acquisition Act.

(b) Landless family /marginal means a family who is holding no land / with one Biswa or less than one Biswa after acquisition, whether as an owner or a tenant.

(c) Eligible family means a family who, after acquisition, holds less than 5 Bighas of land as a land owner or as a tenant.

Tenant as per the record of Govt. of HP and list given by the State Govt. at the time of acquisition and section-4 Notification under LA Act, 1894.

The family who has been sanctioned the houseless grant for house construction shall have to construct a house at the place of their resettlement.

PART-III

3.0 Employment

Employment shall be provided by the Project Authority for personnel in the category of unskilled and skilled workmen as specified in Para 8.1& 8.2 of the Agreement. The eligibility criterion for regular employment, where offered will be as follows. The status will be determined on the date of notification of transfer.

1 (Subject to the above) one member of each effected family will be short listed for consideration for employment depending upon the number of jobs in the Kol Dam Hydel Project, in the following manner:-

Adde. General Manager (Comm.)

3.1.1 One member of each affected family, who is absolute owner of land or house or both, whether male or female, as per entries of Revenue record, and entered as separate family in the Panchayat Parivar Register as on the date of Notification under Section-4 of Land Acquisition Act, 1894.

3.1.2 In case of co-owners in the revenue record one member of each affected family consisting of male owner or widow, who are entered as separate family in the Panchayat Parivar Register as on the date of Notification under Section-4 of Land Acquisition Act, 1894. Unmarried daughters and sons, minor daughters and sons, who are co-owners of land as per entries in Revenue record shall be treated as family members of the widowed mother or any of the married elder brothers as recorded in Panchayat Parivar Register.

3.1.3 Only one member of such affected family consisting of widow as co-owner with her only daughter or daughters as co-owner or sons and daughters, if they all recommend, only one member against all shall be eligible for consideration of employment in the project and if they are entered as separate family in the Panchayat Parivar Register.

3.1.4 Only one member of such affected family consisting of only one or more than one daughter or son or sons and daughters as co-owners, if they all recommend one member against all, for consideration of employment in the project and if they are entered as separate family in Parivar Register.

3.1.5 In case of such affected families who are co-owners as a brothers and sisters and share of acquired land of each of such co-owners is one biswa or less and if they club their shares together with which quantum of acquired land becomes more than one biswa, only one member will be considered for employment against all such co-owners after their mutual consent.

a) Provided that no member of a family whose total land acquired is one biswa or less, married daughter or heirs of pre-deceased/married daughter, who are recorded as co-owners in the revenue record with their brothers, sisters or parents shall be eligible for consideration of employment in the project.

b) No member of affected family shall be eligible for consideration of employment if quantum of his acquired land is one biswa or less.

c) No person shall be eligible for consideration of employment in the project who is not entered as member of the concerned affected family in the Panchayat Parivar Register.

d) No family shall be entitled to give its right for consideration of employment to a member of some other family.

e) No person of his family member shall be eligible for consideration of employment if he becomes owner of land by way of sale, gift, exchange etc. after the date of Notification of Section-4 of Land Acquisition Act, 1894.

f) Priority for consideration for providing employment from amongst eligible persons, not exceeding the number of unskilled and skilled workmen required to be recruited for the Project as decided by the Project Authority, shall be fixed by the concerned Deputy Commissioner in consultation with the Project Authority.

3.2 Procedure for employment

3.2.1 Every head of family will submit his application on the prescribed proforma in the office of Land Acquisition Officers/Relief and Rehabilitation office, Koi Dam Project as the Government may direct along with required affidavit, duly attested. Dates within which such applications are to be filled shall be fixed by the Land Acquisition Officers/ Relief & Rehabilitation Office (RRO) with prior approval of the Deputy Commissioner concerned, in consultation with the executing agency.

3.2.2 Particulars of each affected family shall be entered in the list to be maintained in the office of the Land Acquisition Officer/RRO on the basis of particulars filled in the application and Panchayat Parivar Register entry shall be entered in the list against all such families. LAO/RRO Kol Dam will send the list to the D. C. and names of eligible persons shall be sponsored by the Deputy Commissioner concerned in the shape of Mohal-wise lists to the project authorities for consideration of employment, depending upon the number of vacancies as determined by NTPC.

3.2.3 Form of application along with specimen of affidavit shall be supplied to each head of family by the Land Acquisition Officer/RRO Kol. Dam Project free of cost.

3.3 **Secondary Employment**

For practical reasons it may not be possible for the Project Authorities to provide direct employment to all the eligible persons due to many constraints. But every affected family shall have to be helped in starting some gainful occupation/getting training. Therefore, for such eligible persons who may not be accommodated in direct employment, the Project Authorities will help them in any one of the following manner :

3.3.1 The project authorities will construct shopping complexes in which a limited number of small shops/stalls will be earmarked for allotment to the eligible persons after appropriate consultation regarding capability and aptitude on a nominal rental as fixed by the Corporation.

3.3.2 Some members of the oustee families may qualify to go for vocational training courses like ITI etc. NTPC will pay the training cost including tuition, residential hostel charges, books and stationery requirement charges. However, no job commitment could be given to trained persons.

3.3.3 For starting an income generation scheme / self employment etc. the Project Authority will provide financial grant of Rs. 15,000/- except in the case of shops allotted to the land oustees.

3.3.4 The project authorities will also consider to award petty contracts to the Cooperatives of eligible families on preferential basis so that some of them may be engaged in such jobs also. Secondly, the project authorities will persuade their contractors to engage eligible persons from affected families on a preferential basis wherever possible during construction stage.

3.3.5 The oustee families shall be given preference in fishing rights in the Project Reservoir as a mode of livelihood.

3.3.6 These steps will ultimately lead to facilitation for adjustment of all the eligible persons in different employment/income generation scheme/self employment etc for appropriate rehabilitation.

A Village Development Advisory Committee will be constituted by the executing agency with the representatives of State Govt., executing agency, land oustees and village Panchayat for monitoring & implementing the above scheme.

Note : Words " Project Authority" wherever occuring, shall be replaced by the words "NTPC".

Annexure-D

IN THE HIGH COURT OF HIMACHAL PRADESH AT SHIMLA

RFA No. 32 of 2015

Decided on 29th February, 2024

Naradhu

...Appellant

Versus

State of Himachal Pradesh and others

...Respondents

Coram

Hon'ble Mr. Justice Ajay Mohan Goel, Judge

[1]Whether approved for reporting? Yes

For the petitioner: Mr. Hirdya Ram, Advocate.

For the respondents: Mr. Anup Rattan, Advocate General, with Mr. Sumit Sharma, Deputy Advocate General, for respondent No.1.

Mr. Neeraj Gupta, Senior Advocate, with Mr. Vedhant Ranta, Advocate, for respondent No.2.

Ajay Mohan Goel, Judge

By way of this appeal, the appellant/landlord has challenged the award passed by the Court of learned District Judge, Mandi, H.P., in Reference Petition No. 72 of 2008, dated 23.07.2012, in terms whereof, the Reference Petition filed by the appellant was dismissed by the learned Reference Court.

2. Brief facts necessary for the adjudication of the present appeal are that the land of the appellant situated in Village Tatapani, District Shimla was acquired for the purpose of the construction of Kol Dam Hydro Electric Project. Notification under Section 4 of the Land Acquisition Act was issued on 11.12.2000. After complying with the codal formalities, the award was passed by the Collector on 16.02.2008. Feeling aggrieved by the said award, the appellant preferred a Reference Petition on the ground that the compensation awarded to the land owner was low, inadequate and was liable to be modified. According to the landlord, the entire acquired land was situated on road-head in Village Tatapani, which was a tourist spot and also had religious significance and according to the land owner, the commercial potentiality of the land was ignored by the Collector, while announcing the award. The contention of the land owner was not accepted by the beneficiary of the acquisition proceedings.

3. On the basis of the pleadings of the parties, the Reference Court framed the following issues:-

"1. *Whether the marked value of the acquired land assessed by the Collector is not adequate. If so, what is the market value of the land and to what amount of compensation, the petitioner is entitled? OPP*

2. *Relief."*

4. On the basis of the evidence led by the parties in support of their respective contentions, the issues were decided as under:-

"Issue No.1: *No*

Relief *Petition dismissed as per operative part of the award."*

5. Learned Reference Court held that the land owner was not able to demonstrate that the award announced in favour of the land owner was inadequate. It further held that no sale deed etc., was produced by the land owner to substantiate his contention. It further held that there was no contention raised in the Reference Petition that the compensation paid for the structure/building was inadequate or the same was not paid and the evidence which was led in this behalf by the land owner could not be considered for the purpose of the enhancement of the compensation.

6. Learned counsel for the appellant has drawn the attention of this Court to CMP No. 18409 of 2023 filed under Order 41 Rule 27 read with Section 151 of the Code of Civil Procedure, which application hereby stands allowed, as the additional evidence sought to be led by the petitioner is the copy of the award dated 13.09.2013, passed by the learned Reference Court in the case of persons similarly situated as the appellant, which is necessary and relevant for the purpose of adjudication of this appeal. Learned counsel placing reliance on said Award, submits that as the award amount announced by the Collector, was enhanced by the learned Reference Court in the other Reference Petitions by holding that the land owners were entitled to the market value of the highest quality of land acquired, the appellant herein is at least entitled to the said relief because in the present case the award has been announced on the basis of the classification of land. He submitted that this appeal, therefore, deserves to be allowed and the award passed by the learned Collector as well as the learned Reference Court require modification to the extent that the appellant be held entitled to compensation on the basis of

the market value of the best quality of land assessed by the Collector.

7. Learned Senior Counsel appearing for respondent No.2 has emphatically denied this contention of the appellant and submitted that the appeal being devoid of any merit be dismissed.

8. I have heard learned counsel for the appellant as well as learned Senior Counsel for respondent No.2 as well as learned Additional Advocate General.

9. As the counsel for the appellant has restricted his arguments qua the grant of the best price as was assessed for the classification of land, therefore, the Court is not dwelling upon the other issues. As far as this aspect of the matter is concerned, a perusal of the record demonstrates that the award that was passed by the learned Collector in favour of the land owner was on the basis of the classification of the land of the land owner. The market value for different classification as proposed for village Tatapani, on the basis of which the award was announced by the learned Collector are quoted herein below:-

"Village	Classification of land	Market value per bigha
Tattapani	Dhani Abal	Rs.6,41,032.00
	Dhani Dom	Rs.5,29,548.00
	Barani Abali/Abadi, Khalwara etc.	Rs.3,90,194.00
	Barani Dom	Rs.3,13,548.00
	Barani Som	Rs.2,09,032.00
	Bagicha Barani/Kulahu	Rs.6,96,774.00
	Banjar Kable Kashat/Banjar Jadid	Rs.1,04,516.00
	Khadyatar Gair Mumkin	Rs.83,613.00"

10. In terms of the award passed by the learned Reference Court in the case of other land owners, similarly situated as the present appellant, whose land was also acquired for the purpose of the construction of Kol Dam in Village Tatapani, learned Reference Court held that in view of the law laid down by the Hon'ble Supreme Court of India as well as this Court, the compensation was liable to be determined on the highest value determined by the Collector and taking the highest value assessed by land Acquisition Collector to be the indicator of the market value prevalent in the area at the time of notification, the land owners were entitled compensation at the rate of Rs.6,41,032/- per bigha irrespective of the classification of land as the land was

acquired for the same purpose and no development was required to be made by the respondents.

11. In the present case also, as the land of the appellant was acquired for the same project, meaning thereby, that acquisition is for the same purpose and no development is required to be made by the respondents, therefore, herein also the appellant is entitled for compensation at the rate of Rs.6,41,032/- per bigha irrespective of the classification of the land. To this relief, the appellant is entitled to on the basis of the settled law by the Hon'ble Apex Court as also this Court.

12. Accordingly this appeal is allowed by modifying the award passed by the learned Reference Court and by holding that the appellant is held entitled for compensation at the rate of Rs.6,41,032/- per bigha irrespective of the quality of the land for the reason that the land has been acquired for the same purpose and was situated in the same area as was the land of the land owners in Reference Petition No. 72 of 2008, appended with the application filed under Order 41 Rule 27 read with Section 151 of the CPC. Rest of the award passed by learned Collector is not disturbed by this Court.

13. With these observations, the appeal stands disposed of, so also pending miscellaneous applications, if any.

(Ajay Mohan Goel)
Judge

February 29, 2024
(Vinod)

कार्यालय भू-अर्जन अधिकारी, कोलबांध परियोजना बिलासपुर (हि0प्र0)

संख्या : एलएओ / केडी / बीएलपी/ एन/ टी/ 2024- ११। दिनांक :०१/०५/२५

प्रेषक:

भू अर्जन अधिकारी,
कोलडैम बिलासपुर (हि0प्र0)।

प्रेषित:

महाप्रबंधक,
एनटीपीसी कोलडैम जमथल,
तह0 सदर जिला बिलासपुर (हि0प्र0)।

विषय : माननीय उच्च न्यायालय हि0प्र0 शिमला के फैसला दिनांक 29–02–2024 के अनुसार **RFA No. 32 of 2015** की मुआवजा गणना तालिका भेजने बारे।

महोदय,

विषय उपरोक्त के सन्दर्भ में निवेदन है कि माननीय उच्च न्यायालय हि0प्र0 शिमला द्वारा RFA No. 32 of 2015 शिर्षक नराधू बनाम सरकार हिमाचल प्रदेश व अन्य में दिनांक 29–02–2024 को पारित आदेशों अनुसार मुआवजा गणना तैयार करके आगामी कारवाई हेतू सेवा में सादर प्रेषित है।

भवदीय,

भू–अर्जन अधिकारी,
कोलडैम बिलासपुर (हि0प्र0)।

तहरीज 28–55 मुहाल तत्तापानी / 123 तहसील करसोग, जिला मण्डी (हि0प्र0)
आदेश दिनांक 29–02–2024, वर केस न0 32 ऑफ 2015, द्वारा माननीय उच्च न्यायालय शिमला (हि0प्र0)

क्र0		रकबा (बिघों में)	मुआवजा मुताबिक फैसला (641892 रू0 प्रति बीघा)	मुआवजा भूमि मुताबिक एवार्ड	बचा हुआ मुआवजा	जरूरी अधिग्रहण @30%	अतिरिक्त मुआवजा @12% 21-12-2000 से 9-3-2008 (2634 दिन)	कुल मुआवजा राशि भूमि (6 से 8)	कुल मुआवजा राशि भूमि पर ब्याज @9% 9-3-2008 से 9-3-2009 (वार्षिक)	कुल मुआवजा राशि भूमि पर ब्याज @15% 9-3-2009 से 15-05-2024 (5544 दिन)	कुल मुआवजा राशि भूमि (ब्याज सहित) (9 से 11)
1	2	3	4	5	6	7	8	9	10	11	12
1	[illegible]	5-0-5	3215172.90	1739705.71	1473467.19	442040.16	1275397.79	3191005.14	287190.46	7270246.22	10748441.82

Kanungo
Land Acquisition KolDam
Bilaspur (H.P.)

Naib Tehsildar
Land Acquisition Koldam
Bilaspur (H.P.)

Collector,
Land Acquisition,
Kol Dam Bilaspur (H.P.)

गणना तालिका मुहाल सतापानी / 123 तहसील करसोग, जिला मण्डी (हि०प्र०)
आदेश दिनांक 29-02-2024, वर केस न० 32 ऑफ 2015, द्वारा माननीय उच्च न्यायालय शिमला (हि०प्र०)

क्र० केस नं०		[illegible]	[illegible]	खसरा नं०	हिस्सा	रकबा (बिघा में)	मुआवजा मुताबिक फैसला ([illegible])	मुआवजा भूमि मुताबिक अवार्ड	बकाया मुआवजा (8-9)	सोलेशियम 30%	अतिरिक्त मुआवजा 12% [illegible]	कुल मुआवजा राशि भूमि [illegible]	कुल मुआवजा राशि भूमि पर ब्याज [illegible] (वार्षिक)	कुल मुआवजा राशि भूमि पर ब्याज [illegible] 19-05-2024 [illegible]	कुल मुआवजा राशि भूमि [illegible]
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	32/2015	329	[illegible]	[illegible]	1/30	[illegible]	107108.76	57990.19	39118.57	14734.67	42516.59	108366.80	9573.02	242341.54	358281.00

Kanungo
Land Acquisition KolDam
Bilaspur (H.P.)

Naib Tehsildar
Land Acquisition Koldam
Bilaspur (H.P.)

Collector
Land Acquisition,
Kol Dam Bilaspur (H.P.)

CMA/173/2019.

In the Court of Pankaj Sharma, Additional District Judge, Sundernagar, District Mandi, HP.

Case Type	CMA.
Filling No.	515/2019.
CIS Registration No.	173/2019.
CNR No.HPMA	170009312019.
Date of Institution	22.03.2019.
Date of Decision	29.04.2024.

1. Sher Singh S/o Smt.Gulabi,
2. Pyar Singh S/o Smt.Gulabi,
3. Rukmani D/o Smt.Gulabi.

All residents of Village Ropa Post Office Dhawal, Tehsil Sundernagar, District Mandi, Himachal Pradesh.

.....**Applicants.**

-Versus-

1. Land Acquisition Officer, Koldam Bilaspur, District Bilaspur, Himachal Pradesh.
2. NTPC, through its General Manager, VPO Barmana, Tehsil Sadar, District Bilaspur, Himachal Pradesh.

.....**Respondents.**

Application under section 146 CPC.

For the Applicants : Sh.P.S Sen, learned Advocate.
For the Respondent No.1 : Sh.Vinay Verma learned Dy.DA.
For the Respondent No.2 : Sh.J.S. Chandel, learned Advocate.

ORDER

Present application has been filed by the applicants under section 146 of the Civil Procedure Code, 1908 for seeking enhanced compensation for their land acquired in Muhal Ropa/239 in Khata Khatauni No.20/2026 share in Khasra No.191,194, total land measuring 05-19-00 bighas for which they had received compensation of Rs.3,57,872/-.

2. As per the application, the mother of applicants i.e. Smt.Gulabi Devi and the applicants were co-owners with their uncles Sh.Khajana and Sh.Sita Ram in the acquired land.

3. It has been asserted that the land of co-owners of the applicants, was also acquired vide same award, who had

PANKAJ SHARMA

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preferred Reference Petition No.81/2002/132/2005 titled as Sita Ram Vs Collector for enhancement of the compensation. It has been asserted that the value of the land was enhanced to Rs.5,00,000/- per bighas including interest under Section 23(1)(A), 23(2) at the rate of 9% and 15% in the said petition by the Presiding Officer Fast Track Court, District Mandi, Himachal Pradesh vide Award dated 17.01.2009. It is the prayer of the applicants that they are also entitled for the same rate, being the co-owners, however the applicants, being illiterate, could not file the petition under Section 18 of the Land Acquisition Act.

4. The applicants have been refused the relief of enhanced compensation on 01.01.2019, when the applicants visited the office of respondents as the appeal of the respondents was dismissed by Hon'ble High Court of Himachal Pradesh in the year 2017. By way of present application, the applicants have prayed for granting the enhanced compensation as per the Award dated 17.01.2009, passed by learned Presiding Officer Fast Track Court, Mandi.

5. On notice, the respondents appeared and contested the application by filing separate replies. The respondent No.1 in his reply took preliminary objections that the application is not maintainable, applicants have no locus standi to file the application, applicants have not come to the Court with clean hands and the application is barred by law of limitation. On merits, it has been submitted that the land of applicants had been acquired and the applicants are co-owners of Sh.Khazna and Sh.Sita Ram. It has also been admitted that the co-owners of the applicants had filed reference petition. It was further submitted that the applicants have not filed any reference petition under Section 18 or 28-A of the Land Acquisition Act. Similar reply was filed by respondent No.2 and it was prayed that the application is liable to be dismissed.

6. Rejoinder was not filed. On the pleadings of parties, following issues were framed on 26.03.2021: -

1.	Whether the applicants are entitled for compensation at the same rate as other co-owners have been awarded? OPP
2.	Relief.

7. In support of their case, the applicants examined the applicant No.1 Sh.Sher Singh as PW-1 and tendered his affidavit Ext.PW-1/A reasserting the contents of application. PW-1 also tendered in evidence Award Ext.PW-1/B, Fehrist mark-A, Statement No.28 mark-B, Copy of Award Ext.PW-1/C. In his cross-examination conducted on behalf of respondent No.2, he admitted that he along with his brother and sisters have not filed any reference petition in respect of acquired land. He stated that they had come to know about the enhancement in the year 2019. He also admitted that they had not filed any application to get the same value of land before Land Acquisition Officer. He admitted that he had got the copy of decision in those days from the office of Land Acquisition Officer, Bilaspur. He stated that he had not obtained the copy of decision of Hon'ble High Court of HP, wherein the compensation of Rs.5,00,000/- per bigha was awarded. He further admitted that there was no decision made in their favour to enhance the market value at Rs.5,00,000/- per bigha. He admitted that the persons who had filed reference petition had received the compensation. In cross-examination conducted by learned counsel for respondent No.1, he admitted that they had not filed any reference petition.

8. The petitioners also examined Sh.Harpal Singh Negi Naib Tehsildar from the office of Land Acquisition Officer Bilaspur as PW-2 who stated that the land of applicants was acquired for Koldam, for which, they had received compensation. He also admitted that Sh.Sita Ram and Sh.Khazana Ram were co-owners of the applicants in Khewat No.20. He stated that applicants had received the share of their mother Smt.Gulabi Devi. He also stated that he had brought the voucher of compensation received by the applicants. He proved

the register 'Asamivar' Ext.PW-2/A and standing order No.28 Ext.PW-2/B in this respect. In his cross-examination conducted by learned counsel for respondent No.2, he stated that the applicants had received the land from their mother Smt.Gulabi and Sh.Kulmu. He admitted that the applicants had not filed any Reference Petition under Section 18 or 28-A of the Land Acquisition Act. Thereafter, the evidence of applicants was closed on 30.12.2021.

9. On the other hand, the respondents have examined Sh.Harpal Singh Negi as RW-1, who tendered his affidavit in evidence Ext.RW-1/A, wherein he reasserted the averments as made in the reply. He stated that the applicants have been given due compensation for the acquisition of their land. In his cross-examination conducted by learned counsel for the applicants, he admitted that the Ext.PW-1/C is the Award of Muhal Ropa. He admitted that the land of PW-1 is in Muhal Ropa, for which, the Award Ext.PW-1/B was passed. He admitted that the land of Smt.Gulabi Devi was acquired vide Ext.PW-2/A for which the payment was made vide statement Ext.PW-2/B. He also admitted that Sh.Khazana and Sh.Sita Ram, co-owners of Smt.Gulabi Devi, had filed Reference Petition Ext.PW-1/C. He also admitted that the appeal against Ext.PW-1/C was dismissed by Hon'ble High Court of Himachal Pradesh. This is the entire evidence led by the respondents and the same was closed on 18.04.2023.

10. Sh.P.S. Sen, learned Advocate for the applicants has argued that it has been proved on record that the applicants are co-owners of the reference petitioners Sh.Khazana and Sh.Sita Ram as such they are entitled to the enhanced amount of Rs.5,00,000/- per bigha in respect of their land acquired in muhal Ropa by the respondents, as enhanced by learned Fast Track Court, Mandi vide Award dated 17.01.2009 in the Reference Petition No.81/2002/132/2005 filed by the co-owners of the applicants. Learned counsel for the applicants has relied

upon the judgment of Hon'ble Supreme Court in the cases titled as **Dinesh Kumar and others V/s State of HP AIR 2012 HP 68, Jallandhar Improvement Trust V/s State of Punjab and others AIR 2003 SC 620, A.Viswanatha Pillai and others V/s Special Tehsildar for Land Acquisition No.IV and others AIR 1991 SC 1966**, Judgments of Hon'ble High Court of HP in case titled as **Lesru Ram (deceased) through LRs Kalu Devi and others V/s Collector Land Acquisition NHPC and another 2018 (4) Him.LR(HC) 2336, Collector Land Acquisition NHPC Limited V/s Pune Ram (since deceased) through LRs Purva Devi and others 2018 (4) Him.LR (HC) 2380, NTPC Ltd V/s Lekh Ram and others RFA No.325/2012 decided on 15.12.2016.**

11. Sh.J.S. Chandel, learned counsel for the respondent No.2, has argued that the application in hand is not maintainable as the applicants had already received the market value of their land acquired in the acquisition proceedings. The applicants had only remedy to approach the Reference Court by filing petition under section 28-A of the Land Acquisition Act and that too within the period of limitation provided therein. He has further argued that provision of section 146 of Civil Procedure Code cannot be invoked to claim the enhanced market value, when there is Special Act dealing with the cases of land acquisition. Learned counsel for the respondent No.2 has relied upon the judgments of **Prayag Upnivesh Awas Avem Nirman V/s Allahabad Vikas Pradhikaran and another Civil Appeal No.3064 of 2000 decided on 16.04.2023, Bharat Singh and others V/s The State of Maharashtra CA No.21792 of 2017 decided on 12.12.2017, Ramsingbhai (Ramsanbhai) JeRambhai V/s The State of Gujrat and anr CA No.4885 of 2018 decided on 24.04.2018, Sant Ram and others V/s NTPC and another CWP No.2207 of 2017 decided on 28.05.2019.** Learned counsel for the respondent No.2 has also cited the judgment in the case titled as **Lalita Devi Vs LAC and another** passed by

Sh.R.K Chaudhary learned District Judge, Bilaspur on 09.12.2019 and the judgment in the case titled **Kanshi Ram alias Narain Singh Vs LAC NTPC and another passed** by Sh.Rakesh Kainthla, the then learned District Judge Mandi on 02.12.2021.

12. I have heard Sh.P.S. Sen learned counsel for the applicants, Sh.Vinay Verma learned Dy.DA for respondent No.1 and Sh.J.S. Chandel learned counsel for respondent No.2. I have also gone through the record of the case and cited precedents as well as judgments passed by learned District Judge Bilaspur and learned District Judge Mandi.

13. For the reasons to be recorded hereinafter while discussing the aforesaid issues, my findings on these issues are as under: -

Issue No.1	Yes.
Final order.	The application is allowed as per the operative part of the order.

REASONS FOR FINDINGS

Issue No.1

14. Perusal of the evidence led by the applicants reveal that Sh.Sher Singh (PW-1) has stated about the land of applicants acquired in muhal Ropa for the purpose of Koldam. This fact has not been denied by the respondents. This witness has also stated in the affidavit Ext.PW-1/A that all the three applicants were simpleton villagers and were not knowing that they could also file the Reference petition. The fact stated by this witness that Sh.Sita Ram and Sh.Khazana are Co-owners of the applicants has also not been disputed in his cross-examination by the respondent No.2, rather this fact was confirmed in the cross-examination of PW-2 Sh.Harpal Singh Negi Naib Tehsildar from the office of Land Acquisition Officer, Koldam Bilaspur, that Co-owners of the applicants had filed the reference petition before learned Fast Track Court Mandi and market value of acquired land was enhanced to Rs.5,00,000/- per bigha. It was

further admitted in his cross-examination that the appeals preferred by the respondents against the decision of learned Presiding Officer Fast Track Court Mandi before Hon'ble High Court of Himachal Pradesh were decided in the year 2017. It is quite clear that they had visited the office of respondents on 01.01.2019 and filed the present application on 09.03.2019 when they were refused enhanced compensation. It is quite clear that the award passed by learned Fast Track Court Mandi attained finality after the decision of appeals preferred by respondents before Hon'ble High Court of Himachal Pradesh in the year 2017.

15. From the evidence available on record, admittedly, the land of applicants was acquired by the respondents, for which Smt.Gulabi Devi was Awarded compensation vide the Award No.1 of 2001 Ext.PW1/B passed by the Land Acquisition Collector Koldam Sundernagar, and the detail of which is Ext.PW-2/A. It is also proved in the testimony of PW-2 Sh.Harpal Singh Negi Naib Tehsildar from the office of Land Acquisition Officer Bilaspur that the applicants are co-owners of Sh.Khazana and Sh.Sita Ram who had filed the reference petition No.81/2202, 132/2005 before learned Fast Track Court Mandi in which award Ext. PW-1/C was passed.

16. The main question for consideration is whether a co-owner is entitled to the same enhancement for acquisition of land, even if he/she had not filed reference petition. Both the parties have vehemently argued their respective cases. First of all, it would be profitable here to reproduce the following sections of the Land Acquisition Act, 1894 which are as under: -

> "Section 3 (b) defines expression "person interested" which includes all persons claiming an interest in compensation to be made on account of the acquisition of land under this Act; and a person shall be deemed to be interested in land if he is interested in an easement affecting the land;
>
> Section 53: Code of Civil Procedure to apply to proceedings before Court: - Save in so far as they may be inconsistent with anything contained in this

> Act, the provisions of the (See now the Code of Civil Procedure, 1908 (5 of 1908).) Code of Civil Procedure shall apply to all proceedings before the Court after this Act."

17. It is quite clear that the applicants come under the definition of "person interested". It is also quite clear that section 146 of the Civil Procedure code applies to the proceedings under the land acquisition Act, 1894.

18. Before proceeding further, it would be important to refer here a recent decision of Hon'ble High Court of Himachal Pradesh in the case titled as **Krishan Lal V/s State of HP and others CWP No.8361 of 2021 decided on 28.06.2023,** where Hon'ble High Court discussed the importance of constitutional right to property as under: -

> "10) As held by the Supreme Court in **Hari Krishna Mandir Trust vs State of Maharashtra and others,** though the right to property is not a fundamental right, it is still a constitutional right under Article 300A of the Constitution of India and also a human right; in view of the mandate of Article 300A, no person can be deprived of his property save by the authority of law; though the State possesses the power to take or control the property of the owner of the land for the benefit of public, it is obliged to compensate the injury by making just compensation. The Supreme Court held that though the right to claim compensation or the obligation of the State to pay compensation to a person who is deprived of his property is not expressly provided in Article 300A of the Constitution, it is inbuilt in the said Article and the State, seeking to acquire private property for public purpose, cannot say that no compensation shall be paid. It also held that the High Courts exercising their jurisdiction under Article 226 of the Constitution of India, not only have the power to issue a Writ of Mandamus or in the nature of Mandamus, but are duty bound to exercise such power, where the Government or a public authority has failed to exercise or has wrongly exercised discretion conferred upon it by a Statute, or a rule, or a policy decision of the Government or has exercised such discretion malafide, or on irrelevant consideration. In all such cases, the High Court must issue a Writ of Mandamus and give directions to compel performance in an appropriate and lawful

manner of the discretion conferred upon the Government or a public authority. In appropriate cases, it held that in order to prevent injustice to the parties, the Court may itself pass an order or give directions which the Government or the public authorities should have passed, had it properly and lawfully exercised its discretion. The High Court is not deprived of its jurisdiction to entertain a petition under Article 226 merely because in considering the petitioner's right to relief questions of fact may fall to be determined and the High Court has jurisdiction in a petition under Article 226 to try issues both of fact and law."

19. It is settled law that as per the mandate of Article 300-A, no person can be deprived of his property save by the authority of law, because right to property is still a constitutional right under Article 300-A of the Constitution of India and also a human right. As far as the case laws cited by learned counsels for the both the parties are concerned, first of all, it would be important to discuss the case laws cited by learned counsel for the applicant. In the case titled as **Dinesh Kumar and others Vs State of HP (supra)**, it was decided by our Hon'ble High Court that even a co-sharer who has not preferred reference to the Court is entitled for enhanced compensation pro-rata in accordance with his share in the acquired land and his right is irrespective of any claim for re-determination of the amount of compensation on the basis of Award of the Court under section 28-A of the Act. In **Lesru Ram (deceased) through L.Rs Kalu Devi and others (supra)**, while dealing with the similar question, it was held by our own Hon'ble High Court that the co-owners who had not sought reference under section 18 of the Act, were also entitled to enhanced compensation on pro-rata basis as per their share. In the case of **Collector Land Acquisition NHPC Limited Vs Pune Ram (supra)**, an application under section 146 of CPC was allowed by our Hon'ble High Court setting aside the order of learned Additional District Judge, Kullu, HP in similar type of execution.

20. On the other hand, the case laws cited by learned counsel for the respondent No.2 deal with some other situation and have no application to the facts of the present case. Learned counsel for the respondents has argued that the applicant had neither filed any reference petition under section 18 of the Land Acquisition Act nor they had approached the Court for the determination of the compensation under section 28-A of the Act. He further argued that execution of the Award can only be sought, where the matter was adjudicated by Court in between the parties, but in the present case the applicants cannot seek the execution of the Award, to which they were never a party. Learned counsel for the respondent No.2 has relied upon execution petition titled as **Kanshi Ram Vs LAC (supra)** where an application under order 21 rule 30 CPC was dismissed by learned District Judge Mandi on the ground that no reference was made by the applicant as such, he was not entitled to enhanced compensation. Learned counsel for the respondent No.2 has also relied upon the judgment of Hon'ble Apex Court in the case titled as **Prayag Upnivesh Awas (supra)**, where it was held that the reference Court cannot widen the scope of its jurisdiction or decide the matters which are not referred to it. The short question that arose for consideration is whether the SLAO had made a reference under section 18 of the Act and the original reference was only under section 30 of the Act for apportionment as there was a dispute as to who should get the compensation. In **Bharat Singh Vs State of Maharashtra (supra)** an application under section 28-A of the Act was allowed by Hon'ble Apex Court. In **Ramsingbhai Vs State of Gujrat and another (supra)**, the question under consideration was whether an application under section 28-A of the Land Acquisition Act, 1894 could be filed within a period of three months from the date of judgment of the High Court or Supreme Court passed in appeal under section 54 of the Act. Learned Counsel for the respondent No.2 has further relied upon the judgment of our Hon'ble High Court of HP in the bunch of cases titled as **Sant**

Ram and others V/s NTPC (supra) and others. Even, in this case, Hon'ble High Court of HP allowed the co-sharers/petitioners to approach the Land Acquisition Court under section 28-A of the Act, when the limitation to file the same was already expired. Lastly, learned counsel for the respondent No.2 has cited the judgment of learned District Judge Bilaspur in the case titled as **Lalita Devi V/s LAC Koldam and NTPC (supra)** vide which an application under section 146 CPC read with section 151 of the Code was dismissed. Another case cited by learned counsel for the respondent No.2 i.e **A.Viswanatha Pillai (supra)**, Hon'ble Apex Court held that when one of the co-owners or coparceners made a statement in his reference application that himself and his brothers were dissatisfied with the Award made by the Collector, they were held entitled to higher compensation and to receive compensation on pro-rata basis as per their shares. In **Jallandhar Improvement Trust Case (supra)**, while dealing with the similar situation, Hon'ble Apex Court granted relief to the co-owners.

21. Learned Counsel for the applicants has also produced the copy of Judgment of Hon'ble High Court of HP in the case titled as **Lalita Devi V/s Land Acquisition Collector and anr Civil Rev.No.7 of 2021 decided on 21.12.2021,** whereby the judgment of learned District Judge Bilaspur in the case titled as Lalita Devi Vs LAC Koldam and NTPC vide which the application under section 146 CPC read with section 151 of the Code was dismissed, has been set aside.

22. Coming to the case in hand, it is not disputed that the Co-owners of the applicants i.e Sh.Khazana and Sh.Sita Ram had preferred reference petition No.81/2002, 132/2005 before learned Fast Track Court Mandi, which was decided on 17.01.2009 and the market value of the acquired land was enhanced to Rs.5,00,000/- per Bigha. The Award dated 17.01.2009 passed by learned Fast Track Court Mandi in the reference petition has also attained finality. In view of the

discussion made above and the law cited on behalf of the applicant i.e **Lalita Devi V/s Land Acquisition Collector and anr Civil Rev.No.7 of 2021 decided on 21.12.2021,** the applicants are entitled for the enhancement of market value of their acquired land by the respondents. Even, it has not been proved by the respondents that the Collector had given any immediate notice of his award to the applicants when he passed the award as provided under section 12(2) of the Land Acquisition Act, 1894. As such, the version of applicants is believable that they came to know about the award of learned Fast Track Court Mandi in the year 2017 when the appeal of respondents was dismissed and the application filed by them is within time. Hence, issues No.1 is decided in affirmative.

Final Order

23. In view of my aforesaid discussions, present application filed by the applicants is allowed and they are held entitled to enhanced market value at the rate of Rs.5,00,000/- per Bigha (Rs.Five Lacs per Bigha) for their land in muhal Ropa acquired by the respondents. The applicants are also held entitled to other statuary benefits awarded as per the terms of Award passed by learned Fast Track Court Mandi dated 17.01.2009 in Reference petition No.81/2002, 132/2005 filed by the co-owners of the applicants.

24. It is made clear that the amount of compensation already paid to the applicants shall be adjusted towards the amount of compensation awarded in this application. File after completion be consigned to Record Room.

Announced in the Open Court on this 29th day of April 2024.

(Pankaj Sharma)
Additional District Judge,
Sundernagar, District Mandi, HP.

slv

List of Witnesses **Form-A**

Sr. No.	Name of Witness	Whether witness of petitioner or respondents.
PW-1	Sh.Sher Singh.	Applicant himself.
PW-2	Sh.Harpal Singh Negi.	Applicant's witness.
RW-1	Sh.Harpal Singh Negi.	Respondent's witness.

List of Exhibits **Form-B**

Exhibit	Date of Exhibit	Description of Exhibits.
Ext.PW-1/A	30.12.2021	Affidavit of Sher Singh.
Ext.PW-1/B	-do -	Award No.1/2001.
Ext.PW-1/C	-do -	Award dated 17.01.2009.
Ext.PW-2/A	-do -	Fehrist Asamiwar muhal Ropa.
Ext.PW-2/B	-do -	Statement under para-55.
Ext.RW-1/A	18.04.2023.	Affidavit of Harpal Singh.

(Pankaj Sharma)
Additional District Judge,
Sundernagar, District Mandi, HP.

slv

कार्यालय भू-अर्जन अधिकारी, कोलबांध परियोजना बिलासपुर (हि0प्र0)

संख्या : एलएओ / केडी / बीएलपी/ एन/ टी/ 2024- 998 दिनांक :30/05/24

प्रेषक:

भू अर्जन अधिकारी
कोलडैम बिलासपुर (हि0प्र0)।

प्रेषित:

महाप्रबंधक,
एनटीपीसी कोलडैम जमथल,
तह0 सदर जिला बिलासपुर (हि0प्र0)।

विषय : माननीय अतिरिक्त जिला न्यायधीश सुन्दरनगर व मण्डी–1 (कैम्प करसोग) द्वारा पारित आदेशोंनुसार मुहाल रोपा, वयाण व ततापानी की मुआवजा गणना तालिका भेजने बारे।

महोदय,

विषय उपरोक्त में आपके कार्यालय पत्र संख्या शुन्य दिनांक 06.05.2024 के संदर्भ में निवेदन है कि माननीय अतिरिक्त जिला न्यायधीश सुन्दरनगर व मण्डी–1 (कैम्प करसोग) द्वारा पारित आदेशानुसार मुहाल रोपा का केस न0 516/2019 मुहाल वयाण के केस न0 305/2019, 78/2018 व मुहाल ततापानी का केस न0 78/2016 की मुआवजा गणना तैयार करके आगामी कारवाई हेतू आपको प्रेषित है।

भवदीय,

नायब तहसीलदार,
भू-अर्जन कार्यालय,
कोलडैम, बिलासपुर (हि0प्र0)

गणना तालिका वर केस न० 515/2019 (Enhanced Amount) मुहाल रोपा, तहसील सुन्दर नगर, जिला मण्डी (हि०प्र०) द्वारा अतिरिक्त जिला न्यायाधीश सुन्दरनगर जिला मण्डी (हि०प्र०)

क्र०	खसरा न०	रकबा (बीघों में)	मुआवजा भूमि मुताबिक फैसला (5,00,000/- प्रति बिघा)	मुआवजा भूमि मुताबिक पंचाट	बढा हुआ मुआवजा	जबरी अधिग्रहण @30%	अतिरिक्त मुआवजा @12% 12-12-2000 ता 11-09-2001 (274 दिन)	कुल मुआवजा राशि भूमि	कुल मुआवजा राशि भूमि पर ब्याज @ 9% (12-09-2001 ता 11-09-2002 वार्षिक)	कुल मुआवजा राशि भूमि पर ब्याज @ 15% 12-09-2002 ता 15-05-2024 (7914 दिन)	कुल मुआवजा राशि भूमि (ब्याज सहित) (9 ता 11)
1	2	3	4	5	6	7	8	9	10	11	12
1	20	5-19-0	2975000.00	1958655.08	1016344.92	304903.48	91554.58	1412802.97	127152.27	4594899.75	6134855.00

Kanungo
Land Acquisition KolDam
Bilaspur (HP)

Naib Tehsildar
Land Acquisition Koldam
Bilaspur (H.P.)

Collector,
Land Acquisition,
Kol Dam Bilaspur (H.P.)

मनोज कुमार ...
अपर महाप्रबंधक ...
Addl. General Manager (Comm...)
एन टी पी सी लिमिटेड / NTPC Limited
EOC Anshera Bldg. A-8A Sector-24 NOIDA-201301 (U.P.)

गणना तालिका पर केस नं० 515/2019 (Enhanced Amount) मुहाल [illegible], तहसील सुन्दर नगर, जिला मण्डी (हि०प्र०)
द्वारा अतिरिक्त जिला न्यायाधीश सुन्दरनगर जिला मण्डी (हि०प्र०)

क्र० नं०	केस नं०	खसरा नम्बर	नाम भूस्वामी मुआवजादार	खेवट नं०	हिस्सा	रकबा (बिघों में)	मुआवजा भूमि मुताबिक फैसला (6,00,000/- प्रति बिघा)	मुआवजा भूमि मुताबिक अवार्ड	बढ़ा हुआ मुआवजा	जबरी अधिग्रहण @30%	अतिरिक्त मुआवजा @12% 12-12-2000 से 13-09-2001 (274 दिन)	कुल मुआवजा राशि भूमि (10+11+12)	कुल मुआवजा राशि भूमि पर ब्याज @9% (12-09-2001 से 13-09-2002 वार्षिक)	कुल मुआवजा राशि भूमि पर ब्याज @15% 13-09-2002 से 15-05-2024 (7914 दिन)	कुल मुआवजा राशि भूमि (ब्याज सहित) (13+14+15)
[illegible]	2	3	4	5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11	[illegible]	13	[illegible]	15	16
1	515/2019	12 Min	शेर सिंह पुत्र श्रीमती गुलाबी [illegible]	20	1/24	0-4-19	123958.33	81610.63	42347.71	12704.31	3814.77	58866.79	5298.01	191454.16	255619.00
2		12 Min	प्यार सिंह पुत्र श्रीमती गुलाबी [illegible]	20	1/24	0-4-19	123958.33	81610.63	42347.71	12704.31	3814.77	58866.79	5298.01	191454.16	255619.00
3		12 Min	कलमगी पुत्री श्रीमती गुलाबी [illegible]	20	1/24	0-4-19	123958.33	81610.63	42347.71	12704.31	3814.77	58866.79	5298.01	191454.16	255619.00
					कुल जोड़-	0-14-17	371875.00	244831.89	127043.12	38112.93	11444.32	176600.37	15894.03	574362.47	766857.00

Kanungo
Land Acquisition KolDam
Bilaspur (H.P.)

Naib Tehsildar
Land Acquisition Koldam
Bilaspur (H.P.)

Collector,
Land Acquisition,
Kol Dam Bilaspur (H.P.)

अपर महाप्रबंधक [illegible]
Addl. General Manager [illegible]
(एनटीपीसी लिमिटेड / NTPC Limited
[illegible] Bilaspur (H.P.)

Annexure-E

(2) Every owner of the specified dam shall maintain a record of readings of the instrumentations referred to in sub-section (*1*) and forward the analysis of such readings to the State Dam Safety Organisation, in the form, manner and at such interval as may be specified by the regulations.

Establishment of hydro-meteorological station.

33. (*1*) Every owner of a specified dam shall establish a hydro-meteorological station in the vicinity of each specified dam capable of recording such data as may be specified by the regulations.

(2) Every owner of the specified dam shall collect, compile, process and store data referred to in sub-section (*1*) at a suitable location.

Installations of seismological station.

34. (*1*) In the case of every specified dam, having a height of thirty metres or above or falling under such seismic zone, as may be specified by the regulations, the owner of the specified dam shall establish a seismological station in the vicinity of each such dam for recording micro and strong motion earthquakes and such other data as may be specified by the regulations.

(2) Every owner of a specified dam shall collect, compile, process and store data referred to in sub-section (*1*) at such suitable location and in such manner as may be specified by the regulations.

CHAPTER VIII

EMERGENCY ACTION PLAN AND DISASTER MANAGEMENT

Obligation of owner of specified dam.

35. (*1*) Every owner of a specified dam, in respect of each specified dam, shall,—

(*a*) establish well designed hydro-meteorological network and an inflow forecasting system;

(*b*) establish an emergency flood warning system for the probable flood affected areas downstream of the dam;

(*c*) test or cause to be tested periodically the functioning of systems referred to in clauses (*a*) and (*b*);

(*d*) install such scientific and technical instruments which are invented or adopted from time to time for the purpose of ensuring the dam safety and the life and property of people downstream;

(*e*) make available the information relating to maximum anticipated inflows and outflows including flood warning and an adverse impact of the same, if any, on persons and property towards the upstream or downstream of the dam, to the concerned district authorities and also make available the information in public domain; and

(*f*) render necessary assistance to the Authority in establishment and running of the early warning system for the exchange of real time hydrological and meteorological data and information related to the operation of reservoirs.

(2) Every owner of a specified dam, for each of its dam shall, carry out risk assessment studies at such interval as may be specified by the regulations and the first such study shall be made within five years from the date of commencement of this Act.

Emergency action plan.

36. (*1*) Every owner of a specified dam, in respect of each of specified dam, shall,—

(*a*) prepare emergency action plan before allowing the initial filling of the reservoir and thereafter update such plans at regular intervals;

(*b*) in respect of the dam which is constructed and filled before the commencement of this Act, prepare emergency action plan within five years from the date of commencement of this Act and thereafter update such plans at regular intervals as may be specified by the regulations.

(3) विनिर्दिष्ट बांधों के प्रत्येक मालिक को बाढ़ के पूर्वानुमान और चेतावनी के लिए अच्छी तरह से डिजाइन किए गए जल-मौसम विज्ञान संबंधी उपकरण नेटवर्क की स्थापना करनी होगी।

अनिल जैन, अध्यक्ष

[विज्ञापन-III/4/असा./142/2024-25]

NATIONAL DAM SAFETY AUTHORITY

NOTIFICATION

New Delhi, the 20th May, 2024.

F. No. TE-32/2/2023-NDSA-MOWR.—In exercise of the powers conferred by sub-section (1), read with clauses (a) and (k) of sub-section (2) of section 54 of the Dam Safety Act, 2021 (41 of 2021), the National Dam Safety Authority, on the recommendations of the National Committee on Dam Safety, hereby makes the following regulations, namely: -

1. **Short title and commencement.** – (1) These regulations may be called the Surveillance, Inspection and Hydro-meteorological Station of Specified Dams Regulation, 2024.

(2) They shall come into force on the date of their publication in the Official Gazette.

2. **Definitions:** - (1) In these regulations, unless the context otherwise requires, -

(a) "Act" means the Dam Safety Act, 2021(41 of 2021);

(b) "Authority" means the National Dam Safety Authority established under section 8 of the Act;

(c) "section" means section of the Act.

(2) Words and expressions used herein and not defined in these regulations but defined in the Act shall have the meanings respectively assigned to them in the Act.

3. Guidelines, standards and other directions for achieving the satisfactory level of dam safety assurance. –

(1) Every State Dam Safety Organisation, either through dam owners or by any other means, shall keep perpetual surveillance of all specified dams under their jurisdiction, to observe various anomalies including cracks in the body of the dam or abutment, unusual seepage, deflection in the dam body and any other problem related to dam or hydro-mechanical equipment, for the safety of the dam and follow the instructions in the operation and maintenance manual for the said dam.

(2) Every State Dam Safety Organisation, either through dam owners or by any other means, shall carry out the following inspections, namely: -

(i) pre and post-monsoon inspections shall be carried out in accordance with the provisions of sub-section (1) of section 31, and the regulations made thereunder;

(ii) inspections during or after every 1 in 50-year return period flood for barrages and 1 in 100-year return period flood for dams, immediately after an earthquake which causes structural damage to the project or such natural calamities as glacial lake outburst flood, landslide lake outburst flood, avalanches shall be carried out in accordance with the provision of sub-section (2) of section 31 of the Act and the regulations made thereunder;

(iii) inspection in case of any sign of distress or any unusual behaviour if noticed in the dam body or any of its appurtenant structure for whatsoever reason, shall be carried out in accordance with the provisions of sub-section (2) of section 31 of the Act and the regulations made thereunder;

(iv) inspection under clauses (i), (ii) and (iii) shall be carried out in accordance with the guidelines and checklist specified under sub-section (3) of section 31 of the Act by the owners or the project authorities of the dam;

(v) inspection shall be conducted before the initial filling of reservoirs in accordance with the provision of sub-section (2) of section 27 of the Act.

(3) Monitoring of operation and maintenance of each specified dam shall be carried out as per the provisions of Operation and Maintenance manual of the said dam and a continuous flow of information from dam owners to State Dam Safety Organisation shall be ensured for this purpose.

4. Hydro-meteorological stations of specified dams - (1) Hydro-Meteorological Station for measuring the following inputs shall be established near dam vicinity, namely : -

(i) rainfall (precipitation);

(ii) water level;

(iii) discharge;

(iv) temperature;

(v) humidity;

(vi) evaporation;

(vii) wind velocity and direction; and

(viii) snowfall, as applicable.

(2) The frequency of data measurement through the appropriate instruments shall be once a day or more depending upon the requirement, the instruments are to be placed at the dam site or at around 250 m radius from any abutment and the discharge measurement at the dam site shall be through a well calibrated rating curve which shall be updated every two years.

(3) Every owner of the specified dam shall install well-designed hydro- meteorological instrumentation network for inflow forecasting and flood warning.

ANIL JAIN, Chairman

[ADVT.-III/4/Exty./142/2024-25]

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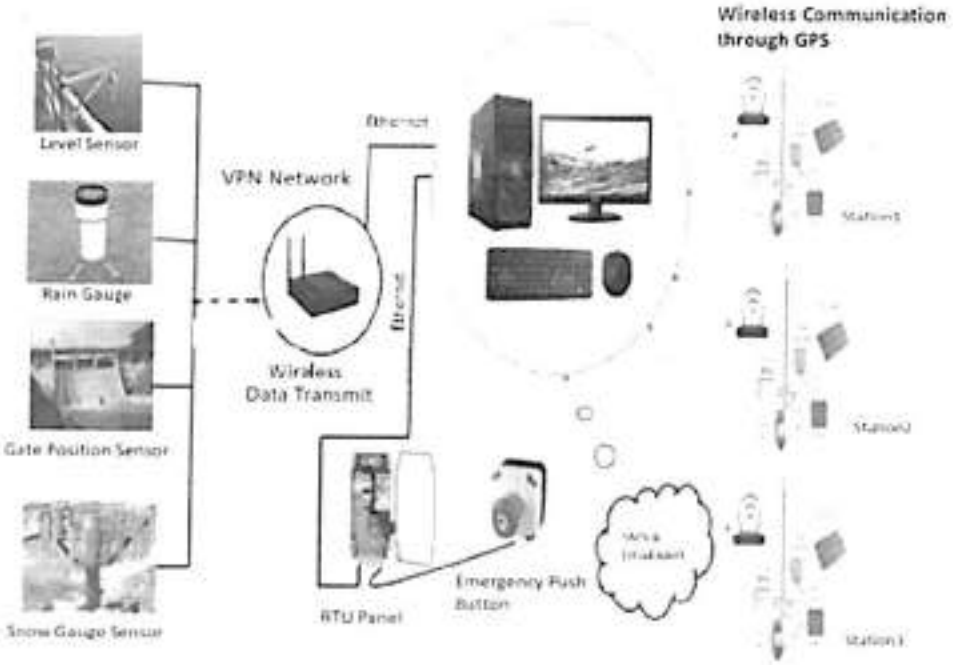
MANOJ KUMAR VERMA

Standard Operating Procedure
for
Early Warning System
in Hydro Projects



केंद्रीय विद्युत प्राधिकरण

Central Electricity Authority

जल विद्युत अभियांत्रिकी व प्रौद्योगिकी विकास एवं नवीनीकरण व आधुनिकीकरण प्रभाग

Hydro Engg. & Tech. Dev. and Renovation & Modernization Division

June, 2024

LIST of CONTENT

STANDARD OPERATING PROCEDURE FOR EARLY WARNING SYSTEM IN HYDRO PROJECTS

1. BACKGROUND

Hydro projects, situated in upper reaches of Hilly regions are normally more vulnerable to occurrence of Cloud Burst, Flash Flood, GLOF, LLOF, Avalanche, Landslide, Snow Slide/ Rock Slide etc. Therefore, there is a need to establish an Early Warning System (EWS) for Hydro Projects in these Hilly Regions so that loss of human & animal lives and property, infrastructures, loss of biodiversity etc. could be minimized in case of occurrence of this kind of disaster.

Risk knowledge of hazards, data collection, processing, communication and relief operations are important elements of an Early Warning System (EWS). Such systems can be realized through modern technological advancements in majority of disaster monitoring applications, so that affected people may be warned in advance and precious lives could be saved.

A thorough risk identification and hazard classification of each dam needs to be identified/explored by Project Authority. The risks should include GLOF/LLOF, Cloud burst, Avalanche, PMF, Dam Break / failure etc. and the EWS should be capable to catering to the lead time for each risk identified for the Dam. Based on the type of risks and degree of hazard, the EWS shall be designed. The EWS design shall also keep into view other factors like type of dam, its storage, rule curve, spillway capacity and river channel capacity downstream of the dam, Dam Break Analysis (DBA) and inundation maps, population downstream, type of terrain, reliability of the network, distance from glacial lakes identified under risk identification and hazard classification, as applicable for the dam etc.

NEED OF SOP

Standard Operating Procedure (SOP) aims to provide broad guidelines for implementation of Early Warning System for Hydro Projects in case of occurrence of Cloud Burst, Flash Flood, GLOF, LLOF, Avalanche, Landslide, Snow Slide/ Rock Slide etc.

All Projects/ Power stations should have their own EWS. Till such EWS are established, Projects/ Power stations located in cascade may coordinate for information with the upstream Projects/ Power stations. The Project Authorities should have their own SOPs for Flood Warning Procedures prior to flood releases for effective disaster management.

Control Room should have proper coordination with downstream projects while releasing water from the dam both planned like during peaking operation, reservoir flushing operation, etc. as well as unplanned release of water ensuring blowing of Sirens/Hooters/announcements and operation of Beacon lights to give prior warning to the people before release of water from the dam. The upstream under construction projects will also share information in case any warning is generated by their flood warning system or if any event of concern is noticed by them with the downstream operational and under construction projects. Proper co-ordination with the upstream projects as well is required for timely forecast of the vulnerable situations at the site.

2. Hazard/ Risk Mapping and Vulnerability Analysis in Hydro Electric Project Catchment Area

The scope of work will include identification, inventory generation and mapping/monitoring the following geo-hazards of mountainous regions:

1. **Identification/ Inventory management in GIS environment**

- Digital database generation of the study area including Digital Elevation Model (DEM).

- Delineation of catchment area
- Generation of drainage, streams, river network etc.
- Road / routes, locations, permanent & temporary structures etc.
- Land Use Land Cover (LULC) map of study area
- Permanent Ice/ Glacier Boundary
- Glacier Lakes and their classification based on type and size
- Geological and geomorphological maps of study area
- Snow Cover Distributions (Max and Min.) and Snowline variations

2. **Mapping of following Geo-hazards**

a) **Avalanches**: Identify avalanche-prone slopes and assess the potential impact on infrastructure and communities. Mapping of avalanche prone areas as follows:

- Identification and demarcation of probable avalanche sites
- Identification and demarcation of potential release areas (PRA) for avalanches
- Estimation of fracture depth of snow for avalanche release
- Generation of avalanche occurrence scenarios
- Conducting avalanche flow simulation using high resolution Digital Elevation Model (DEM) data for different scenarios
- Estimation of avalanche velocity, run out distance, debris depth and impact pressure using avalanche flow simulation model based on varying PRA
- Mapping of avalanche hazard areas with respect to road/route and settlements and risk assessment.
- Generation of avalanche hazard maps over high resolution satellite images

b) **Landslides [Rockfall]**: Identify areas prone to slope instability and mass movements, including debris flows, rockfall and soil erosion along the major streams.

- Creation of landslide inventory map of the area
- Preparation of landslide susceptibility map
- Locate potential landslide/rockfall areas and assess the susceptibility of different slopes to landslide/rockfall events.
- Assessment of lead time and discharge in case LLOF forms near the potential sites and risk assessment.

c) **Glacial lake outburst floods (GLOF) Hazards**: Assess the risks associated with GLOFs.

- The mapping of permanent ice, glacier boundaries and glacier lakes are to be carried out by manual delineation on high resolution (HR) images.
- Inventory of Glacial lakes with an area of more than 1 hectare (0.01 sq. km) and their classification (such as supra glacier, moraine dammed etc.)
- Identification of potential GLOF susceptible lakes
- Six-month monitoring (**April - September**) of potential lakes on monthly basis using satellite data.
- GLOF simulation for selected hazardous lakes using hydrodynamic modelling and risk assessment.

Methods:

(i) **Identification and mapping/monitoring using Remote Sensing and GIS:**

- Inputs required are high resolution Digital Elevation Model (DEM) of resolution 5 m or better, high resolution satellite images of 0.5 m resolution or better.
- To assess the susceptibility mapping for different mountain geo-hazards in the study area, terrain parameters (elevation, slope, aspect, curvature etc.) and surface characteristics (snow

covered, glaciated, forested, barren, rocky etc.) are required and the same can be generated using high-resolution (HR) DEM and HR/Medium resolution satellite data.

- Demarcation of catchment/basin is required to estimate the amount of water accumulated due to the precipitation (Rain/Snow) and to understand the water discharge. The hydrological tools available in ArcGIS (web application) and QGIS (Quantum Geographic Information System-web application) etc. can be used for catchment/basin delineation using HR DEM along with HR satellite images.
- Drainage, stream, river network etc. are important to identify the water flow path and to understand the flow pattern in the catchment/basin and can be generated using the HR DEM.
- Mapping of Land Use Land Cover (LULC), Road/route, location, permanent and temporary structures etc. using HR satellite images and ancillary data.
- The temporal monitoring of Snow cover area (SCA) for minimum past 10 years is to be carried out using medium resolution optical satellite data of Indian Advanced Wide Field Sensor (AWiFS) and foreign (Sentinel 2, Landsat etc.) origin, to estimate the maximum and minimum snow cover and also to observe the variations in snow line. Estimation of seasonal snow line based on snow cover maps to understand the permanent snow-covered areas.
- Integration of different raster & vector data in Geographic Information System (GIS) platform for hazard maps generation and visualization.

(ii) Field Investigations:

- Conduct ground truthing/field validation to verify and supplement remote sensing data.
- Identify specific hazardous areas, such as unstable slopes, active landslide sites, or potential avalanche release zones.
- Collect additional data on ground conditions, such as soil properties, geological structures, and hydrological features.

(iii) Hazard and vulnerability assessment:

- Integrate spatial hazard/susceptibility maps and vulnerability assessment themes to develop multi-hazard risk maps.
- Analytical Hierarchy Process (AHP) based model or machine-learning techniques, such as Logistic regression, support vector machine, random forest based modelling approach may be used to generate these hazard/susceptibility maps.
- These maps will visualize the spatial distribution of risks, highlighting areas that require immediate attention for implementation of EWS and mitigation measures.

Deliverables in GIS ready Format:

- Various thematic maps generated using Remote Sensing (RS) data
- Multi-hazard vulnerability maps
- Vulnerability assessment and Field investigations report including recommendations for risk mitigation measures and initial inputs for implementation of EWS.

3. IMPACT ON HYDRO PROJECT

Hydro Power Projects are constructed for harnessing electricity, located in hilly terrain and are associated with natural hazards such as landslides, floods, and earthquakes etc. which are to be considered in design of the structures. Being young mountains, hydro projects in Himalayan region are more susceptible to these hazards. Considering above aspects, mitigation measures are to be adopted during development of such projects. However, many unpredicted incidents in the nature may also cause disasters.

As in the case of Glacial Lake Outburst Flood (GLOF), the velocity may vary from **10 to 15 m/sec**. The lead time for the GLOF to reach the Dam body will be very less causing significant impact on project components because of the flood water carrying large amount of sediment/ debris.

The hydro project in a basin shall be set up at a safe distance from the glacier, so that information regarding Lake Burst etc. is received in advance. **The first dam in every basin shall be a Concrete Dam based on a solid rock formation and shall be constructed at least 15-20 kms away from the glacial lake mouth** so as to have sufficient lead time for responding to the situation and for evacuation of peoples and shifting of important infrastructures/ equipments/ machineries in downstream area.

The project developers in a particular basin shall share their contribution towards costs incurred in installation of the Early Warning System/ Sensors (flow/ level) throughout the basin. The cost shall be shared rationally by all projects in the basin.

CEA shall also carry out physical inspections on half yearly basis to review the status of implementation of EWS in existing and under construction Hydro Power Projects.

4. SATELLITE BASED IMAGE PROCESSING AND ANALYSIS

Early information can be gathered through acquisition of satellite imagery from concerned agencies such as ISRO, IMD (Indian Meteorological Department) etc. by the project developers and interpreting the satellite imagery shall inform about the increase in size of lake and other activities so that necessary action can be taken. This would provide a broad overview of weather patterns and potential flood areas and may be useful for monitoring large geographical regions in inaccessible locations. However, they do not provide real-time data in short span of time (minutes/hours) and require highly skilled professionals. Further, satellite imageries are limited by weather conditions & visibility and their initial investment & operational costs can be significant.

Project Developers shall explore the possibilities of collaborating with various agencies such as ISRO/IMD for obtaining satellite imagery on daily basis during critical period in single licence and shared to others on common platforms to optimise the cost.

5. STRUCTURE OF EARLY WARNING SYSTEM (EWS) AT HYDRO POWER STATION

Strategic locations (G&D sites) on the river stream/ tributaries in the upstream of the dam/ barrage site be identified where suitable equipment/ sensors with reliable communication systems could be established with **a lead time of at least one to two hours**. The site should preferably be located at a bridge and near a straight reach avoiding bends/ confluences/ turbulent locations. Redundancy of the sensors may be included to ensure fail safe transmission of data from the sensor locations with auto switching facility i.e. in case of failure of one sensor, the second sensor should automatically take over. Healthiness check of the instruments, batteries, communication system shall also be available in real-time.

Sensors along with CCTV/ video cameras shall be deployed at potentially dangerous glacial lakes for continuous monitoring of the movement/ shift in glaciers/water bodies. The sensors should be deployed for monitoring the precipitation of snow, the snow carrying capacity (i.e. the max size of formation after which snow slides), depth measurement of lake, severity of snow at mouth of lakes etc. For the validation of the sensor data, the results should be occasionally compared with the traditional data obtained through manual gauges and systems. It is thus essential to establish manual gauge / weather sites for correct assessment of significant events.

The upstream most project shall be made responsible to monitor glacial lakes and pass on the information to the downstream projects. The cost may be shared rationally by all the developer in a particular basin.

A technologically advanced Early Warning System (EWS), which can be practically implemented, consists of:

i) Sensor and Equipment for Early Warning System for flood forecasting in Hydro Power Projects to be deployed at U/S G&D sites and D/S of Dam /Barrage.
ii) Site selection for automatic water level recorder (AWLR) / gauge and discharge (G&D) site.
iii) Mounting of sensors.
iv) Instruments/Arrangements/Establishments required for Data Transmission from Sensors
v) Un-interrupted/ continuous Power Supply Arrangements for sensors and communication system.
vi) Central Command and Control Station.

5.1 SENSOR/ EQUIPMENT FOR EARLY WARNING SYSTEMS FOR FLOOD FORECASTING IN HYDRO POWER PROJECTS TO BE DEPLOYED AT UPSTREAM G&D SITES AND DOWNSTREAM OF DAM/ BARRAGE

These equipment can be deployed standalone or in a combination at G&D / Dam / Barrage sites for Flood forecasting and calculating Lead Time for floods at Dam / Barrage Site:

a) Automatic Water Level Recorder with CCTV (if feasible).
b) Automatic Velocity Sensor with CCTV (if feasible).
c) Automatic Weather Station with CCTV (if feasible).
d) Hooter/ Siren.
e) Drone Scanning.
f) Manual gauge/discharge/weather/rain gauge sites etc.
g) Dam instrumentation for immediate feedback which is crucial for monitoring dam behaviour and responding quickly to any changes in the dam.

a) Automatic Water Level Recorder (AWLR)

The water level sensor is an equipment which is used universally for observing water levels automatically:

Pros:

- **Wide Application Range:** The radar-based sensor can be used for various fluids and solids, making it versatile for different applications.
- **Not Affected by Environmental Factors:** The sensor is not influenced by temperature, dust, or steam, making it suitable for challenging environmental conditions.
- **Unaffected by Narrow Beam Angle:** The radar system is not affected by a narrow beam angle, ensuring accurate measurements even in situations where a focused beam is required.
- **Accurate and Reliable:** The sensor provides accurate and reliable level measurements, with a large signal-to-noise ratio, even in Applications with rapidly changing levels.
- **Low Power Consumption:** The sensor has low power consumption, making it energy-efficient and potentially suitable for remote or off-grid locations.

Cons:

- **Accuracy Affected by Solids:** The accuracy of the sensor can be affected by the presence of solids in the measured material.

- **Continuous Power Requirement:** The sensor requires continuous power, which can be a limitation in areas with unreliable power sources. Additionally, the need for power backup increases the overall power consumption.

b) Automatic Velocity Sensor

The velocity sensor is an equipment, which is used universally for observing velocity of objects or fluids automatically:

Pros

- **Non-contact Measurement:** Radar-based velocity sensors allow for non-contact measurements, reducing wear and tear compared to contact-based sensors.
- **Wide Range of Applications:** Can be used in various Applications to measure the velocity of objects or fluids, providing versatility.
- **Accuracy:** Radar sensors can offer high accuracy in velocity measurements.
- **Remote Sensing:** Radar sensors can be deployed at a distance from the target, making them suitable for remote sensing applications.

Cons:

- **Complexity:** Radar-based velocity sensors may be more complex than some other types of velocity sensors, leading to potential challenges in installation and maintenance.
- **Erroneous results due to voltage fluctuations:** These sensors have been mentioned to give wrong results in case of voltage fluctuations. So, the results should be occasionally compared with traditional velocity data obtained through manual gauges.
- Expensive to maintain and install.
- May not give very accurate results during turbulent flows and when the river changes its course.
- Efficiency not yet proven in Himalayan Rivers owing to sediment laden water.

The General Technical Specification of sensors (a) Surface Velocity Sensor, (b) Water Level Sensors are given at **Appendix-1A & 1B**.

Acoustic Doppler Current Profiler (ADCP)

It is a type of velocity sensor, used to measure how fast water is moving i.e. velocity across an entire water column. An ADCP anchored to the bed can measure current speed not just at the bottom, but also at equal intervals all the way up to the surface. The instrument can also be mounted horizontally on bridge pilings in rivers and canals to measure the current profile from shore to shore. In very deep areas, they can be lowered on a cable from the surface. Getting Automatic warning may be explored. This system can be used for calibrating gauge and discharge computed by AWLR and Velocity sensor.

Pros:

- In the past, measuring the current depth profile required the use of long strings of current meters. This is no longer needed.
- Measures small scale currents.
- ADCPs measure the absolute speed of the water, not just how fast one water mass is moving in relation to another.
- Measures a water column up to 1000m long.

Cons:

- High frequency pings yield more precise data, but low frequency pings travel farther in the water. So scientists must make a compromise between the distance that the profiler can measure and the precision of the measurements.
- ADCPs set to "ping" rapidly also run out of batteries rapidly.
- If the water is very clear, the pings may not hit enough particles to produce reliable data.
- Bubbles in turbulent water can cause the instrument to miscalculate the current.

- Users must take precautions to keep *'algae'* from growing on the transducers.
- May not give very accurate results during turbulent flows and when the river changes its course. In turbulent waters it may not possible to deploy the equipment.

c) **Automatic Weather Station (AWS)**

This equipment is used for automatically observing weather related data such as rainfall, evaporation, wind speed, wind direction, relative humidity, temperature etc.:

Pros:

- **Comprehensive Data Collection:** Weather stations can collect a wide range of meteorological data, including temperature, humidity, wind speed, rainfall, and atmospheric pressure.
- **Real-time Monitoring:** Weather stations can provide real-time data, enabling timely response to changing weather conditions.
- **Distributed Deployment:** Multiple weather stations can be deployed across a region, providing a comprehensive view of local weather variations.
- **Integration with Other Sensors:** Data from weather stations can be integrated with other environmental sensors to enhance the overall situational awareness.
- **Remote Sensing:** Weather stations can be installed in remote or hard-to-reach areas, improving coverage for monitoring and forecasting.

Cons:

- **Cost:** Weather stations can be expensive to install, maintain, and operate, especially when considering a network of stations across a large area.
- **Maintenance Requirements:** Regular maintenance is necessary to ensure the accuracy and reliability of the data collected.
- **Dependency on Power:** Weather stations typically require a continuous power supply, which can be a challenge in remote locations or during power outages.

Specifications of AWS sensors are given at **Appendix-2.**

d) **Hooter and Siren Systems**

The scope of the work of installation of Hooter and Alarm consists of designing, engineering, manufacturing, supply, installation & commissioning of Alert, Inform and Direct System (AI&D System) for before the release of water from dam of a Power House, during heavy rainfall or military operations through Phone, E-mail, SMS and Siren systems.

- This project is Alert, Inform and Direct (AI&D) equipped with Pre Alarm System which helps to alert and guide the people living nearby river banks when the water is planned to release from the Dam.
- This project consists of an AI & D system, Motorized Sirens, Strobe Light/Siren, GSM, Level Sensor, RTU, SCADA, Alarm Annunciator, Loud Speaker, Mobile, community based bulk SMS, Mobile vehicle and Amplifier to complete the project.
- An Early Warning System (EWS) can be defined as a set of capacities needed to generate and disseminate timely and meaningful warning information of the possible extreme or disasters (e.g. floods, dam failure, fire, earthquakes and tsunamis) that threatens people's lives.
- The very purpose of this information is to enable individuals, communities and organizations which are threatened, to prepare and act appropriately in due sufficient time to reduce the possibility of harm, loss and risk.

The General Technical Specification of Siren is given at **Appendix-3.**

e) **Drone Scanning for potential Regions and Damage assessment after disaster**

Pros:

- **Rapid Response:** Drones enable quick deployment and can provide immediate aerial imagery, facilitating rapid assessment of the extent of damage after an event such as an earthquake, flood, or landslide.
- **High-Resolution Imaging:** Drones equipped with high-resolution cameras can capture detailed images of the affected areas, allowing for a thorough analysis of the damage.
- **Integration with GIS:** The images are integrated into Geographic Information System (GIS) platforms for mapping and analysis, providing a spatial understanding of the impact.
- **Flexibility in Deployment:** Drones can be deployed in various terrains and environments, including remote or hard-to-reach areas, providing a comprehensive view of the affected region.
- **Cost-Effective:** Compared to traditional aerial surveys or satellite imagery, drones can be more cost-effective solution for obtaining high-quality images for damage assessment.
- **Real-time Monitoring:** Drones can transmit real-time images, enabling continuous monitoring of the situation and helping emergency responders make informed decisions.
- **Communication to Stakeholders:** Visualizations and assessments derived from drone imagery are communicated to relevant stakeholders, including CEA, rescue teams, and the public, aiding in transparency and coordination.

Cons:

- **Limited Flight Time:** Drones typically have limited battery life, restricting their flight time. This limitation can impact the coverage area and the duration of real-time monitoring.
- **Weather Dependency:** Adverse weather conditions, such as strong winds or heavy rain, can affect the drone's ability to fly and capture images.
- **Regulatory Constraints:** Drones are subject to aviation regulations, and obtaining necessary permits for deployment may be required. Regulatory constraints can vary by location and may impact the timely use of drones in emergency situations.
- **Continuous Power Requirement:** The sensor requires continuous power, which can be a limitation in areas with unreliable power sources. Additionally, the need for power backup increases the overall power consumption.
- **Skill Requirements:** Effective drone operation and image analysis require skilled operators and analysts, which may not always be readily available in emergency response situations.

5.2 SITE SELECTION FOR AUTOMATIC WATER LEVEL RECORDER (AWLR) / GAUGE AND DISCHARGE (G&D) SITE

For implementation of the Early warning System (EWS), location of the G&D site with Automatic Water Level Recorder (AWLR) and Telemetric communication at upstream location of dam are selected based on the catchment and river characteristics. Assuming flow velocity of 3-7 m/s (10-25 kmph) during floods as per site specific conditions, it is desirable that the AWLR/ G&D site be established at least at sufficiently upstream of concerned dam locations to provide at least 1 to 2 hour lead time to react, issue warning and for proper coordination among authorities. If a site is established for measuring Glacial Lake Outburst Flood (GLOF) then velocity of the range of 10-15 m/s need to be considered for deciding location of site for early warning.

If any major tributary is joining upstream of dam, a G&D site with AWLR and Telemetric communication shall also be established on it.

Measurement Range, Stability, Sensitivity, Scale Readability, Accessibility, flow conditions, network availability, Flood Protection etc. are criteria for the site selection for the establishment of a gauging station.

5.3 MOUNTING OF SENSORS

a) Location for installation of the sensors shall preferably be on a bridge at the centre of the river.
b) Sensors shall be installed on steel structure mounted on bridge, if required, with height as deemed to be suitable by the OEM/ Vendor considering highest flood level at that location.
c) If there is no bridge available for installation of the sensor, arrangement of GI cantilever beam shall be made at a suitable location at the river bank at a safe height. The GI cantilever beam shall be supported with Iron rope running from the top of the vertical pole to the far end of the cantilever beam to provide enough strength. This arrangement shall be within the scope of Vendor. Provision for extension shall be kept in the cantilever beam to take care of lean season/change in course of the river. Sensors should be mounted in such a robust way that in case of any disaster, the instrument does not get displaced or washed away.
d) Supply and transportation of GI pipes and other mounting arrangements till the project store shall be ensured.
e) Transportation of the mounting arrangements from the store to the G&D site shall be ensured Further, civil works including masonry, clearing of site etc. pertaining to installation of the poles and towers shall also be ensured.
f) Sensors should be properly protected from theft and vandalism.

5.4 INSTRUMENTS/ARRANGEMENTS/ESTABLISHMENTS REQUIRED FOR DATA TRANSMISSION FROM SENSORS

Effective data transmission in Early Warning System (EWS) for floods is important for several reasons:

- It enables the collection of real-time hydro-meteorological data from various sources, such as rain gauges, stream gauges, satellites, radars, and weather models.
- It facilitates the generation and dissemination of flood forecasts and warnings to the communities at risk, and the coordination of response and evacuation measures among different stakeholders, such as local authorities, emergency services, and media.

Internet connectivity shall be maintained at G&D site for communicating data from datalogger to the vendor's API server. Above connectivity shall be established using dual sim based **GPRS/3G/4G/5G upgraded modem**, if reliable mobile data network is available at the G&D Site. Facility for dual sim with auto switching of network is mandatory *(if two or more network available)* for ensuring continuous connectivity.

At sites where mobile data is not available or unreliable, the communication shall be established using VSAT. Separate battery bank also needs to be installed for providing continuous power to the VSAT system. The battery bank should be capable of providing backup power to the system continuously for not less than 15 days in case of non-availability of power. The battery bank shall be charged using regular power supply or through solar power to be decided by project authority.

Both GPRS and VSAT based communication system have chances of being destructed during extreme weather condition. VSAT systems consume a lot of power, making it a costly affair.

Another way of effective communication is satellite based (INSAT/INMARSAT) network, which is presently available to Government agencies. It requires licensing and has limited frequency range, therefore it needs government intervention to be used by other users too.

The General specifications for GPRS/3G/4G MODEM and VSAT are given at **Appendix-4.**

5.5 UN-INTERRUPTED/ CONTINUOUS POWER ARRANGEMENTS FOR SENSORS AND COMMUNICATION SYSTEM

a. The system shall run using Sealed Maintenance Free (SMF) Lithium batteries (12V) rechargeable through regular power supply (preferable, wherever available) or hybrid chargers (Solar+AC) or through solar panel wherever regular power supply is not available. The choice for this arrangement shall be made by the project/ power station for best results as per site conditions.

b. The battery shall be capable to run the system continuously for minimum period of one week and in case of locations that remain inaccessible for longer duration, 2 weeks on full load irrespective of power supply availability or cloudy/ foggy conditions.

c. A parameter for conveying the battery health status shall also be provided in the API.

d. The Battery bank shall also be equipped with a Battery Health Management System to monitor the health status of the battery. Further, current battery voltage level and battery health status like healthy/ unhealthy information shall also be passed in the API.

e. There shall be separate battery banks for
   - Datalogger and related devices
   - VSAT and related devices (if required)

The General Technical Specification for Datalogger and Solar panel & Battery are given at **Appendix-5A, 5B & 5C.**

5.6 CENTRAL COMMAND AND CONTROL STATION (CCCS)

a. Establishment of CCCS:

Central Command and Control Station (CCCS) shall be established at project/ power station for 24x7 monitoring. Establishment of CCCS shall be under the scope of the project authority. For the purpose of 24x7 monitoring of Early Warning System, Desktop PC with UPS and colour printer shall be installed at CCCS. 24x7 Internet connectivity shall be required at CCCS.

Following systems/ equipment shall be considered for Establishment of CCCS:

i. **Communication System**: Necessary equipment / system for communicating with all the Sensor Stations simultaneously through VSAT as well as Terrestrial (GSM/GPRS) mode for receiving water level, velocity/ flow & weather data along with others status / alarm signals on real-time basis. Necessary equipment/ system for communication of EWS Alarms to designated recipients through SMS / WhatsApp/ other means.

ii. **Data Centre**: All Hardware and Software including Servers and peripherals, Flow Modelling Software, inundation modelling, dam break modelling etc. for analyzing the received Sensor data to provide suitable Early Alert regarding anticipated flood conditions at Dam/ Barrage and Power House sites, Storage & Retrieval of Historical data.

iii. **HMI System**: All Hardware and Software including Operator Work Stations (OWS) with Full HD Screens of appropriate size, 2D Map application, HMI Software, etc. for Dynamic display of EWS data (both raw data from Sensor Stations and processed data from EWS software), Alarms & SOPs for Emergency conditions. All Hardware and Software for converting the alarm signals to formats suitable for dissemination like SMS, voice messages, Text to Speech (TTS), email, emergency sirens, etc.

iv. **Power Supply**: Reliable and redundant Power Supply system based on 415 V / 240 V AC Uninterrupted Power Supply (UPS) along with adequately sized Battery Bank, the input for which is to be tapped from projects AC Supply system.

v. **Electronic siren**: Electronic siren system for alarming purpose.
vi. **Miscellaneous**: Necessary mounting arrangement for the outdoor equipment/ systems mentioned above and other item as per the requirement of system.

b. Application Programming Interface (API) & API Server required to be connected to Master Control Room

Data from the sensors like water level, velocity, date time and battery voltage, battery status as per the API format given below shall be communicated through API in JSON format for integration with other systems.

{"Project Name": "ABC Project", "Location Name": "G&D Location 1", "date_time": "2024-01-01 12:45:00", "Water Level": "1276.044", "Battery Volt": "13.2V", "Battery Health": "healthy"}

*a key with 'velocity' may be included if velocity sensor is installed.

i. Server for hosting the API shall be maintained by the vendor. The physical location of the server shall be within the territory of India. If third party cloud services are hired for hosting the API/ Web portal, the service should be MeitY Approved.
ii. Data from datalogger shall be transmitted to the API server continuously for getting the latest data.
iii. 24x7 internet connectivity of the server shall be ensured.
iv. API/ Web portal shall be served over internet using secured https connection.
v. The corresponding data including rainfall may be provided to IMD in the form of API's which will further help in improving IMD forecast and warnings in the Numerical Weather Prediction (NWP) models.

The Manufacturers/ Suppliers of Sensor solutions for EWS and indicative list of vendors for EWS are given at **Appendix-6 & 7** respectively.

6. MEASURES TO BE TAKEN ON RECEIVING OF ALERT/ALARM IN CASE OF OCCURRENCE OF DISASTER

i. **Pre-Incident Actions:**
   a. Pre-incident actions for early warning systems at dams are crucial for ensuring the safety of downstream communities and infrastructure.
   b. As per Dam Safety Act, 2021, the pre-monsoon inspection of specified dam is done before monsoon that include inspection, maintenance and testing of the early warning system components including sensors, communication systems, alarm systems and other emergency equipment.
   c. A comprehensive risk assessment and analysis of historical data to identify potential hazards and vulnerabilities is critical which can help in anticipating probable incidents.
   d. The emergency response planning as per Emergency Action Plan/Disaster Management Plan is to be shared with stakeholders and local administration to create awareness among downstream communities for coordinated response in case of incident. Teams of divers and lifesaving material to be kept ready to co-ordinate with District Administration.
   e. Regular mock drills and exercises to test the effectiveness of the emergency response plan are undertaken to familiarize officers and other stakeholders with their roles and responsibilities during an emergency.
   f. The disaster information is being shared/ notified with systems at state and national level for effective rescue operations in case of incident.

ii. **Colour Coded Lighting System for Warning Purpose**

A colour coded warning scheme in the form of Red/ Amber/ Green lighting shall be devised based on the perceived risk assessment of the emerging abnormal emergency situation by the control room/ project authorities with Red indicating Severe Risk Category and the Green indicating Least Risk Category.

The personnel working at project site should be made aware of the impending emergency situation through the colour coded warning scheme. Project Authorities shall identify vulnerable locations where such lights scheme can be installed such as dam galleries, transformer gallery, machine floor area etc. of power house, enclosed areas or any other identified vulnerable locations at the project.

iii. **Automatic siren system**

There shall be an automatic siren system which could be programed to activate with the abrupt rise in water level in the river upstream of the hydroelectric project. Marking of danger levels at vulnerable places and setup of permanent warning posts (in English, Hindi and local language) along the river course in the upstream areas shall be made.

The Hooters/ Sirens System should be able to operate with just a touch of the button. On the lines of colour coding of the perceived risk, gradation of Hooters/ Sirens needs to be defined and blowing pattern of the Hooters/ Sirens could be distinguished based on the Red/ Amber alert. Loudness of the Hooter System have to be sufficiently high so as to be audible in case of occurrence of flash floods wherein the ambient decibel level rises significantly.

Apart from the installation of adequate number of sirens (both manual and electrically operated), marking of danger levels at vulnerable places and setup permanent warning posts (in English, Hindi and local language) along the river course in the downstream areas shall be made.

Whenever there is abrupt rise in the level or some releases are to be increased from turbines/spillway/ Barrage, all the sirens shall be operated to warn the people living nearby. A typical gradation scheme classified as Blue, Yellow, Orange, and Red alert according to their seriousness and severity as specified in Emergency Action Plan / Disaster Management Plan (EAP/DMP) shall be adopted. Accordingly, the gradation of hooter with no sound to gradual increase in number of repetitions of long tones (each of 45 seconds) of sound mode are being played corresponding to gravity of catastrophic situation. The gradation of hooters is typically accompanied by other available communication channels, such as public address systems, emergency contacts, WhatsApp or mobile SMS alerts, to ensure that all officers having responsibility for maintaining essential services and rescue/evacuation as well as residents receive timely warnings and instructions without panic.

iv. **Instantaneous/ automatic opening of gates**

All the Hydro Dams/ Barrages gates **should be capable to operate in auto mode in addition to manual mode**. Further, inter-connection between Dam/Barrage site Control Room and Power House Control Room shall be provided through redundant optical fiber cable to operate the gates in case of emergency in line with SOP of gate opening/closing of the individual project/Project Authority. Therefore, a Plant wise SOP needs to be prepared regarding opening sequence of gates according to severity of the Early Warning Alert e.g. the Red alert warrants opening of all the gates simultaneously and accordingly downstream population may be suitably informed.

Operational readiness of all Dams/ Barrages and intake gates, for its full opening/ closing in remote and local control needs to be ensured and accordingly their test operations should be carried out regularly

v. There shall be provision for an Un-gated spillway with crest at Full Reservoir Level (FRL) to regulate unprecedented inflow between FRL and Maximum Water Level (MWL) for the upcoming projects. This feature may serve as a crucial mechanism to mitigate potential risks posed by Glacial Lake Outburst Floods (GLOFs) or Flash Floods, particularly in scenarios where the opening of a gate may not be feasible due to the severity of the catastrophic situation at hand.

vi. Location of diversion / regulating structures shall not be close to a nallah/ stream / tributary in the upstream which may damage the structure/ regulating gates in the event of a cloud burst induced flash flood carrying large quantity of sediments.

vii. **Evacuation of manpower from tunnels**
Fluorescent direction indicators, EXIT lights in tunnels etc. shall be suitably provided for evacuation of manpower from tunnels in the Projects. During construction stage where tunnelling is involved, escape tunnels in the form of designated shafts may be kept as escape routes in the event of any catastrophe and the same are to be made operational from the initial construction stage of any large hydropower project. During construction stage, openings of adits/ tunnels could be equipped with gates, wherever feasible, which could be closed to avoid water ingress into the tunnels.

viii. The information in respect of early warning of any disaster/ emergency situation to upstream/ downstream hydro projects/ local population/ local civil & state administration shall be communicated on 24x7 basis in real time basis through hotline mechanism/ bulk messaging /bulk voice calling system to their mobile phone. This could be done by forming a Common User Group (CUG) among the hydro projects in the same river valley. The CUG should also include the officials from DDMA, SDMA and the District/ State administration of the region affected along with NDMA. This will help in early indication to project authorities in decision making to take advance step for disaster management.

ix. Dual mode of communication using VSAT (Extended C Band) and GSM/ GPRS (5G) shall solve the problem up to reasonable extent. In case of availability of 5G signals from more than one service provider, dual GSM/GPRS sim modems can be used discarding VSAT as it will greatly reduce the battery back-up requirement.

x. A detailed updated inventory of Glacial Lakes for a particular river basin shall be jointly prepared by all the developers in the river basin. The same may be got prepared through NRSC ISRO. The cost may be shared by all the developers.

xi. Project Authorities shall ensure that Emergency Action Plan (EAP), Crisis & Disaster Management Plan shall be in place even in under construction projects and should be well integrated with the SOP of EWS. Mock Drills shall be conducted on regular basis (e.g. quarterly/ half-yearly), to evacuate plant personnel in case of emergency situation in minimum time. An annual EAP review shall be conducted to ensure that contact names and numbers are current on the Notification Flowcharts.

xii. The instruments/ sensors deployed for early warning shall be able to communicate with control room in 24x7 real-time or near real-time basis & in fail proof manner automatically/ without human intervention.

xiii. The control room is to be equipped with Mobile phone/ satellite phone, internet connectivity, Wi-Fi Connection (with UPS) and emergency power supply (with DG backup) to operate efficiently in case of blackout during any emergency. Emergency Handling Items & equipment such as life Jackets, Helmets, Long Beam Torch are to be available in the Control Room. List of Contact Numbers of Project Head, key Personnel of the project and local administration, nearby Hospitals and other relevant agencies should be prominently displayed at suitable locations for early information of any impeding emergency situation to all concerned authorities in parallel for necessary action.

xiv. The control room shall also take feedback from other agencies/sources such as IMD, CWC, National Center for Seismology, DGRE, Weather reports, Forecasts, nowcast on different websites (mosdac.gov.in, ffc-india-water.gov.in, cwc.gov.in, city,imd.gov.in etc.) and register with them.

xv. Control room shall continuously monitor real time inputs i.e. Velocity, Level of sensor stations and healthiness of the system as per Check list for Automated Flood Warning System (AFWS).

xvi. The software regarding keeping the flow data history may also be developed and included in the existing EWS data logger. This will give necessary warning/indication when previous high floods value reach at any time and provide alert through automatic alarms signals accordingly.

xvii. A detailed inventory of rivers/ major tributaries etc. shall be prepared by the Project authority and be made available in the Control Room.

xviii. **Level of In-charge & manpower deployment**

Control room shall be manned by executives of project authorities on 24x7 basis and electronic recording of activities being monitored shall be ensured. The in-charge of Control Room at project site shall be senior most with adequate manpower for 3 shifts of 8 hours each. The control Room shall also maintain a Log Register wherein activities being monitored round the clock shall also be physically recorded. The Control room shall not be left unmanned at any point of time.

Chief Engineer/equivalent to Chief Engineer shall be designated overall in-charge responsible for the management of Emergency Action Plan/ Disaster Management Plan. Alternatively, the choice for the manpower arrangement shall be made by the Project Authority for best results as per site conditions. The Notification Flow Chart and emergency control rooms have been made an integral part of EAP/DMP to pass on the information about the developing situation to all responsible and concerned project officers and other support staff for undertaking evacuation, rescue, and relief operations in coordination with District Administration. The teams for rescue, relief and evacuation operations at Dam and Township area, Technical Teams for electricity and transportation, communication team and medical assistance teams are well specified in EAP/DMP. Project Authorities shall also remain in close contact for coordination with the civil administration including Deputy Commissioner, SDMs, Tehsildars, and District/State Disaster Management Authorities etc. to mitigate the effect of disaster.

xix. A dedicated vehicle shall be provided to the Control Room Personnel for movements within the Project site and Manual Observation Posts.

xx. At least two Cellular Smart Phone with mobile connectivity, one Wi-Fi Connection with adequate Data plan, Search Light/ Long Beam Torch and PA System shall be provided in the Control Room. The Satellite phone, unless prohibited by Defence Forces for the plants located at sensitive locations from National Defence aspect, shall also be provided in the Control Room.

xxi. Depending on analysis of the feedback from Manual Observation Guard posts/ Automated Flood Warning System or any other source, Control room shall initiate alarm to disseminate information about any emergency at Site to Project authorities and other concerned as per the Emergency Communication Flow chart attached to take appropriate action for evacuation of people from site (s).

xxii. The Control Room Shall use Siren/ Public Address system for alerting the people working at Sites depending upon the nature of Emergencies as per the existing approved Disaster Management Plan (DMP).

xxiii. The routine dam maintenance, such as annual weed control, conducting dam integrity inspections and notifying the nominated Nodal Officer for Dam Safety of any potential emergency situations shall be ensured. Pre-monsoon and post-monsoon inspections of the dam shall be made to evaluate its structural safety, stability, and operational adequacy.

xxiv. The availability of equipment, supplies, or personnel shall be ensured which may be necessary for use during a dam emergency.

xxv. All people involved in the EAP shall be trained to ensure that they are thoroughly familiar with its elements, the availability of equipment, and their responsibilities and duties under the plan. Personnel shall 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.

xxvi. Synchronization with upstream projects, if available, may also be helpful in providing real-time data and detailed information regarding the EWS parameters. Further, the synchronization with inter-projects in a particular area may also help to obtain more detailed parameters of the projects and enhance the functioning of EWS in a better way.

xxvii. A stakeholders' consultative meeting shall be held periodically with a view to assess the performance of the EWS and explore upgradation of the warning system based on the past experiences and advancement of technology.

xxviii. There shall be documentation and record-keeping during and after an event by the Project Authority. Accurate records are crucial for post-event analysis, compliance with regulatory requirements, and transparency.

xxix. There shall be a provision of dedicated Nodal officer along with the team for Early Warning System in each project. Further, the nodal officers of EWS of all the hydro projects in a basin shall regularly have a meeting for better coordination and shall remain in touch on hot-line.

xxx. The upstream most hydro project of the particular basin shall have regular meetings with SDMA, DDMA and local administration for strong coordination and communication to mitigate all the probable losses with the help of Early Warning System.

Appendix-1A

General Technical Specifications of Sensors

a. Surface Velocity Sensor

Parameter	Requirement
Technology	Radar
Measurement range	0.1 -15 m/sec
Flow velocity Resolution	0.01 m/sec
Flow Accuracy	1% or better
Installation height above water level	As per site condition
Power supply voltage	9-27 VDC
Operating temperature	-40 to 70°C
Sample rate	10 sps
IP rating	IP 67 or Higher
Communication protocol	MODBUS RTU
Communication interface	2-Wire RS-485

b. **Water Level Sensor**

Parameter	Requirement
Technology	Radar
Process fitting & Beam Angle	Thread G2, Flange from DN 80; Beam Angle 5° or better. Fitting as per suitability of site.
Measurement range	0-30 m (may be increased depending upon site condition)
Resolution	5mm
Accuracy	±3mm-4mm
Power supply voltage	9-27 VDC
Operating temperature	-40 to 70°C
Signal Output	4-20 mA/HART (2-Wire/4-Wire)
IP rating	IP67 or higher
Communication protocol	MODBUS RTU/ OEM specific to meet application requirement
Communication interface	2-Wire RS-485

c. **Automatic Gauge & Discharge Stations (Imagery Based)**

Automatic Gauge & Discharge Stations having non-contact imagery based water level and velocity sensors.

Width of River /River Span	≤ 120 m
Resolution of sensor	3 MP Full HD 1080p PoE IR
Protection Class	IP 66
Measuring Range	0.2 - 15 m/s
Frame Rate	30 FPS
Operating system	Linux/Windows
Accuracy	Flow velocity: < 5% of measure value*
	Water level: < 1 cm*
	Discharge: < 10% of measured value*
Data Output	MODBUS/4-20 mA / RS 485 / SDI - 12
External water level output	4 -20 mA/RS485/RS232/SDI -12
Operating temperature camera	: -40° C to + 50° C
Power supply	230 V/12 V, grid or solar power
Measurement Principle	Image Velocimetry

Appendix-2

1. SPECIFICATIONS OF AWS SENSORS-

- For all sensors offered, it should be rugged, well proven sensors and used for operational purpose.
- Cables used for sensors to connect Data logger should be Teflon insulated multi strand and silver coated.
- **For sensors, valid Certification from reputed International/ Indian institute is to be submitted.**
- **Detailed Technical Specifications of Sensors are mentioned below:**

Temperature and Relative Humidity Sensor with Radiation Shield	
Air Temperature	
a) Sensor type	Pt 100 RTD
b) Measurement Range	-40 °C to +60 °C
c) Accuracy (with radiation shield)	± 0.20 °C or better for +10°C to +60 °C ± 0.35 °C or better for -40°C to +10 °C
d) Resolution	0.1 °C
e) Output	Analog/ Digital
Relative Humidity	
a) Measurement	Range 0% to 100%
b) Accuracy (including nonlinearity, hysteresis and repeatability)	± 3% RH or better with membrane filter (In the Range 10% to 100%)
c) Output	Analog / Digital
d) Resolution	1% or better
e) Sensor type	Capacitive / solid state
Radiation Shield	
a) Type	Thermoplastic
b) Louvered	Minimum 9
c) Ventilation	Natural
d) Mounting Accessories	Aluminium Mounting bracket and Stainless-steel U Bolt clamp.
Wind Sensor (Ultrasonic 2 Dimensional)	
Wind Speed	
a) Range (Operation)	0 to 60m/s or better
b) Sustainability	Up to 60 m/sec
c) Accuracy	± 0.5 m/s or better
d) Resolution	0.1 m/s
e) Threshold	0.5 m/s
f) Response time	1 sec or better
g) Output	Digital
Wind Direction	

a) Range	0 to 359 Degrees
b) Accuracy	±5 degrees or better
c) Resolution	1 deg. or better
d) Response time	1 sec or better
e) Output	Analog/ Digital
Tipping Bucket Rain Gauge sensor or with better technology	
a) Collector Area	Specified Collector Area should be between 200 cm^2 to 325 cm^2
b) Height above funnel	Height above funnel should be sufficient to accumulate rain during heavy rainfall as per WMO guidelines.
c) Switch	Rugged Magnetic Proximity
d) Resolution	0.5 mm per tip
e) Output	0.1 sec switch closure
f) Accuracy	±2% or better, for rain rate up to 25 mm/hr ±3% or better, for rain rate between 25mm/hr to 50 mm/hr ±4% or better, for rain rate between 50mm/hr to 100 mm/hr ±5% or better, for rain rate>100 mm/hr
g) Material of Outer Body/housing (Base/Collector)	Rust Proof Housing.
h) Levelling	Suitable levelling adjustment screws and circular spirit level must be provided on the base of TBRG for levelling the Tipping bucket Mechanism.
i) Debris protection filter	Suitable (Wire mesh) debris protection filter should be provided inside the collector.
Pressure sensor	
a) Range	600 to 1100 hPa
b) Accuracy	± 0.2hPa or better for complete range (600 to 1100 hPa)
c) Resolution	0.1 or better
d) Output	Digital

2. 2. SPECIFICATIONS FOR POWER SUPPLY

- The complete AWS station shall have capability for unattended operation at **remote place** using Sealed Maintenance Free (SMF) battery, Electrical charger, Solar charge controller and rechargeable through a Solar panel.
  (i) **Battery**: Single 12 V chargeable SMF batteries 65 AH capacity or better.
  (ii) **The switch with fuse is required for power supply to the Data logger.**

(iii) **Solar Charge controller (MPPT)**: It should charge the 12 V, 65 AH SMF battery through 75 W Solar panel and also Over-load protection, Short circuit protection, Protection from the lightning strike and Under-voltage protection. It should have provision to controlled power supply to the Datalogger.

(iv) **Solar Panel (Mono Crystalline)**: Rated capacity 75 W or better,

- AWS should run for 20 days during cloudy day or without charging the battery.

4. 3. SPECIFICATIONS FOR WEATHER PROOF FRP ENCLOSURE FOR AWS

- Two separate enclosures are required for AWS.
- Weather proof Enclosure of AWS should be FRP Enclosure (IP 66) and for outdoor use to provide a degree of protection against falling dirt, rain, sleet, snow, windblown dust, splashing water, and hose-directed water.
- **One enclosure** FRP Enclosure (IP 66) is suitable to keep Data logger, solar charge Controller, Pressure sensors, switch with suitable fuse for power supply to Data logger and GPRS modem.
- **Another separate** FRP Enclosure (IP 66) for 12 V, 65 AH SMF batteries
- Silicone gasket is used for both Enclosures for harsh environments and extreme temperatures.
- FRP Enclosure (IP 66) enclosures should be designed for outdoor applications that require corrosion protection against chemicals and water. From humble to harsh environments, it safeguards vital electrical and electronic components with enclosures, climate control and accessories to help keep operations up and running smoothly.
- Enclosure with hinged door and locking facility.
- Data Pockets provide convenient storage for wiring diagrams, operation manuals and other documentation inside an enclosure.

5. 4. MAST FOR AWS (Tiltable type / Foldable/Sliding up and down)

- Mast shall be 10-meter (**Tiltable type / Foldable/Sliding up and down**) mast. The mast is designed to withstand high wind conditions, up to 60 m/s of maximum wind speed, with a standard set of guy wires.
- It shall be corrosion resistant and salt water resistant.
- The Mast can be lowered down any time to remove for maintenance and reinstallation of the wind sensors.
- Instrument booms suitable for mounting on the Mast need to be designed on the basis of the mounting requirements of the sensors.
- The bidder shall be responsible for installation of sensors at various levels, fixing and laying of the signal cables from all the sensors up to the ground level along with fixing the cable identification tags. The signal cables should be laid out properly on the mast and tied to the structure elements with cable ties of appropriate lengths.
- Tension in the guy wires shall be adjusted by means of tension meters or any standard method for adjusting the tension in the guy wires may be followed and tension should be adjusted in the presence of representative of developer.
- The overall specifications of Mast are given in table below:

1	Height	10 m
2	Wind	60 m/s
3	Guy levels	At 6 m
4	Lightning Arrestor	A lightening arrestor with spiked copper rod of atleast 10 meter height should be installed at the top of the mast and connected to an earth pit with copper bars and suitable copper cable. Separate maintenance free type earth pit conforming to the relevant IS specifications should be provided for this purpose.

5	Cable routing	Provision for cable routing from instrument booms / junction boxes to the bottom of the mast will be provided. The cable bunch has to run in a flexible PVC pipe / with equivalent arrangement from top to the lower end of the tower and into the instrument enclosure

Appendix-3

General Technical Specification of Siren

Serial No.	DESCRIPTION OF EQUIPMENT FOR LOCAL STATIONS	Specifications
C1.	**Local station for Alert, Information and Direct system comprising of the following hardware/software:** • Panel/Housing with power supply module • Dual SIM 3G/4G communication Router • Intelligent Remote Terminal Unit (RTU) or Programmable Logic Controller • Electronic Siren •Starter with feedback arrangement for siren • Strobe Light with three color •Mounting hardware and cable connectors etc. • Set of applications and system software	**Panels for Mounting Hardware:** The panel should be duly wired and sufficiently spaced to accommodate all the equipment with IP65 protection, CRCA sheet metal. Earthing bolts available at single sides. The enclosure should have single door. The panel should have lock arrangement and wall mounting arrangement. The system should run-on single-phase power 230V AC, operating in the range 170-250V /50Hz and should be rugged enough to withstand voltage fluctuations without damage. **Power and Backup:** All the stations equipment (i.e. Electronic Siren, strobe lights, PLCs etc.) must be powered and activated by single phase power. The status of Power Supply must be available in the Central Control Room. **Siren System:** • Must have provision of Pre-recorded/programmed electronic warning tone. **Strobe Light:** • Light Color: Red, Amber, Green • Operating Voltage: 24/12V DC • Flash pattern: Double Flash • Mounting: Permanent Mount • Flashes per minute -75 Double Strobe Light should be installed in Local Stations in a manner that it is visible. **Controller/PLC/RTU:** The Controller shall be designed to have communication compatibility for any wireless mode like GSM, GPRS, Radio, Satellite or Wired mode like Internet, Broadband to transmit data and receive commands remotely. **Cyber security on Hardware:** 1. Access to the controller shall be password-protected. Additionally, only selected devices are allowed to connect to controller. 2. Memory protection mode is available via

		physical inputs or software configuration. The application and user data are protected in this mode 3. Run/Stop protection mode is available via physical inputs or software configuration
C2.	**Electronic Siren up to 50db**	• Considering ambient noise, system audio output must be at least 3 dB above the ambient noise conditions. • High Power Electronic Siren System each with a minimum acoustic power of 50dB @ 1M (Lab Tested). • Siren Controller box must be IP55 compliant (or better). • Operating Temperature: -20 to +60deg C • The system must have a capability to run continuously for 10 minutes without overheating/failure. • The system must adhere to EN 60065 certification for compliance to highest European Safety Standards and ISO 9001:2008 certification of product design and manufacturing. Equivalent International i.e., UL, FEMA and Indian Certifications are also acceptable. • Standby mode current should not exceed 40mA. • Dual feature of Control – Remotely from Control Room and Locally at the Siren Controller box for authorized user.
C3.	**Feedback Unit for status of Local Stations at Control Room**	All feedbacks (on, off, trip, faults etc.) of the equipment installed for Alert, Information and Direct system should communicated to main Control room SCADA/MCR/CCCS.
C4.	**Interface system for Radio and 3G/4G link on wireless communication through dual SIM and associated software at control room**	A suitable interface/communication system of reputed make should be installed in the Local Station with the capability of operating over 3G/4G Link through Dual SIM and should be accordingly interfaced with main Control Room SCADA.

C5.	**Cable and required mounting accessories**	Power Cables and Accessories: All required power cables and accessories to make the system functional will be supplied by the vendor. Cables should comply with IS-694, IS-3961, IS-8130 and IS-5831. MAKE: Polycab / Finolex or reputed.
C6.	**Mandatory Spares (one set)**	I) Electronic Siren- 1 Nos II) RTU/PLC – 1 Nos III) Modem – 1 Nos IV) Strobe Light – 3 Nos (Red, Amber, Green)
C7.	**Siren type**	**Required Technical Specification**
	Acoustic power	50 dB(A) / 1 m
	Number of alarm messages	Min. 5 x 6 min.
	Operating power	230 VAC/ 24 VDC
	Load impedance	4 Ohm / 8 Ohm
	Number of warning voice messages	100 Nos. with USB
	Overall records length /1GMB Flash memory/	Min. 16 hours
	Voltage	110 – 250 V / 24 VDC/50 Hz
	Stand-by mode current	40 mA / 230 V
	Max. input /stand-by input (Pi/Pp) / 230V	150 VA / 11 VA
	Control circuits voltage	24V/12V
	Battery	2 x 12V, Ah capacity based on Design/requirement.
	Service temperature	-10°C to +60°C
	Service temperature of local control module	-10°C to +60°C
	Weight of 1 horn	<=5 kg
	Dimensions of siren box / L x H x W / mm	As per design
	Siren box cover	IP55 for Panel Mount
	Interfaces	
	USB device	Inbuilt Tone
	Tone	2 Tone
	Selection of Tone	By Toggle Switch
	Wireless	Wired
	LAN	10/100Mbit Ethernet link
	8x Binary input 2x Binary output	User programmable I/O lines

	Power amplifier	As per Design. Full diagnostics, including speaker impedance.
	Real time clock	RTC circuit with battery backup, GPS time Synchronization
	Authorization	For authorized Users only

Appendix-4

A. General Technical Specification for GPRS/ 3G/ 4G/ 5G MODEM

4G based GPRS Modem (compatible with 3G) with dual SIM facility and also have provision of fast and reliable wireless data communications along with support for IP based access to the central server IP. The GPRS Modem shall be compatible to all SIM. The following technical specifications are indicative.

(i) GPRS facility with fast and reliable wireless data communications.
(ii) Remote dial-up facility.
(iii) Shall support SMS, Email and FTP.
(iv) Accept dual standard SIM card.
(v) Ethernet/RS 232/485/USB interface with DATALOGGER.
(vi) Indication of network availability (signal strength).
(vii) Suitable High gain GPRS Antenna for reliable communication.

In order to provide redundancy in Connectivity for facilitating Data transfer from AWS to Master Control Room, VSAT services (Ku / Ka / Extended C) with Internet facility can provided for which minimum specifications are as follows:

Indoor Unit (IDU)

Forward Channel

1. DVB-S2X with Adaptive Coding and Modulation (ACM)
2. Frequency: C-band, Ku-band and Ka-band
3. Modulation: QPSK, 8PSK, 16APSK, 32APSK, 64APSK
4. Encapsulation: GSE
5. Symbol rate: Up to 235 Msps

Return Channel

1. MF-TDMA
2. LDPC FEC with efficient variable block/burst sizes
3. OQPSK, QPSK, 8PSK, or 16APSK
4. Symbol rate from 256 Ksps to 12Msps
5. Adaptive Coding and Modulation (ACM) capability

Network Interfaces

1. 2/4 GigE LAN ports
2. USB

ODU

1. Radio interface: Operates in Extended C-, Ku- , or Ka-Band Networks
2. Antennas: 74 cm, 98 cm, 120 cm, or 180 cm.
3. IFL cable type and length: Dual RG-6, 75-ohm, F – type connector up to 150'

IP Features

1. Dual stack IPv4/IPv6
2. Static and Dynamic addressing
3. BGP Routing Support
4. Policy Based Routing
5. DHCP
6. VRRP
7. Access Control List (ACL)
8. DNS Caching
9. SIP Call Proxy
10. Advanced Web Acceleration
11. Layer 2 transport with acceleration and compression

GPRS Network Service

There should be provision for SMS and IP based communication with DATALOGGER remotely to access and configure the DATALOGGER through GPRS / VSAT modem.

- **GSM & GPRS MODEM**
  a. Shall have embedded HTTP/FTP/TCP/UDP Protocol.
  b. Shall be compatible with standard 3G and 4G GSM network of all reputed national operator.
  c. Shall be compatible with the data logger proposed by the vendor.
  d. Shall have ISO 16759 qualification.
  e. Standby current: < 0.90 mA
  f. Shall have GSM/GPRS functionality scalable to customer needs.
  g. The modem/software in the data logger shall be configurable to send SMS/GPRS packets to the central reception facility at a user defined interval ranging from 1 minutes to 24 hours.
  h. The modem configuration shall ensure that no data is missed. The modem or the data logger should send data in packets (GPRS) at pre-defined interval. In case of non-availability of mobile network during its schedule transmission time, the data will be transmitted as and when mobile network is available. In such cases, all the data that has not been transmitted till any particular time, shall be transmitted once mobile network is available.

B. General Technical Specification for VSAT

a. Dedicated 256Kbps Bandwidth
b. Ku/ Extended C band VSAT
c. Antenna size: 1.2m
d. Separate battery bank for VSAT to provide power backup for minimum 15 days.
e. Other Standard IDU and ODU features.
f. Smooth operation during rainy or cloudy conditions.

Appendix-5A

A. General Technical Specification of Data Logger

a) The DATALOGGER shall have facility to sample the output of the attached sensors with user selectable sampling interval. The process of the samples collected is to obtain instantaneous, average, maximum and minimum values along with their time stamp for the selected measurement interval for transmission.

b) There should be provision of Maximum wind observation (Gust and squall) for both wind sensors along with their time stamp.

c) All DATALOGGER should have suitable port to interface with any external display unit.

d) The sampling and measurement interval for individual parameters shall also be user selectable.

e) The DATALOGGER should have capability to store the data for specified parameter at user defined intervals in distinct multiple log files for each sensor and other related parameters (data volume 1GB or more).

f) Stored data shall be retrievable via Telemetry/serial port/ USB port/Ethernet port to a PC/laptop and a pen drive or any other compact and commercially available solid-state memory device in standard text file format without requirement of specific software to retrieve the data.

g) DATALOGGER should have menu driven keypad and backlit LCD/LED display (internal/external unit) and facility to display the command, data characters.

h) All the Analog and Digital channels in the DATALOGGER must be compatible to the sensors supplied and integrated with the system.

i) The DATALOGGER should have a built-in high-performance analog channels, adequate number of built-in digital channels to accommodate digital output of the sensors, Counter channels for rainfall measurement.

j) The DATALOGGER shall have suitable interface for 4G dual SIM GPRS modem.

k) DATALOGGER should have provision to accept SMS command from remote mobile for Remote configuring DATALOGGER for communicating
   i) Changing time interval of server communication from 1min to 15min.
   ii) Display current data.
   iii) Monitoring the signal strength of mobile network.

l) Provision to access to the DATALOGGER through GPRS modem shall also be made with password protection.

m) In order to facilitate data processing, the DATALOGGER shall have a provision for 24-hour Real-Time Clock (RTC) powered by a battery (with min. one-year lifetime) to ensure that time is maintained even during power outages. The DATALOGGER shall have provision to easily include and change the "Unique station identification code", "Station Name", "Time of observation and transmission", "Measurement schedule" and "Sensor identification information", for all parameters, as mandatory requirements. Any change in the DATALOGGER should be properly logged along with user, date and time details.

n) The DATALOGGER should transmit the AWS data as per specified data format to receiving server.

B. Solar Panel and Battery

a. Mono crystalline Solar panel of rated capacity 50W or better, Open Circuit voltage: 21 V or better, Short circuit current: 2.5A or better and a sealed maintenance free (SMF) battery of minimum 65 AH (12 V) of reputed national brand shall be used to power the system. In no sun condition the AWS should operate for at least 15 days. The vendor shall provide a calculation sheet to demonstrate the same.

b. The system shall have a battery charger of proper rating to charge the battery through the solar panel.

c. The system shall have photovoltaic battery charge controller for protection of battery from over charging, Under-voltage protection, Short circuit protection and Protection from the lightning strike.

d. All fixing devices required to fix the solar panel to the tower/mast shall be provided by the vendor.

Data Logger for Automatic Weather Station

i. It should have menu-driven status monitoring and settings to enable.
ii. View connected sensor data onsite.
iii. View real-time data.
iv. Take data backup in USB drives onsite.
v. View station ID System Health, etc. View system clock onsite.
vi. Sensor Measurement/Auto Transmission as scheduled by the User.
vii. The data logger should support a minimum of 8 uni-polar channels or 4 bi-polar channels (passive transducers) or mixed-up.
viii. It should have multiple communication facilities including RS 232, SDI–12, Ethernet (Compact flash), USB, etc.
ix. Two or more numbers of SDI-12 Interface ports.
x. 24-bit or better Analog to Digital converter.
xi. Conversion Accuracy ± 1 LSB.
xii. Maximum scan rate of data logger 1000 Hz.
xiii. Should support individual recording intervals for different sensors/parameters connected.
xiv. Firmware Operating System: Multi-tasking operating system - must log data and transmit at the same time.
xv. Internal memory of the data logger should be sufficient to store a minimum of 10,00,000 readings, expandable to 100,00,00,000 readings (16 GB) via an internal SDHC card.
xvi. If internal memory is full, it should overwrite the data. While overwriting, it should delete the oldest data and store the current data.
xvii. Power supply: 12V DC, low current drain (quiescent ≤10.0mA).
xviii. Internal battery backup for clock: Lithium-ion Battery with storage: 3 years.
xix. Charge Controller: Internal or External.
xx. User Permissions: System of user rights/passwords, access restricted to authorized personnel.
xxi. Shall receive time synchronization with NAVIC/GPS time (UTC/GMT) through a NAVIC/GPS receiver connected to the data logger. The time synchronization should be automatic, at least once in 6 hours.
xxii. Should have an LED Display with a Graphical dot matrix of minimum 122 × 32 pixels or LCD Display of minimum 16 x 2 alphanumeric display.
xxiii. Should have a separate key for navigation of the menu and other functions.
xxiv. Should have at least one USB 3.0 Compatible host for data backup in a USB Memory Stick.
xxv. Sensor Interface: 8 × Sensor Channels, 4 × Sensor Power Control.
xxvi. Operating Temperature Range: -5° C to +60° C.
xxvii. Battery-Backed SRAM: Minimum 4 MB.
xxviii. The data logger software shall be compatible with the Microsoft Windows 10 operating system or an updated version with all required licenses.
xxix. Necessary accessories: Serial cable + adaptor for notebook connection. All accessories (fixing units, etc.) as required.
xxx. Tools: complete tool kit for installation and routine maintenance giving full detail (number of pieces and type).
xxxi. Manuals: Full documentation and maintenance instructions in English (1 copy per station).

Data Logger Specifications for Automatic G&D and AWLR

a. Four analog/digital input channels
b. Input range: The data logger should have multiple input ranges to measure the sensors accurately without any loss of accuracy. The data logger should have at least these input ranges: ±5000mV, ±2500mV, ±78mV
c. SDI-12 Input: at least 1 Channel
d. RS485 Input: at least 1 Channel (Programmable as Master or Slave Modbus)

Analog to Digital Conversion

a. Resolution: (16 Bit) or more
b. Conversion Accuracy +/-1 LSB
c. The DCP should have watchdog timer to reset the system and restore the previous set-up case of microprocessor resets and power glitch.
d. Visual Display and Keypad type numeric or alphanumeric or touch with the keypad and display it should be possible to program the data logger, manually initiate data transfer, and display data.
e. The display should be 2 lines x 20 characters and should have soft keypad for configuration.
f. The display should have a time-out feature to conserve the power.

Real Time Clock

In addition, the system should also have battery backed real time clock so that the time is updated even during power failure. The accuracy of this clock should be better than 6 seconds per month.

RS 232- Port

The DCP should have multiple RS 232 port capable of having communication with external devices like GSM/GPRS Modem, VSAT, LOS Radio modem and INSAT Satellite Transmitter. Also, it should be possible to configure the port through software. It should support MODBUS communication.

Ethernet Port

The DCP should have an Ethernet port for interfacing with VSAT Terminal for data transmission where there is no cellular network. Should also support Modbus communication.

Data Storage

The data logger shall have the capacity to store 1 year data at 15 seconds sampling and 15 minutes of averaging.

Power Requirements

Measurement Interval	1.0 Second to 24 hours (Programmable)
Number of Measurements Supported	Unlimited
Accuracy	0.002% of 5V
Expandable	Option for future channel expansion
Functions Supported	frequency inputs, quadrature input, Status inputs, counter inputs,
Output Type	Open collector with 100-ohm current limiting resistor, 100 mA max, 15V max

Excitation Channels	5 Channels
Communication Ports	RS232 for communications
Telemetry	INSAT Satellite Transmitter, Radio, Direct Connect, GPRS, MODBUS, and custom devices via BASIC/Python
Number of Simultaneous Communications	4
Operating Temperature	-40°C to +60°C
Display Operating Temperature	LED operates to -20°C
Programming	Menu driven setup, Expanded complexity via BASIC/Python Custom capability via C++/Python
ADC Resolution	16 bit or better

Appendix-6

Indicative list of Manufacturers/ Suppliers of Sensor solutions for EWS

Sensor System	Description	Make
Datalogger for Hydro Met and geotechnical Stations	Datalogger AWS - Meteorology	HyQuest Solution
	Datalogger AWS - Level and Velocity Monitoring	HyQuest Solution
	Datalogger AWS - Level Monitoring	HyQuest Solution
	Datalogger AWS - Distrometer	HyQuest Solution
	Datalogger AWS - Hail	HyQuest Solution
	Datalogger - Seismic sensors and seismographs	HyQuest Solution
	Datalogger - Geotechnical & Geodetic	HyQuest Solution
	Datalogger - Snowmelt and Glacial melt	HyQuest Solution
Monitoring of rivers and streams for level, velocity, and discharge.	Velocity Monitoring (Non-Contact)	SOMMER
	Level and Velocity Monitoring (Non-Contact)	
	Level Monitoring (Non- Contact)	VEGA
	Level Monitoring (Non- Contact)	Geolux
	Level and Velocity Monitoring (Non-Contact)	HyQuest Solution
	Level Monitoring	OEM / TerraTransfer
	Level Monitoring	3rd Party / Keller
Monitoring of meteorological parameters in the atmospheric pressure, temperature, wind precipitation	Air Temperature	OEM / Theta
	Barometric Pressure	
	Air Humidity	
	Wind Speed	
	Wind direction	
	Global Radiation	
	Air Temperature	3rd Party / Lambrecht
	Barometric Pressure	
	Air Humidity	
	Wind Speed	
	Wind direction	
	Global Radiation	
	Precipitation: Weighing Principle Precipitation Gauge	HyQuest Solutions
	Precipitation: Tipping Bucket	HyQuest Solutions
Monitoring of meteorological snowfall	Snow Fall - Distrometer	HyQuest Solution
	Hail Monitoring	HyQuest Solutions
Monitoring of seismic activities	Seismic sensors and seismographs	3rd Party / Woelfel
Geotechnical and Geodetic sensors for monitoring of Landslide Lake Outburst Flood, Avalanche, Landslides, Subsidence, Rockfall, Debris flow, Monitoring of Snowmelt	Extensometers	3rd Party / RST
	Piezometers	
	Inclinometers	
	Tiltmeters	
	Crack Meters & Joint Meters	
	Load-Cells	

and Glacial melt, Avalanche, Landslides, subsidence, rockfall, debris flow	Pressure Cells	
Monitoring of Snowmelt and Glacial melt.	Snow Depth Sensor	3rd Party / SOMMER
	Snow Pack Sensor	
	Snow Melt Sensor	
	Snow Temperature Sensor	
Others	Air Flow Wireless Sensor	3rd Party / E+E
	Portable DC Voltage Measurement Wireless Sensors & Transmitters (0-50V DC)	3rd Party / Fluke
	Portable DC Current Measurement Wireless Sensors & Transmitter including dismountable current transformer, as applicable (0-300 amp)	3rd Party / Fluke
	CCTV	3rd Party / Paessler
	Thermal Cameras & Infrared cameras	3rd Party / Fluke
	Professional experts for interpreting satellite imageries for advance information on forthcoming situations	3rd Party

Appendix-7

1. **List of probable Vendors for EWS (Suggestive Only)**
   a) M/s. Intergraph SG&I
   b) M/s. Fluent Grid
   c) M/s. Everbridge
   d) M/s. DHI
   e) M/s. Cyber Swift
   f) M/s. Consol Geotech
   g) M/s. CMS
   h) M/s. Blue Ocean
   i) M/s. BECIL
   j) M/s. AIT
   k) M/s. Telecon
   l) M/s. TCIL
   m) M/s. Sterlite
   n) M/s. Satpalda Geospatial Services
   o) M/s. Oberoi Thermit
   p) M/s. NEC
   q) M/s. Lotus Wireless
   r) M/s. Kisters AG
   s) M/s. iSenses
   t) M/s. CROPC
   u) M/S AIMIL
   v) M/S Virtual
   w) M/s Alpha pacific
   x) M/S M2M logger
   y) M/s BIPS
   z) M/s Srijon Microsystems

2. **Preferred Brand Name for Different Hydro meteorological Instruments (Suggestive Only)**

S.No.	AWS	AG&D (Radar Based)	Data Logger	AWLR	Automatic Imagery based G&D
1	Campbell Scientific	OTT	OTT (Sutron)	Campbell	SEBA Hydrometrie
2	GILL Instruments	Sommer	Campbell Scientific	Vega	
3	OTT	Geolux	Data Taker	Sommer	
4	RM Young	Vega	National Instruments	OTT	
5	Virtual Hydromet	Campbell Scientific	Kinemetrics	Geolux	
6	Vaisala	Hyquest	Optima	Siemens	
7	Microstep		Hyquest	EIP	
8			Vaisala Siemens		