IN THE HON'BLE NATIONAL GREEN TRIBUNAL

EASTERN ZONE BENCH, KOLKATA

ORIGINAL APPLICATION NO. 171/ 2023

IN THE MATTER OF: -

News Item Appeared In East Mojo On 05.10.2023 Titled Sikkim Here Why The Chungthang Hydro Dam Bresch Is a Big Deal

...Applicant

Versus

State of Sikkim

...Respondent

SUDIP CHAUDHURI NOTARY 6584/2008 24 PGS. (N) GOVT. OF INDIA

INDEX

S. NO	PARTICULARS	PAGE NO.
1.	Counter Affidavit	1-8
2.	**Annexure-1** Copy of order dated 28.11.2023	9-10
3.	**Annexure-2** Copy of the Environment Impact Assessment Notification, 2006	11-55
4.	**Annexure-3** Copy of Site Clearance dated 03.08.2005	56-57
5.	**Annexure-4** Copy of the EAC Minutes of 44th Meeting held on 28.06.2006	58-62
6.	**Annexure-5** Copy of EAC Minutes of 45th Meeting held on 19.07.2006	63-68
7.	**Annexure-6** Copy of EC dated 04.08.2006	69-73
8.	**Annexure-7** Copy of the Monitoring Report dated 16.06.2017	74-81
9.	**Annexure-8** Copy of Letter dated 08.01.2024	82-83
10.	**Annexure-9** Copy of Site Inspection Report dated 09.02.2024	84-712
11.	**Annexure-10** Copy of Letter issued to Project Proponent dated 09.02.2024	713
12.	**Annexure-11** Copy of reply received from Project Proponent dated 20.02.2024	714-747

Place: Kolkata

Dated: 16th May, 2024

Respondent No. 4

Through

Rashmi Singhee
Advocate

SL. NO. 570 /20.24

IN THE HON'BLE NATIONAL GREEN TRIBUNAL

EASTERN ZONE BENCH, KOLKATA

ORIGINAL APPLICATION NO. 171/ 2023

IN THE MATTER OF: -

News Item Appeared In East Mojo On 05.10.2023 Titled Sikkim Here Why The Chungthang Hydro Dam Bresch Is a Big Deal

...Applicant

Versus

State of Sikkim

...Respondent

SUDIP CHAUDHURI NOTARY 6584/2008 GOVT OF INDIA

BEFORE THE NOTARY PUBLIC AT BIDHANNAGAR DIST.-NORTH 24 PARGANAS

REPLY AFFIDAVIT ON BEHALF OF RESPONDENT NO. 4, MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE

I, Dr. Shahida Parvin Quazi, daughter of Late Quazi Sirazul Haque, aged about 46 years, presently working as 'Scientist – E' at the Sub Office Kolkata of Bhubaneswar Regional Office under the Ministry of Environment, Forest and Climate Change, having its office at IB-198, Sector- III, Salt Lake City, Kolkata – 700 106, do hereby solemnly affirm on oath and state as under:

1. It is submitted that I am working as 'Scientist - E' in the office of the Respondent No. 4 and as such am well acquainted with the facts and circumstances of the case on the basis of the records available in my office and am thus duly authorized to file this Affidavit on behalf of the Respondent No. 4 herein, i.e. the Ministry of Environment, Forest &Climate Change (hereinafter referred to as 'Ministry'). Specifically admitted hereunder:

2. That, this Hon'ble Tribunal had registered the Original Application No. 171 of 2023 taking SUO MOTU cognizance, based on the News item in the East Mojo dated 05.10.2023 titled as "Sikkim: Here's why the Chungthang Hydro-dam breach is a BIG DEAL". As per the said

16 MAY 2024

SUDIP CHAUDHURI * NOTARY 6584/2008 * GOVT. OF INDIA

newspaper report, the glacial lake out-burst of South Lhonak Lake in North Sikkim, had caused flood in Teesta River leading to several death and destruction. In this incident, about 5.08 million cubic meters of water was released from hydro reservoir affecting mountains and communities. As per the reports, major flooding in Chungthang caused significant damage to public properties and structures on river bed. Further, it was also reported about a breach of stringent safety measures and potential risk associated with some of the large-scale infrastructure projects, which require robust disaster preparedness.

That, while hearing the matter, this Hon'ble Tribunal had issued the following directions, as per the order uploaded at NGT website, on 28.11.2023 (copy attached as **Annexure-1**);

"We are of the view that Ministry of Environment, Forests and Climate Change (MoEF&CC) as well as Central Water Commission (CWC) should be impleaded in the array of Respondents in the present Original Application as Respondent Nos.4 and 5 respectively."

In light of the aforesaid matter, it is most humbly submitted that the following submissions be taken into consideration:

APPLICABLE PROVISIONS:

3. That, the MoEF&CC grants Environmental Clearance (hereinafter referred to as "EC") to Hydro-electric projects in accordance with the provisions laid down in Environment Impact Assessment Notification, 2006 and its amendments thereof. The EIA Notification, 2006 clearly states the requirement of prior EC before start of any construction work in case of new projects or expansion and modernization of existing projects or activities as per the Schedule to the EIA Notification, 2006 which gives details of the categories of Projects or Activities which require prior environmental clearance.

4. It is submitted that the provisions of EIA Notification, 2006 lays down detailed procedure for the grant of Environmental Clearance as mentioned in the following sub paras:

16 MAY 2024

a. The Ministry has constituted the Expert Appraisal Committee (EAC)/ State Expert Appraisal Committee (SEAC) in pursuance of the EIA Notification, 2006, as amended from time to time. That, the EAC/SEAC follows the due procedure prescribed in the EIA Notification, 2006 while appraising a developmental project requiring prior Environmental Clearance and making appropriate recommendations. The Appraisal by the Expert Appraisal Committee or State Level Expert Appraisal Committee is based on the details submitted at the time of the application and other documents like the Final EIA report, outcome of the public consultations including public hearing proceedings etc.

SUDIP CHAUDHURI NOTARY 6584/2008 24 PGS. (N) GOVT. OF INDIA

b. The process involved for grant of Environmental Clearance is as following:

- Stage (1) – Screening
- Stage (2) - Scoping – i.e. prescribing Terms of Reference (TOR) or undertaking detailed Environment Impact Assessment Studies
- Stage (3) - Public Consultation – to be conducted by the respective State Pollution Control Board/UT Pollution Control Committee
- Stage (4) - Appraisal – by Expert Appraisal Committee (EAC)

c. In accordance with the provisions prescribed in the EIA Notification, 2006, the Project Proponent, based on the Terms of Reference, prepares the EIA Report. Timelines have been prescribed under the EIA Notification, 2006 and in accordance with that timeline; TOR is recommended by the EAC/SEIAA for approval by the Competent Authority. Thereafter, as per the TOR issued, the Project Proponent is required to comply with the terms and conditions mentioned in the TOR which inter-alia, includes (i) monitoring of baseline data for one season, other than rainy season (Three months), (iii) conducting the public consultations, and (iv) submission of final EIA/EMP Reports to the Ministry along with all the relevant documents.

16 MAY 2024

d. On submission of final EIA/EMP report, the project is appraised by the concerned EAC/SEAC in a transparent manner in which the Project Proponent is invited for furnishing necessary clarification in person or through an authorized representative / consultant. Thereafter, the EAC/SEAC recommends/rejects the proposals and the Competent Authority, thereafter, takes the final decision to accord the Environmental Clearance as per the EIA Notification, 2006. It is submitted that various facts necessary for the adjudication of the present case are stated in the subsequent paras.

SUDIP CHAUDHURI NOTARY 6584/2008

e. The process involving grant of Environmental Clearance is transparent & the same is placed in public domain after issue including the application for grant of Environmental Clearance, submissions and supporting documents filed by the Project Proponent, the minutes of meeting of the EAC/SEAC and the Environmental Clearance issued in the case.

A copy of the Environment Impact Assessment Notification, 2006 is enclosed as **Annexure 2**.

PROJECT BACKGROUND

5. It is submitted that the Project Proponent in question namely, M/s Teesta Urja Limited had submitted the proposal named Teesta Hydroelectric Project Stage-III (1200 MW) in North District, Sikkim vide letter dated 17.06.2005. It envisaged construction of a concrete face rock fill dam of 60m height across Teesta River at about 400m downstream of confluence of river Lachen Chu and Lachung Chu near village Chungthang to create a gross storage of 5.08 Mm^3 at full reservoir level of 1585m.

It is submitted that after examination of the above proposal and taking into consideration the project documents, the Site Clearance for Investigation and Survey was granted on 03.08.2005 as per the

16 MAY 2024

provisions of the then EIA Notification, 1994 for collection of environmental data for preparation of comprehensive EIA Report which includes seismicity, disaster management plan etc.

Thereafter, the Teesta Hydroelectric project (1200 MW) in an area of 196.967 ha by M/s Teesta Urja Limited in North District, Sikkim was appraised by the Expert Appraisal Committee (hereinafter referred to as 'EAC') for River Valley & Hydroelectric Power Projects (RV & HEP) in its 44th and 45th Meeting held on 28.06.2006 and 19.07.2006 respectively. Comments of the public were taken through Public Hearing which was conducted on 08.06.2006. The EAC, after detailed deliberations and considering all the facts of the project as presented by Project Proponent, recommended for grant of EC, under the provisions of EIA Notification, 1994. Accordingly, based on the recommendation of the EAC, the MoEF&CC accorded the EC to the project on 04.08.2006 subject to strict compliance of the terms and conditions mentioned therein.

SUDIP CHAUDHURI NOTARY 6584/2008 GOVT. OF INDIA

The copy of the Site Clearance dated 03.08.2005, EAC Minutes of 44th and 45th Meeting held on 28.06.2006 and 19.07.2006 as well as EC dated 04.08.2006 is annexed as **Annexure 3**, **Annexure 4, Annexure 5 and Annexure 6** respectively.

MONITORING REPORT BY REGIONAL OFFICE, SHILLONG DATED 16.06.2017:

6. That, prior to the flash flood incident, the said project was monitored by the Regional Office, Shillong of this Ministry on 10.06.2017. The Monitoring Report dated 16.06.2017 which highlights the observations regarding collection of data for downstream discharge, restoration of dumping area, etc. is annexed as **Annexure-7**.

CURRENT STATUS OF THE PROJECT:

7. It is submitted that Regional Office (Eastern Zone), Bhubaneswar (hereinafter referred to as 'RO Bhubaneswar') of this Ministry, vide

16 MAY 2024

letter dated 08.01.2024, was requested to conduct a site visit to verify the compliance status of the conditions stipulated in the EC letter granted to the said project and submit a factual report. The RO, Bhubaneswar forwarded the said letter of the Ministry to its Sub Office Kolkata (hereinafter referred to as 'SO Kolkata') for further necessary action. The SO Kolkata conducted a site visit on 16.01.2024 and 17.01.2024 and accordingly Site Inspection Report including factual status of the project and Certified Compliance Report of EC conditions (hereinafter referred to as 'CCR') was forwarded to the Ministry on 09.02.2024. Further, a letter dated 09.02.2024 has been issued to the Project Proponent/Authorities for taking corrective measures on some of the points mentioned in the report. In this regard, the Project Proponent vide its letter dated 20.02.2024 submitted its response wherein it was found that observation raised by SO-Kolkata has been complied.

SUDIP CHAUDHURI NOTARY 6584/2008 24 PGS. (N) GOVT. OF INDIA

The copy of the said Letter to RO Bhubaneswar dated 08.01.2024, copy of Site Inspection Report dated 09.02.2024, Letter to Project Proponent dated 09.02.2024 and Reply of Project Proponent dated 20.02.2024 are annexed herewith as **Annexure 8, Annexure 9, Annexure 10 and Annexure 11** respectively.

8. It is also pertinent to mention that a factual status report of the project was also annexed with the Site Inspection report. The observations under factual status report are reproduced hereunder:

"3. During monitoring on 16.01.2024, it was observed that PAs have engaged workers for clearing the silt/ mud that had deposited in the Power House (Photos: A1-A7). Certain portion of the Power house was still inaccessible due to silt deposition. PAs informed that the underground power houses were flooded with water during the flood and on inspection by expert climbers on 26.10.2023, it was observed that silt had deposited in the Mat Access Tunnel & Cable Access Tunnel (3-4 ft), about 2-3 ft in machine hall and MIV floor was seen with silt laden water.

16 MAY 2024

4. The Tail Race Tunnel could not be monitored due to inaccessible conditions. The undersigned along with other Officials were able to visit the river bed only. PAs informed that that the Tail Race Tunnel was full of silt laden water and the outlet mouth of TRT is buried under the river bed (10m blow the river bed) (Photos: A8-A10)

5. For the Dam site, it was observed that the Dam has been washed away (Photos: All to A-19). The colony has also been washed away. The project is non-operational at present"

9. The Project Proponent also conducted a mock drill rehearsal on 25.04.2023 on the subject of Cloud Burst in upstream (Dam). The mock drill report is annexed as Annexure-E8 with the Site Inspection report.

10. It is submitted that the present reply affidavit may kindly be taken on record and into consideration and the Hon'ble Tribunal may pass appropriate Order(s), direction(s) as deemed fit and proper under the facts and circumstances of the present case.

11. That other/ancillary issues raised in the application under reply do not pertain to the answering respondent. The answering respondent seeks leave to make additional submissions, if required, during the course of the proceedings.

Q. Shahida Parvin

DEPONENT

डॉ. शाहिदा परवीन क़ाज़ी / DR. SHAHIDA PARVIN QUAZI
वैज्ञानिक-ई / SCIENTIST-E
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय
MINISTRY OF ENVIRONMENT, FOREST & CLIMATE CHANGE
क्षेत्रीय कार्यालय, भुवनेश्वर / REGIONAL OFFICE, BHUBANESWAR
उप-कार्यालय, कोलकाता / SUB-OFFICE, KOLKATA
आई बी-198, सेक्टर III, साल्ट लेक सिटी, कोलकाता-700106
IB-198, SECTOR-III, SALT LAKE CITY, KOLKATA - 700106

VERIFICATION

I, the above-named deponent do hereby solemnly affirm and state that the contents of the aforesaid affidavit are true and correct to my personal knowledge and have been derived from the official records

16 MAY 2024

SUDIP CHAUDHURI NOTARY 6584/2008 NORTH 24 PGS. (N) GOVT. OF INDIA

maintained by the Respondent. No part of it is false nor has anything material been concealed therefrom.

Verified at Kolkata on this 16th day of May, 2024

Q. Shahida Parvin

DEPONENT

डॉ. शाहिदा परवीन काजी / DR. SHAHIDA PARVIN QUAZI
वैज्ञानिक-ई / SCIENTIST-E
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय
MINISTRY OF ENVIRONMENT, FOREST & CLIMATE CHANGE
क्षेत्रीय कार्यालय, भुवनेश्वर / REGIONAL OFFICE, BHUBANESWAR
उप-कार्यालय, कोलकाता / SUB-OFFICE, KOLKATA
आई बी-198, सेक्टर III, साल्ट लेक सिटी, कोलकाता-700106
IB-198, SECTOR-III, SALT LAKE CITY, KOLKATA - 700106

S. CHAUDHURI
★NOTARY★
GOVT. OF INDIA
Regd. No.-6584/08
Bidhannagar Court
Dist.-North 24 Pgs.

16 MAY 2024

Identified by me

Advocate

ANNEXURE-1

Item No.01 Court No.1

BEFORE THE NATIONAL GREEN TRIBUNAL
EASTERN ZONE BENCH, KOLKATA
(THROUGH PHYSICAL HEARING WITH HYBRID MODE)

Original Application No.171/2023/EZ

Re.: News Item appeared in East Mojo
On 05.10.2023 titled "Sikkim: Here's why the
Chungthang Hydro-dam breach is a BIG DEAL" Applicant(s)

Date of hearing: 28.11.2023

CORAM: HON'BLE MR. JUSTICE B. AMIT STHALEKAR, JUDICIAL MEMBER
HON'BLE DR. ARUN KUMAR VERMA, EXPERT MEMBER

For Applicant(s) : *Suo Motu*

For Respondent(s) : Mr. Sameer Abhyankar, Advocate a/w
Ms. Vani V. Chhetri, Advocate for State of Sikkim (in Virtual Mode),
Ms. Amrita Pandey, Advocate for R-2 (in Virtual Mode),
Mr. V. Vyas, Advocate for R-3 (in Virtual Mode)

ORDER

1. Mr. Sameer Abhyankar, learned Counsel appearing (in Virtual Mode), prays for and is granted four weeks time for filing counter-affidavit on behalf of the Respondent No.1, State of Sikkim.

2. Ms. Amrita Pandey, learned Counsel appearing (in Virtual Mode), prays for and is granted four weeks time for filing counter-affidavit on behalf of the Respondent No.2, National Hydroelectric Power Corporation (NHPC).

3. Mr. Vidhan Vyas, learned Counsel appearing (in Virtual Mode), prays for and is granted four weeks time for filing counter-affidavit on behalf of the Respondent No.3, Sikkim Urja Limited.

4. We are of the view that Ministry of Environment, Forests and Climate Change (MoEF&CC) as well as Central Water Commission (CWC) should be impleaded in the array of Respondents in the present Original Application as Respondent Nos.4 and 5 respectively.

5. Ms. Anamika Pandey, learned Counsel who is present (in Virtual Mode), accepts notice on behalf of the Respondent No.4, Ministry of Environment, Forests and Climate Change (MoEF&CC). The learned Counsel prays for and is granted four weeks time for filing counter-affidavit.

6. Mr. Ashok Prasad, learned Counsel who is present in Court, accepts notice on behalf of the Respondent Nos.5, Central Water Commission (CWC). The learned Counsel prays for and is granted four weeks time for filing counter-affidavit.

7. Office of the Tribunal shall provide e-copy of the Original Application along with all its annexures to the learned Counsel for the Respondents within two days.

8. **List on 10.01.2024.**

.....
B. Amit Sthalekar, JM

.....
Dr. Arun Kumar Verma, EM

November 28, 2023,
Original Application No.171/2023/EZ
SKB

ANNEXURE-2

(Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii)
MINISTRY OF ENVIRONMENT AND FORESTS
New Delhi 14th September, 2006
Notification

S.O. 1533(E). - Whereas, a draft notification **under sub-rule (3) of Rule 5 of the Environment (Protection) Rules, 1986 for imposing** certain restrictions and prohibitions on new projects or activities, or on the expansion or modernization of existing projects or activities based on their potential environmental impacts as indicated in the Schedule to the notification, being undertaken in any part of India1, unless prior environmental clearance has been accorded in accordance with the objectives of National Environment Policy **as approved by the Union Cabinet on 18th May, 2006** and the procedure specified in the notification, by the Central Government or the State or Union territory Level Environment Impact Assessment Authority (SEIAA), to be constituted by the Central Government in consultation with the State Government or the Union territory Administration concerned under sub-section (3) of section 3 of the Environment (Protection) Act, 1986 for the purpose of this notification, was published in the Gazette of India ,Extraordinary, Part II, section 3, sub-section (ii) vide number S.O. 1324 (E) dated the 15th September ,2005 inviting objections and suggestions from all persons likely to be affected thereby within a period of sixty days from the date on which copies of Gazette containing the said notification were made available to the public;

And whereas, copies of the said notification were made available to the public on 15th September, 2005;

And whereas, all objections and suggestions received in response to the above mentioned draft notification have been duly considered by the Central Government;

Now, therefore, in exercise of the powers conferred by sub-section (1) and clause (v) of sub-section (2) of section 3 of the Environment (Protection) Act, 1986, read with clause (d) of sub-rule (3) of rule 5 of the Environment (Protection) Rules, 1986 and in supersession of the notification number S.O. 60 (E) dated the 27th January, 1994, except in respect of things done or omitted to be done before such supersession, the Central Government hereby directs that on and from the date of its publication the required construction of new projects or activities or the expansion or modernization of existing projects or activities listed in the Schedule to this notification entailing capacity addition with change in process and or technology shall be

---

1: II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

undertaken in any part of India only after the prior environmental clearance from the Central Government or as the case may be, by the State Level Environment
Impact Assessment Authority, duly constituted by the Central Government under sub-section (3) of section 3 of the said Act, in accordance with the procedure specified hereinafter in this notification.

---

[1]Includes the territorial waters

2. Requirements of prior Environmental Clearance (EC):- The following projects or activities shall require prior environmental clearance from the concerned regulatory authority, which shall hereinafter referred to be as the Central Government in the Ministry of Environment and Forests for matters falling under Category 'A' in the Schedule and at State level the State Environment Impact Assessment Authority (SEIAA) for matters falling under Category 'B' in the said Schedule, before any construction work, or preparation of land by the project management except for securing the land, is started on the project or activity:

(i) All new projects or activities listed in the Schedule to this notification;

(ii) Expansion and modernization of existing projects or activities listed in the Schedule to this notification with addition of capacity beyond the limits specified for the concerned sector, that is, projects or activities which cross the threshold limits given in the Schedule, after expansion or modernization;

(iii) Any change in product - mix in an existing manufacturing unit included in Schedule beyond the specified range.

3. State Level Environment Impact Assessment Authority:- (1) A State Level Environment Impact Assessment Authority hereinafter referred to as the SEIAA shall be constituted by the Central Government under sub-section (3) of section 3 of the Environment (Protection) Act, 1986 comprising of three Members including a Chairman and a Member – Secretary to be nominated by the State Government or the Union territory Administration concerned.

(2) The Member-Secretary shall be a serving officer of the concerned State Government or Union territory administration familiar with environmental laws.

(3) The other two Members shall be either a professional or expert fulfilling the eligibility criteria given in Appendix VI to this notification.

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

(4) One of the specified Members in sub-paragraph (3) above who is an expert in the Environmental Impact Assessment process shall be the Chairman of the SEIAA.

(5) The State Government or Union territory Administration shall forward the names of the Members and the Chairman referred in sub- paragraph 3 to 4 above to the Central Government and the Central Government shall constitute the SEIAA as an authority for the purposes of this notification within thirty days of the date of receipt of the names.

(6) The non-official Member and the Chairman shall have a fixed term of three years (from the date of the publication of the notification by the Central Government constituting the authority).

[I] "(7) All decisions of the SEIAA shall be taken in a meeting and shall ordinarily be unanimous:

Provided that, in case a decision is taken by majority, the details of views, for and against it, shall be clearly recorded in the minutes and copy thereof sent to MoEF."

4. Categorization of projects and activities:-

(i) All projects and activities are broadly categorized in to two categories - Category A and Category B, based on the spatial extent of potential impacts and potential impacts on human health and natural and man made resources.

(ii) All projects or activities included as Category 'A' in the Schedule, including expansion and modernization of existing projects or activities and change in product mix, shall require prior environmental clearance from the Central Government in the Ministry of Environment and Forests (MoEF) on the recommendations of an Expert Appraisal Committee (EAC) to be constituted by the Central Government for the purposes of this notification;

(iii) All projects or activities included as Category 'B' in the Schedule, including expansion and modernization of existing projects or activities as specified in sub paragraph (ii) of paragraph 2, or change in product mix as specified in sub paragraph (iii) of paragraph 2, but excluding those which fulfill the General Conditions (GC) stipulated in the Schedule, *will* require prior environmental clearance from the State/Union territory Environment Impact Assessment Authority (SEIAA). The SEIAA shall base its decision on the recommendations of a State or Union territory level Expert Appraisal Committee (SEAC) as to be constituted for in this notification. [II] "In the absence of a duly constituted SEIAA

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

or SEAC, a Category 'B' project shall be considered at Central Level as a Category 'B' project;"

5. Screening, Scoping and Appraisal Committees:-

The same Expert Appraisal Committees (EACs) at the Central Government and SEACs (hereinafter referred to as the (EAC) and (SEAC) at the State or the Union territory level shall screen, scope and appraise projects or activities in Category 'A' and Category 'B' respectively. EAC and SEAC's shall meet at least once every month.

(a) The composition of the EAC shall be as given in Appendix VI. The SEAC at the State or the Union territory level shall be constituted by the Central Government in consultation with the concerned State Government or the Union territory Administration with identical composition;

(b) The Central Government may, with the prior concurrence of the concerned State Governments or the Union territory Administrations, constitutes one SEAC for more than one State or Union territory for reasons of administrative convenience and cost;

(c) The EAC and SEAC shall be reconstituted after every three years;

(d) The authorised members of the EAC and SEAC, concerned, may inspect any site(s) connected with the project or activity in respect of which the prior environmental clearance is sought, for the purposes of screening or scoping or appraisal, with prior notice of at least seven days to the applicant, who shall provide necessary facilities for the inspection;

(e) The EAC and SEACs shall function on the principle of collective responsibility. The Chairperson shall endeavour to reach a consensus in each case, and if consensus cannot be reached, the view of the majority shall prevail.

6. Application for Prior Environmental Clearance (EC):-

An application seeking prior environmental clearance in all cases shall be made in the prescribed Form 1 annexed herewith and Supplementary Form 1A, if applicable, as given in Appendix II, after the identification of prospective site(s) for the project and/or activities to which the application relates, before commencing any construction activity, or preparation of land, at the site by the applicant. The applicant shall furnish, along with the application, a copy

---

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

of the pre-feasibility project report except that, in case of construction projects or activities (item 8 of the Schedule) in addition to Form 1 and the Supplementary Form 1A, a copy of the conceptual plan shall be provided, instead of the pre-feasibility report.

7. Stages in the Prior Environmental Clearance (EC) Process for New Projects:-

7(i) The environmental clearance process for new projects will comprise of a maximum of four stages, all of which may not apply to particular cases as set forth below in this notification. These four stages in sequential order are:-

- Stage (1) Screening (Only for Category 'B' projects and activities)
- Stage (2) Scoping
- Stage (3) Public Consultation
- Stage (4) Appraisal

I. **Stage (1) - Screening**:

In case of Category 'B' projects or activities, this stage will entail the scrutiny of an application seeking prior environmental clearance made in Form 1 by the concerned State level Expert Appraisal Committee (SEAC) for determining whether or not the project or activity requires further environmental studies for preparation of an Environmental Impact Assessment (EIA) for its appraisal prior to the grant of environmental clearance depending up on the nature and location specificity of the project . The projects requiring an Environmental Impact Assessment report shall be termed Category 'B1' and remaining projects shall be termed Category 'B2' and will not require an Environment Impact Assessment report. For categorization of projects into B1 or B2 except item 8 (b), the Ministry of Environment and Forests shall issue appropriate guidelines from time to time.

II. **Stage (2) - Scoping**:

(i) "Scoping": refers to the process by which the Expert Appraisal Committee in the case of Category 'A' projects or activities, and State level Expert Appraisal Committee in the case of Category 'B1' projects or activities, including applications for expansion and/or modernization and/or change in product mix of existing projects or activities, determine detailed and comprehensive Terms Of Reference (TOR) addressing all relevant environmental concerns for the preparation of an Environment Impact Assessment (EIA) Report in respect of the project or activity for which prior environmental clearance is sought. The Expert Appraisal Committee or State level Expert Appraisal Committee

---

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

concerned shall determine the Terms of Reference on the basis of the information furnished in the prescribed application Form1/Form 1A including Terns of Reference proposed by the applicant, a site visit by a sub- group of Expert Appraisal Committee or State level Expert Appraisal Committee concerned only if considered necessary by the Expert Appraisal Committee or State Level Expert Appraisal Committee concerned, Terms of Reference suggested by the applicant if furnished and other information that may be available with the Expert Appraisal Committee or State Level Expert Appraisal Committee concerned. All projects and activities listed as Category 'B' in Item 8 of the Schedule (Construction/Township/Commercial Complexes /Housing) shall not require Scoping and will be appraised on the basis of Form 1/ Form 1A and the conceptual plan.

(ii) The Terms of Reference (TOR) shall be conveyed to the applicant by the Expert Appraisal Committee or State Level Expert Appraisal Committee as concerned within sixty days of the receipt of Form 1. In the case of Category A Hydroelectric projects Item 1(c) (i) of the Schedule the Terms of Reference shall be conveyed along with the clearance for pre-construction activities .If the Terms of Reference are not finalized and conveyed to the applicant within sixty days of the receipt of Form 1, the Terms of Reference suggested by the applicant shall be deemed as the final Terms of Reference approved for the EIA studies. The approved Terms of Reference shall be displayed on the website of the Ministry of Environment and Forests and the concerned State Level Environment Impact Assessment Authority.

(iii) Applications for prior environmental clearance may be rejected by the regulatory authority concerned on the recommendation of the EAC or SEAC concerned at this stage itself. In case of such rejection, the decision together with reasons for the same shall be communicated to the applicant in writing within sixty days of the receipt of the application.

III. **Stage (3) - Public Consultation**:

(i) "Public Consultation" refers to the process by which the concerns of local affected persons and others who have plausible stake in the environmental impacts of the project or activity are ascertained with a view to taking into account all the material concerns in the project or activity design as appropriate. All Category 'A' and Category B1 projects or activities shall undertake Public Consultation, except the following:-

(a) modernization of irrigation projects (item 1(c) (ii) of the Schedule).

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests. (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

(b) all projects or activities located within industrial estates or parks (item 7(c) of the Schedule) approved by the concerned authorities, and which are not disallowed in such approvals.

(c) expansion of Roads and Highways (item 7 (f) of the Schedule) which do not involve any further acquisition of land.

[III] "(cc) maintenance dredging provided the dredged material shall be disposed within port limits.";

[III] "(d) All Building or Construction projects or Area Development projects (which do not contain any category 'A' projects and activities) and Townships (item 8(a) and 8(b) in the Schedule to the notification)."

e) all Category 'B2' projects and activities.

f) all projects or activities concerning national defence and security or involving other strategic considerations as determined by the Central Government.

(ii) The Public Consultation shall ordinarily have two components comprising of:-

(a) a public hearing at the site or in its close proximity- district wise, to be carried out in the manner prescribed in Appendix IV, for ascertaining concerns of local affected persons;

(b) obtain responses in writing from other concerned persons having a plausible stake in the environmental aspects of the project or activity.

(iii) the public hearing at, or in close proximity to, the site(s) in all cases shall be conducted by the State Pollution Control Board (SPCB) or the Union territory Pollution Control Committee (UTPCC) concerned in the specified manner and forward the proceedings to the regulatory authority concerned within 45(forty five) of a request to the effect from the applicant.

(iv) in case the State Pollution Control Board or the Union territory Pollution Control Committee concerned does not undertake and complete the public hearing within the specified period, and/or does not convey the proceedings of the public hearing within the prescribed period directly to the regulatory authority concerned as above, the regulatory

---

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

authority shall engage another public agency or authority which is not subordinate to the regulatory authority, to complete the process within a further period of forty five days,.

(v) If the public agency or authority nominated under the sub paragraph (iii) above reports to the regulatory authority concerned that owing to the local situation, it is not possible to conduct the public hearing in a manner which will enable the views of the concerned local persons to be freely expressed, it shall report the facts in detail to the concerned regulatory authority, which may, after due consideration of the report and other reliable information that it may have, decide that the public consultation in the case need not include the public hearing.

(vi) For obtaining responses in writing from other concerned persons having a plausible stake in the environmental aspects of the project or activity, the concerned regulatory authority and the State Pollution Control Board (SPCB) or the Union territory Pollution Control Committee (UTPCC) shall invite responses from such concerned persons by placing on their website the Summary EIA report prepared in the format given in Appendix IIIA by the applicant along with a copy of the application in the prescribed form, within seven days of the receipt of a written request for arranging the public hearing. Confidential information including non-disclosable or legally privileged information involving Intellectual Property Right, source specified in the application shall not be placed on the web site. The regulatory authority concerned may also use other appropriate media for ensuring wide publicity about the project or activity. The regulatory authority shall, however, make available on a written request from any concerned person the Draft EIA report for inspection at a notified place during normal office hours till the date of the public hearing. All the responses received as part of this public consultation process shall be forwarded to the applicant through the quickest available means.

(vii) After completion of the public consultation, the applicant shall address all the material environmental concerns expressed during this process, and make appropriate changes in the draft EIA and EMP. The final EIA report, so prepared, shall be submitted by the applicant to the concerned regulatory authority for appraisal. The applicant may alternatively submit a supplementary report to draft EIA and EMP addressing all the concerns expressed during the public consultation.

IV. Stage (4) - Appraisal:

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

(i) Appraisal means the detailed scrutiny by the Expert Appraisal Committee or State Level Expert Appraisal Committee of the application and other documents like the Final EIA report, outcome of the public consultations including public hearing proceedings, submitted by the applicant to the regulatory authority concerned for grant of environmental clearance. This appraisal shall be made by Expert Appraisal Committee or State Level Expert Appraisal Committee concerned in a transparent manner in a proceeding to which the applicant shall be invited for furnishing necessary clarifications in person or through an authorized representative. On conclusion of this proceeding, the Expert Appraisal Committee or State Level Expert Appraisal Committee concerned shall make categorical recommendations to the regulatory authority concerned either for grant of prior environmental clearance on stipulated terms and conditions, or rejection of the application for prior environmental clearance, together with reasons for the same.

(ii) The appraisal of all projects or activities which are not required to undergo public consultation, or submit an Environment Impact Assessment report, shall be carried out on the basis of the prescribed application Form 1 and Form 1A as applicable, any other relevant validated information available and the site visit wherever the same is considered as necessary by the Expert Appraisal Committee or State Level Expert Appraisal Committee concerned.

(iii) The appraisal of an application be shall be completed by the Expert Appraisal Committee or State Level Expert Appraisal Committee concerned within sixty days of the receipt of the final Environment Impact Assessment report and other documents or the receipt of Form 1 and Form 1 A, where public consultation is not necessary and the recommendations of the Expert Appraisal Committee or State Level Expert Appraisal Committee shall be placed before the competent authority for a final decision within the next fifteen days .The prescribed procedure for appraisal is given in Appendix V ;

7(ii). Prior Environmental Clearance (EC) process for Expansion or Modernization or Change of product mix in existing projects:

All applications seeking prior environmental clearance for expansion with increase in the production capacity beyond the capacity for which prior environmental clearance has been granted under this notification or with increase in either lease area or production capacity in the case of mining projects or for the modernization of an existing unit with increase in

---

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

the total production capacity beyond the threshold limit prescribed in the Schedule to this notification through change in process and or technology or involving a change in the product –mix shall be made in Form I and they shall be considered by the concerned Expert Appraisal Committee or State Level Expert Appraisal Committee within sixty days, who will decide on the due diligence necessary including preparation of EIA and public consultations and the application shall be appraised accordingly for grant of environmental clearance.

8. Grant or Rejection of Prior Environmental Clearance (EC):

(i) The regulatory authority shall consider the recommendations of the EAC or SEAC concerned and convey its decision to the applicant within forty five days of the receipt of the recommendations of the Expert Appraisal Committee or State Level Expert Appraisal Committee concerned or in other words within one hundred and five days of the receipt of the final Environment Impact Assessment Report, and where Environment Impact Assessment is not required, within one hundred and five days of the receipt of the complete application with requisite documents, except as provided below.

(ii) The regulatory authority shall normally accept the recommendations of the Expert Appraisal Committee or State Level Expert Appraisal Committee concerned. In cases where it disagrees with the recommendations of the Expert Appraisal Committee or State Level Expert Appraisal Committee concerned, the regulatory authority shall request reconsideration by the Expert Appraisal Committee or State Level Expert Appraisal Committee concerned within forty five days of the receipt of the recommendations of the Expert Appraisal Committee or State Level Expert Appraisal Committee concerned while stating the reasons for the disagreement. An intimation of this decision shall be simultaneously conveyed to the applicant. The Expert Appraisal Committee or State Level Expert Appraisal Committee concerned, in turn, shall consider the observations of the regulatory authority and furnish its views on the same within a further period of sixty days. The decision of the regulatory authority after considering the views of the Expert Appraisal Committee or State Level Expert Appraisal Committee concerned shall be final and conveyed to the applicant by the regulatory authority concerned within the next thirty days.

(iii) In the event that the decision of the regulatory authority is not communicated to the applicant within the period specified in sub-paragraphs (i) or (ii) above, as applicable, the

---

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

applicant may proceed as if the environment clearance sought for has been granted or denied by the regulatory authority in terms of the final recommendations of the Expert Appraisal Committee or State Level Expert Appraisal Committee concerned.

(iv) On expiry of the period specified for decision by the regulatory authority under paragraph (i) and (ii) above, as applicable, the decision of the regulatory authority, and the final recommendations of the Expert Appraisal Committee or State Level Expert Appraisal Committee concerned shall be public documents.

(v) Clearances from other regulatory bodies or authorities shall not be required prior to receipt of applications for prior environmental clearance of projects or activities, or screening, or scoping, or appraisal, or decision by the regulatory authority concerned, unless any of these is sequentially dependent on such clearance either due to a requirement of law, or for necessary technical reasons.

(vi) Deliberate concealment and/or submission of false or misleading information or data which is material to screening or scoping or appraisal or decision on the application shall make the application liable for rejection, and cancellation of prior environmental clearance granted on that basis. Rejection of an application or cancellation of a prior environmental clearance already granted, on such ground, shall be decided by the regulatory authority, after giving a personal hearing to the applicant, and following the principles of natural justice.

9. Validity of Environmental Clearance (EC):

The "Validity of Environmental Clearance" is meant the period from which a prior environmental clearance is granted by the regulatory authority, or may be presumed by the applicant to have been granted under sub paragraph (iv) of paragraph 7 above, to the start of production operations by the project or activity, or completion of all construction operations in case of construction projects (item 8 of the Schedule), to which the application for prior environmental clearance refers. The prior environmental clearance granted for a project or activity shall be valid for a period of ten years in the case of River Valley projects (item 1(c) of the Schedule), project life as estimated by Expert Appraisal Committee or State Level Expert Appraisal Committee subject to a maximum of thirty years for mining projects and five years in the case of all other projects and activities. However, in the case of Area Development projects and Townships [item 8(b)], the validity

---

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

period shall be limited only to such activities as may be the responsibility of the applicant as a developer. This period of validity may be extended by the regulatory authority concerned by a maximum period of five years provided an application is made to the regulatory authority by the applicant within the validity period, together with an updated Form 1, and Supplementary Form 1A, for Construction projects or activities (item 8 of the Schedule). In this regard the regulatory authority may also consult the Expert Appraisal Committee or State Level Expert Appraisal Committee as the case may be.

10. Post Environmental Clearance Monitoring:

[IV] "(i)(a) In respect of Category 'A' project, it shall be mandatory for the project proponent to make public the environment clearance granted for their project along with the environmental conditions and safeguards at their cost by prominently advertising it at least in two local newspapers of the district or State where the project is located and in addition, this shall also be displayed in the project proponent's website permanently.

(b) In respect of Category 'B' projects, irrespective of its clearance by MoEF / SEIAA, the project proponent shall prominently advertise in the newspapers indicating that the project has been accorded environment clearance and the details of the MoEF website where it is displayed.

(c) The Ministry of Environment and Forests and the State/Union Territory Level Environmental Impact Assessment Authorities (SEIAAs), as the case may be, shall also place the environmental clearance in the public domain on Governmental portal.

(d) The copies of the environmental clearance shall be submitted by the project proponents to the Heads of local bodies, Panchayats and Municipal Bodies in addition to the relevant offices of the Government who in turn has to display the same for 30 days from the date of receipt.";

[IV] (ii) It shall be mandatory for the project management to submit half-yearly compliance reports in respect of the stipulated prior environmental clearance terms and conditions in hard and soft copies to the regulatory authority concerned, on 1st June and 1st December of each calendar year.

[IV] (iii) All such compliance reports submitted by the project management shall be public documents. Copies of the same shall be given to any person on application to the

---

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

concerned regulatory authority. The latest such compliance report shall also be displayed on the web site of the concerned regulatory authority.

11. Transferability of Environmental Clearance (EC):

A prior environmental clearance granted for a specific project or activity to an applicant may be transferred during its validity to another legal person entitled to undertake the project or activity on application by the transferor, or by the transferee with a written "no objection" by the transferor, to, and by the regulatory authority concerned, on the same terms and conditions under which the prior environmental clearance was initially granted, and for the same validity period. No reference to the Expert Appraisal Committee or State Level Expert Appraisal Committee concerned is necessary in such cases.

12. Operation of EIA Notification, 1994, till disposal of pending cases:

From the date of final publication of this notification the Environment Impact Assessment (EIA) notification number S.O.60 (E) dated 27th January, 1994 is hereby superseded, except in suppression of the things done or omitted to be done before such suppression to the extent that in case of all or some types of applications made for prior environmental clearance and pending on the date of final publication of this notification, the Central Government may relax any one or all provisions of this notification except the list of the projects or activities requiring prior environmental clearance in Schedule I , or continue operation of some or all provisions of the said notification, for a period not exceeding one year from the date of issue of this notification.

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

SCHEDULE

(See paragraph 2 and 7)

LIST OF PROJECTS OR ACTIVITIES REQUIRING PRIOR ENVIRONMENTAL CLEARANCE

Project or Activity		Category with threshold limit		Conditions if any
		A	B	
1		Mining, extraction of natural resources and power generation (for a specified production capacity)		
(1)	(2)	(3)	(4)	(5)
[v] "1(a)	(i) Mining of minerals.	≥ 50 ha. of mining lease area in respect of non-coal mine lease. > 150 ha of mining lease area in respect of coal mine lease. Asbestos mining irrespective of mining area	<50 ha ≥ 5 ha .of mining lease area in respect of non-coal mine lease. ≤ 150 ha ≥ 5 ha of mining lease area in respect of coal mine lease.	General Condition shall apply Note: Mineral prospecting Is exempted.";
	(ii) Slurry pipelines (coal lignite and other ores) passing through national parks / sanctuaries / coral reefs, ecologically sensitive areas.	All projects.		
1(b)	Offshore and onshore oil and gas exploration, development & production	All projects		Note Exploration Surveys (not involving drilling) are exempted provided the concession areas have got previous clearance for physical survey
1(c)	River Valley pojects	(i) ≥ 50 MW hydroelectric power generation; (ii) ≥ 10,000 ha. of culturable command area	(i) < 50 MW ≥ 25 MW hydroelectric power generation; (ii) < 10,000 ha. of culturable command area	[v] "General Condition shall apply. Note: Irrigation projects not involving submergence or inter-state domain shall be appraised by the SEIAA as Category 'B' Projects.";

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

(1)	(2)	(3)	(4)	(5)
1(d)	Thermal Power Plants	V " ≥ 500 MW (coal / lignite / naphtha & gas based); ≥ 50 MW (Pet coke diesel and all other fuels including refinery residual oil waste except biomass); ≥ 20 MW (based on biomass or non hazardous municipal waste as fuel).";	< 500 MW (coal / lignite / naphtha & gas based); <50 MW ≥ 5MW (Pet coke, diesel and all other fuels including refinery residual oil waste except biomass); ≥ 20 MW > 15 MW (based on biomass or non hazardous municipal waste as fuel).";	V "General Condition shall apply. Note: (i) Power plant up to 15 MW, based on biomass and using auxiliary fuel such as coal / lignite / petroleum products up to 15% are exempt. (ii) Power plant up to 15 MW, based on non-hazardous municipal waste and using auxiliary fuel such as coal / lignite / petroleum products up to 15% are exempt. (iii) Power plants using waste heat boiler without any auxiliary fuel are exempt.";
1(e)	Nuclear power projects and processing of nuclear fuel	All projects		
2		Primary Processing		
2(a)	Coal washeries	≥ 1 million ton/annum throughput of coal	<1million ton/annum throughput of coal	General Condition shall apply (If located within mining area the proposal shall be appraised together with the mining proposal)
2 (b)	Mineral beneficiation	≥ 0.1million ton/annum mineral throughput	< 0.1million ton/annum mineral throughput	General Condition shall apply (Mining proposal with Mineral beneficiation shall be appraised together for grant of clearance)

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

3		Materials Production		
(1)	(2)	(3)	(4)	(5)
3(a)	Metallurgical industries (ferrous & non ferrous)	a)Primary metallurgical industry All projects b) Sponge iron manufacturing ≥ 200TPD c) Secondary metallurgical processing industry All toxic and heavy metal producing units ≥ 20,000 tonnes /annum	 Sponge iron manufacturing <200TPD Secondary metallurgical processing industry i.)All toxic and heavy metal producing units <20,000 tonnes /annum ii.)All other non –toxic secondary metallurgical processing industries >5000 tonnes/annum	[v] "General condition shall apply. Note: (i) The recycling industrial units registered under the HSM Rules, are exempted. (ii) In case of secondary metallurgical processing industrial units, those projects involving operation of furnaces only such as induction and electrical arc furnace, submerged arc furnace, and cupola with capacity more than 30,000 tonnes per annum (TPA) would require environmental clearance. (iii) Plant / units other than power plants (given against entry no. 1(d) of the schedule), based on municipal solid waste (non-hazardous) are exempted."
3(b)	Cement plants	≥ 1.0 million tonnes/annum production capacity	<1.0 million tonnes/annum production capacity. All Stand alone grinding units	General Condition shall apply
4		Materials Processing		
(1)	(2)	(3)	(4)	(5)
4(a)	Petroleum refining industry	All projects	-	-
4(b)	Coke oven plants	≥2,50,000 tonnes/annum	<2,50,000 & ≥25,000 tonnes/annum	[v] "General Condition shall apply."
4(c)	Asbestos milling and asbestos based products	All projects	-	-

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

(1)	(2)	(3)	(4)	(5)
4(d)	Chlor-alkali industry	≥300 TPD production Capacity or a unit located out side the notified industrial area/ estate	[v] "(i) All projects irrespective of the size, if located in a Notified Industrial Area/ Estate. (ii) <300 tonnes per day (TPD) and located outside a Notified Industrial Area/ Estate."	[v] "General as well as specific condition shall apply. No new Mercury Cell based plants will be permitted and existing units converting to membrane cell technology are exempted from this notification."
4(e)	Soda ash Industry	All projects	-	-
4(f)	Leather/skin/hide processing industry	New projects outside the industrial area or expansion of existing units out side the industrial area	All new or expansion of projects located within a notified industrial area/ estate	[v] "General as well as specific condition shall apply."
5		Manufacturing / Fabrication		
5(a)	Chemical fertilizers	[v] "All projects except Single Super Phosphate."	[v] "Single Super Phosphate."	-
5(b)	Pesticides industry and pesticide specific intermediates (excluding formulations)	All units producing technical grade pesticides	-	-
5(c)	Petro-chemical complexes (industries based on processing of petroleum fractions & natural gas and/or reforming to aromatics)	All projects -	-	-
5(d)	Manmade fibers manufacturing	Rayon	Others	General Condition shall apply
5(e)	Petrochemical based processing (processes other than cracking & reformation and not covered under the complexes)	Located out side the notified industrial area/ estate -	Located in a notified industrial area/ estate	[v] "General as well as specific condition shall apply."

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

(1)	(2)	(3)	(4)	(5)
5(f)	Synthetic organic chemicals industry (dyes & dye intermediates; bulk drugs and intermediates excluding drug formulations; synthetic rubbers; basic organic chemicals, other synthetic organic chemicals and chemical intermediates)	Located out side the notified industrial area/ estate	Located in a notified industrial area/ estate	[v] "General as well as specific condition shall apply."
5(g)	Distilleries	(i)All Molasses based distilleries (ii) All Cane juice/ non-molasses based distilleries ≥30 KLD	All Cane juice / non-molasses based distilleries – <30 KLD	General Condition shall apply
5(h)	Integrated paint industry	-	All projects	General Condition shall apply
5(i)	Pulp & paper industry excluding manufacturing of paper from waste paper and manufacture of paper from ready pulp with out bleaching	Pulp manufacturing and Pulp& Paper manufacturing industry	Paper manufacturing industry without pulp manufacturing	General Condition shall apply
5(j)	Sugar Industry	-	≥ 5000 tcd cane crushing capacity	General Condition shall apply
5(k)	[v] Omitted			
6		Service Sectors		
6(a)	Oil & gas transportation pipe line (crude and refinery/ petrochemical products), passing through national parks / sanctuaries /coral reefs / ecologically sensitive areas including LNG Terminal	All projects		-

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

(1)	(2)	(3)	(4)	(5)
6(b)	Isolated storage & handling of hazardous chemicals (As per threshold planning quantity indicated in column 3 of schedule 2 & 3 of MSIHC Rules 1989 amended 2000)	-	All projects	General Condition shall apply
7		Physical Infrastructure including Environmental Services		
7(a)	Air ports	[v] "All projects including airstrips, which are for commercial use."	-	[v] "Note: Air strips, which do not involve bunkering/ refueling facility and or Air Traffic Control, are exempted."
7(b)	All ship breaking yards including ship breaking units	All projects	-	-
7©	Industrial estates/ parks/ complexes/ areas, export processing Zones (EPZs), Special Economic Zones (SEZs), Biotech Parks, Leather Complexes.	If at least one industry in the proposed industrial estate falls under the Category A, entire industrial area shall be treated as Category A, irrespective of the area. Industrial estates with area greater than 500 ha. and housing at least one Category B industry.	Industrial estates housing at least one Category B industry and area <500 ha. Industrial estates of area> 500 ha. and not housing any industry belonging to Category A or B.	[v] "Genral as well as special conditions shall apply. Note: 1. Industrial Estate of area below 500 ha. and not housing any industry of Category 'A' or 'B' does not require clearance. 2. If the area is less than 500 ha. but contains building and construction projects > 20,000 Sq. mts. And or development area more than 50 ha it will be treated as activity listed at serial no. 8(a) or 8(b) in the Schedule, as the case may be."
7(d)	Common hazardous waste treatment, storage and disposal facilities (TSDFs)	All integrated facilities having incineration &landfill or incineration alone	All facilities having land fill only	General Condition shall apply

[v] I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

(1)	(2)	(3)	(4)	(5)
7(e)	[v] "Ports, harbours, break waters, dredging."	≥ 5 million TPA of cargo handling capacity (excluding fishing harbours)	< 5 million TPA of cargo handling capacity and/or ports/ harbours ≥10,000 TPA of fish handling capacity	[v] "General Condition shall apply. Note: 1. Capital dredging inside and outside the ports or harbors and channels are included; 2. Maintenance dredging is exempt provided it formed part of the original proposal for which Environment Management Plan (EMP) was prepared and environmental clearance obtained."
7(f)	Highways	i) New National High ways; and ii) Expansion of National High ways greater than 30 KM, involving additional right of way greater than 20m involving land acquisition and passing through more than one State.	[v] " i) All State Highway Project; and ii) State Highway expansion projects in hilly terrain (above 1,000 m AMSL) and or ecologically sensitive areas."	General Condition shall apply. Note: Highways include expressways."
7(g)	Aerial ropeways	[v(xvi)(a)] "(i) All projects located at altitude of 1,000 mtr. And above. (ii) All projects located in notified ecologically sensitive areas."	[v(xvi)(b)] "All projects except those covered in column (3)."	General Condition shall apply
7(h)	Common Effluent Treatment Plants (CETPs)		All projects	General Condition shall apply
7(i)	Common Municipal Solid Waste Management Facility (CMSWMF)		All projects	General Condition shall apply
8		Building /Construction projects/Area Development projects and Townships		
8(a)	Building and Construction projects		≥20000 sq.mtrs and <1,50,000 sq.mtrs. of built-up area#	#(built up area for covered construction; in the case of facilities open to the sky, it will be the activity area)
8(b)	Townships and Area Development projects.		Covering an area ≥ 50 ha and or built up area ≥1,50,000 sq .mtrs ++	++All projects under Item 8(b) shall be appraised as Category B1

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

Note:-

V(xvii) **"General Condition (GC):**
Any project or activity specified in Category 'B' will be treated as Category A, if located in whole or in part within 10 km from the boundary of: (i) Protected Areas notified under the Wild Life (Protection) Act, 1972, (ii) Critically Polluted areas as identified by the Central Pollution Control Board from time to time, (iii) Eco-sensitive areas as notified under section 3 of the Environment (Protection) Act, 1986, such as, Mahabaleshwar Panchgani, Matheran, Pachmarhi, Dahanu, Doon Valley, and (iv) inter-State boundaries and international boundaries:

Provided that the requirement regarding distance of 10 km of the inter-State boundaries can be reduced or completely done away with by an agreement between the respective States or U.Ts sharing the common boundary in case the activity does not fall within 10 kilometres of the areas mentioned at item (i), (ii) and (iii) above."

Specific Condition (SC):
If any Industrial Estate/Complex / Export processing Zones /Special Economic Zones/Biotech Parks / Leather Complex with homogeneous type of industries such as Items 4(d), 4(f), 5(e), 5(f), or those Industrial estates with pre –defined set of activities (not necessarily homogeneous, obtains prior environmental clearance, individual industries including proposed industrial housing within such estates /complexes will not be required to take prior environmental clearance, so long as the Terms and Conditions for the industrial estate/complex are complied with (Such estates/complexes must have a clearly identified management with the legal responsibility of ensuring adherence to the Terms and Conditions of prior environmental clearance, who may be held responsible for violation of the same throughout the life of the complex/estate).

[No. J-11013/56/2004-IA-II (I)]
(R.CHANDRAMOHAN)
JOINT SECRETARY TO THE GOVERNMENT OF INDIA

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

APPENDIX I

(See paragraph – 6)

FORM 1

VI(a) **"(I) Basic Information**

Serial Number	Item	Details
1.	Name of the project/s	
2.	S. No. in schedule	
3.	Proposed capacity/area/length/tonnage to be handled/command area/lease area/number of wells to be drilled	
4.	New/Expansion/Modernization	
5.	Existing Capacity/Area etc.	
6.	Category of Project i.e. 'A' or 'B'	
7.	Does it attract the general condition? If Yes, please specify.	
8.	Does it attract the specific condition? If Yes, please specify.	
9.	Location	
	Plot/Survey/Khasra No.	
	Village	
	Tehsil	
	District	
	State	
10.	Nearest railway station/airport along with distance in kms.	
11.	Nearest Town, city, District Headquarters along with distance in kms.	
12.	Village Panchayats, Zilla Parishad, Municipal Corporation, Local body (complete postal addresses with telephone nos. to be given)	
13.	Name of the applicant	
14.	Registered Address	
15.	Address for correspondence:	
	Name	
	Designation (Owner/Partner/CEO)	
	Address	
	Pin Code	
	E-mail	
	Telephone No.	
	Fax No.	
16	Details of Alternative Sites examined, if any. Location of these sites should be shown on a topo sheet.	Village-District-State 1. 2. 3.
17.	Interlinked Projects	
18	Whether separate application of interlinked project has been submitted?	

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

19.	If yes, date of submission	
20.	If no, reason	
21.	Whether the proposal involves approval/ clearance under: If yes, details of the same and their status to be given. (a) The Forest (Conservation) Act, 1980 ? (b) The Wildlife (Protection) Act, 1972 ? (c) The C.R.Z. Notification, 1991 ?	
22.	Whether there is any Government Order/Policy relevant/ relating to the site ?	
23.	Forest land involved (hectares)	
24.	Whether there is any litigation pending against the project and/or land in which the project is propose to be set up ? (a) Name of the Court. (b) Case No. (c) Orders/directions of the Court, if any and its relevance with the proposed project.	

(II) Activity

1. Construction, operation or decommissioning of the Project involving actions, which will cause physical changes in the locality (topography, land use, changes in water bodies, etc.)

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities /rates, wherever possible) with source of information data
1.1	Permanent or temporary change in land use, land cover or topography including increase in intensity of land use (with respect to local land use plan)		
1.2	Clearance of existing land, vegetation and buildings?		
1.3	Creation of new land uses?		
1.4	Pre-construction investigations e.g. bore houses, soil testing?		
1.5	Construction works?		
1.6	Demolition works?		
1.7	Temporary sites used for construction works or housing of construction workers?		
1.8	Above ground buildings, structures or earthworks including linear structures, cut And fill or excavations		

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

1.9	Underground works including mining or tunneling?		
1.10	Reclamation works?		
1.11	Dredging?		
1.12	Offshore structures?		
1.13	Production and manufacturing processes?		
1.14	Facilities for storage of goods or materials?		
1.15	Facilities for treatment or disposal of solid waste or liquid effluents?		
1.16	Facilities for long term housing of operational workers?		
1.17	New road, rail or sea traffic during construction or operation?		
1.18	New road, rail, air waterborne or other transport infrastructure including new or altered routes and stations, ports, airports etc?		
1.19	Closure or diversion of existing transport routes or infrastructure leading to changes in traffic movements?		
1.20	New or diverted transmission lines or pipelines?		
1.21	Impoundment, damming, culverting, realignment or other changes to the ydrology of watercourses or aquifers?		
1.22	Stream crossings?		
1.23	Abstraction or transfers of water form ground or surface waters?		
1.24	Changes in water bodies or the land surface affecting drainage or run-off?		
1.25	Transport of personnel or materials for construction, operation or decommissioning?		
1.26	Long-term dismantling or decommissioning or restoration works?		
1.27	Ongoing activity during decommissioning which could have an impact on the environment?		
1.28	Influx of people to an area in either temporarily or permanently?		
1.29	Introduction of alien species?		

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

1.30	Loss of native species or genetic diversity?		
1.31	Any other actions?		

2. Use of Natural resources for construction or operation of the Project (such as land, water, materials or energy, especially any resources which are non-renewable or in short supply):

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities /rates, wherever possible) with source of information data
2.1	Land especially undeveloped or agricultural land (ha)		
2.2	Water (expected source & competing users) unit: KLD		
2.3	Minerals (MT)		
2.4	Construction material – stone, aggregates, sand / soil (expected source – MT)		
2.5	Forests and timber (source – MT)		
2.6	Energy including electricity and fuels (source, competing users) Unit: fuel (MT), energy (MW)		
2.7	Any other natural resources (use appropriate standard units)		

3. Use, storage, transport, handling or production of substances or materials, which could be harmful to human health or the environment or raise concerns about actual or perceived risks to human health.

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities /rates, wherever possible) with source of information data
3.1	Use of substances or materials, which are hazardous (as per MSIHC rules) to human health or the environment (flora, fauna, and water supplies)		
3.2	Changes in occurrence of disease or affect disease vectors (e.g. insect or water borne diseases)		
3.3	Affect the welfare of people e.g. by changing living conditions?		
3.4	Vulnerable groups of people who could be affected by the project e.g. hospital patients, children, the elderly etc.,		
3.5	Any other causes		

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

4. Production of solid wastes during construction or operation or decommissioning (MT/month)

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
4.1	Spoil, overburden or mine wastes		
4.2	Municipal waste (domestic and or commercial wastes)		
4.3	Hazardous wastes (as per Hazardous Waste Management Rules)		
4.4	Other industrial process wastes		
4.5	Surplus product		
4.6	Sewage sludge or other sludge from effluent treatment.		
4.7	Construction or demolition wastes		
4.8	Redundant machinery or equipment		
4.9	Contaminated soils or other materials		
4.10	Agricultural wastes		
4.11	Other solid wastes		

5. Release of pollutants or any hazardous, toxic or noxious substances to air (Kg/hr)

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
5.1	Emissions from combustion of fossil fuels from stationary or mobile sources.		
5.2	Emissions from production processes		
5.3	Emissions from materials handling including storage or transport		
5.4	Emissions from construction activities including plant and equipment		
5.5	Dust or odours from handling of materials including construction materials, sewage and waste		

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

5.6	Emissions from incineration of waste		
5.7	Emissions from burning of waste in open air (e.g. slash materials, construction debris)		
5.8	Emissions from any other sources		

6. Generation of Noise and Vibration, and Emissions of Light and Heat:

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
6.1	From operation of equipment e.g. engines, ventilation plant, crushers		
6.2	From industrial or similar processes		
6.3	From construction or demolition		
6.4	From blasting or piling		
6.5	From construction or operational traffic		
6.6	From lighting or cooling systems		
6.7	From any other sources		

7. Risks of contamination of land or water from releases of pollutants into the ground or into sewers, surface waters, groundwater, coastal waters or the sea:

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
7.1	From handling, storage, use or spillage of hazardous materials		
7.2	From discharge of sewage or other effluents to water or the land (expected mode and place of discharge)		
7.3	By deposition of pollutants emitted to air into the land or into water		
7.4	From any other sources		
7.5	Is there a risk of long term build up of pollutants in the environment from these sources?		

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

8. Risk of accidents during construction or operation of the Project, which could affect human health or the environment

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
8.1	From explosions, spillages, fires etc from storage, handling, use or production of hazardous substances		
8.2	From any other causes		
8.3	Could the project be affected by natural disasters causing environmental damage (e.g. floods, earthquakes, landslides, cloudburst etc)?		

9. Factors which should be considered (such as consequential development) which could lead to environmental effects or the potential for cumulative impacts with other existing or planned activities in the locality

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities/rates, wherever possible) with source of information data
9.1	Lead to development of supporting. lities, ancillary development or development stimulated by the project which could have impact on the environment e.g.: • Supporting infrastructure (roads, power supply, waste or waste water treatment, etc.) • housing development • extractive industries • supply industries • other		
9.2	Lead to after-use of the site, which could have an impact on the environment		
9.3	Set a precedent for later developments		
9.4	Have cumulative effects due to proximity to other existing or planned projects with similar effects		

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

(III) Environmental Sensitivity

S.No.	Areas	Name/ Identity	Aerial distance (within 15 km.) Proposed project location boundary
1	Areas protected under international conventions, national or local legislation for their ecological, landscape, cultural or other related value		
2	Areas which are important or sensitive for ecological reasons - Wetlands, watercourses or other water bodies, coastal zone, biospheres, mountains, forests		
3	Areas used by protected, important or sensitive species of flora or fauna for breeding, esting, foraging, resting, over wintering, migration		
4	Inland, coastal, marine or underground waters		
5	State, National boundaries		
6	Routes or facilities used by the public for access to recreation or other tourist, pilgrim areas		
7	Defence installations		
8	Densely populated or built-up area		
9	Areas occupied by sensitive man-made land uses *(hospitals, schools, places of worship, community facilities)*		
10	Areas containing important, high quality or scarce Resources *(ground water resources, surface resources, forestry, agriculture, fisheries, tourism, minerals)*		
11	Areas already subjected to pollution or environmental damage. *(those where existing legal environmental standards are exceeded)*		
12	Areas susceptible to natural hazard which could cause the project to present environmental Problems (*earthquakes, subsidence, landslides, erosion, Flooding or extreme or adverse climatic conditions*)		

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

(IV). Proposed Terms of Reference for EIA studies

VI(b) "I hereby given undertaking that the data and information given in the application and enclosures are true to the best of my knowledge and belief and I am aware that if any part of the data and information submitted is found to be false or misleading at any stage, the project will be rejected and clearance give, if any to the project will be revoked at our risk and cost."

Date: _____

Place: _____

Signature of the applicant
With Name and Full Address
(Project Proponent/Authorised Signatory)

NOTE:

1. The projects involving clearance under Coastal Regulation Zone Notification, 1991 shall submit with the application a C.R.Z. map duly demarcated by one of the authorized agencies, showing the project activities, w.r.t. C.R.Z. (at the stage of TOR) and the recommendations of the State Coastal Zone Management Authority (at the stage of EC). Sinmultaneous action shall also be taken to obtain the requisite clearance under the provisions of the C.R.Z. Notification, 1991 for the activities to be located in the CRZ.
2. The projects to be located within 10 km of the National Prks, Sancturies, Biosphere Reserves, Migratory Corridors of Wile Animals, the project proponenet shall submit the map duly authenticated by Chief Wildlife Warden showing these features vis-à-vis the project location and the recommendations or comments of the Chief Wildlife Warden thereon (at the stage of EC)."
3. All correspondence with the Ministry of Environment & Forests including aubmission of application for TOR/Environmental Clearance, subsequent clarifications, as may be required from time to time, participation in the EAC Meeting on behalf of the project proponent shall be made by the authorized signatory only. The authorized signatory should also submit a document in support of his claim of being and authorized signatory for the specific project."

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

APPENDIX II
(See paragraph 6)

FORM-1 A (only for construction projects listed under item 8 of the Schedule)

CHECK LIST OF ENVIRONMENTAL IMPACTS

(Project proponents are required to provide full information and wherever necessary attach explanatory notes with the Form and submit along with proposed environmental management plan & monitoring programme)

1. **LAND ENVIRONMENT**

(Attach panoramic view of the project site and the vicinity)

1.1. Will the existing landuse get significantly altered from the project that is not consistent with the surroundings? (Proposed landuse must conform to the approved Master Plan / Development Plan of the area. Change of landuse if any and the statutory approval from the competent authority be submitted). Attach Maps of (i) site location, (ii) surrounding features of the proposed site (within 500 meters) and (iii) the site (indicating levels & contours) to appropriate scales. If not available attach only conceptual plans.

1.2. List out all the major project requirements in terms of the land area, built up area, water consumption, power requirement, connectivity, community facilities, parking needs etc.

1.3. What are the likely impacts of the proposed activity on the existing facilities adjacent to the proposed site? (Such as open spaces, community facilities, details of the existing landuse, disturbance to the local ecology).

1.4. Will there be any significant land disturbance resulting in erosion, subsidence & instability? (Details of soil type, slope analysis, vulnerability to subsidence, seismicity etc may be given).

1.5. Will the proposal involve alteration of natural drainage systems? (Give details on a contour map showing the natural drainage near the proposed project site)

1.6. What are the quantities of earthwork involved in the construction activity-cutting, filling, reclamation etc. (Give details of the quantities of earthwork involved, transport of fill materials from outside the site etc.)

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

1.7. Give details regarding water supply, waste handling etc during the construction period.

1.8. Will the low lying areas & wetlands get altered? (Provide details of how low lying and wetlands are getting modified from the proposed activity)

1.9. Whether construction debris & waste during construction cause health hazard? (Give quantities of various types of wastes generated during construction including the construction labour and the means of disposal)

2. WATER ENVIRONMENT

2.1. Give the total quantity of water requirement for the proposed project with the breakup of requirements for various uses. How will the water requirement met? State the sources & quantities and furnish a water balance statement.

2.2. What is the capacity (dependable flow or yield) of the proposed source of water?

2.3. What is the quality of water required, in case, the supply is not from a municipal source? (Provide physical, chemical, biological characteristics with class of water quality)

2.4. How much of the water requirement can be met from the recycling of treated wastewater? (Give the details of quantities, sources and usage)

2.5. Will there be diversion of water from other users? (Please assess the impacts of the project on other existing uses and quantities of consumption)

2.6. What is the incremental pollution load from wastewater generated from the proposed activity? (Give details of the quantities and composition of wastewater generated from the proposed activity)

2.7. Give details of the water requirements met from water harvesting? Furnish details of the facilities created.

2.8. What would be the impact of the land use changes occurring due to the proposed project on the runoff characteristics (quantitative as well as qualitative) of the area in the post construction phase on a long term basis? Would it aggravate the problems of flooding or water logging in any way?

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

2.9. What are the impacts of the proposal on the ground water? (Will there be tapping of ground water; give the details of ground water table, recharging capacity, and approvals obtained from competent authority, if any)

2.10. What precautions/measures are taken to prevent the run-off from construction activities polluting land & aquifers? (Give details of quantities and the measures taken to avoid the adverse impacts)

2.11. How is the storm water from within the site managed?(State the provisions made to avoid flooding of the area, details of the drainage facilities provided along with a site layout indication contour levels)

2.12. Will the deployment of construction labourers particularly in the peak period lead to unsanitary conditions around the project site (Justify with proper explanation)

2.13. What on-site facilities are provided for the collection, treatment & safe disposal of sewage? (Give details of the quantities of wastewater generation, treatment capacities with technology & facilities for recycling and disposal)

2.14. Give details of dual plumbing system if treated waste used is used for flushing of toilets or any other use.

3. VEGETATION

3.1. Is there any threat of the project to the biodiversity? (Give a description of the local ecosystem with it's unique features, if any)

3.2. Will the construction involve extensive clearing or modification of vegetation? (Provide a detailed account of the trees & vegetation affected by the project)

3.3. What are the measures proposed to be taken to minimize the likely impacts on important site features (Give details of proposal for tree plantation, landscaping, creation of water bodies etc along with a layout plan to an appropriate scale)

4. FAUNA

4.1. Is there likely to be any displacement of fauna- both terrestrial and aquatic or creation of barriers for their movement? Provide the details.

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

4.2. Any direct or indirect impacts on the avifauna of the area? Provide details.

4.3. Prescribe measures such as corridors, fish ladders etc to mitigate adverse impacts on fauna

5. AIR ENVIRONMENT

5.1. Will the project increase atmospheric concentration of gases & result in heat islands? (Give details of background air quality levels with predicted values based on dispersion models taking into account the increased traffic generation as a result of the proposed constructions)

5.2. What are the impacts on generation of dust, smoke, odorous fumes or other hazardous gases? Give details in relation to all the meteorological parameters.

5.3. Will the proposal create shortage of parking space for vehicles? Furnish details of the present level of transport infrastructure and measures proposed for improvement including the traffic management at the entry & exit to the project site.

5.4. Provide details of the movement patterns with internal roads, bicycle tracks, pedestrian pathways, footpaths etc., with areas under each category.

5.5. Will there be significant increase in traffic noise & vibrations? Give details of the sources and the measures proposed for mitigation of the above.

5.6. What will be the impact of DG sets & other equipment on noise levels & vibration in & ambient air quality around the project site? Provide details.

6. AESTHETICS

6.1. Will the proposed constructions in any way result in the obstruction of a view, scenic amenity or landscapes? Are these considerations taken into account by the proponents?

6.2. Will there be any adverse impacts from new constructions on the existing structures? What are the considerations taken into account?

6.3. Whether there are any local considerations of urban form & urban design influencing the design criteria? They may be explicitly spelt out.

6.4. Are there any anthropological or archaeological sites or artefacts nearby? State if any other significant features in the vicinity of the proposed site have been considered.

7. SOCIO-ECONOMIC ASPECTS

7.1. Will the proposal result in any changes to the demographic structure of local population? Provide the details.

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

7.2. Give details of the existing social infrastructure around the proposed project.

7.3. Will the project cause adverse effects on local communities, disturbance to sacred sites or other cultural values? What are the safeguards proposed?

8. BUILDING MATERIALS

8.1. May involve the use of building materials with high-embodied energy. Are the construction materials produced with energy efficient processes? (Give details of energy conservation measures in the selection of building materials and their energy efficiency)

8.2. Transport and handling of materials during construction may result in pollution, noise & public nuisance. What measures are taken to minimize the impacts?

8.3. Are recycled materials used in roads and structures? State the extent of savings achieved?

8.4. Give details of the methods of collection, segregation & disposal of the garbage generated during the operation phases of the project.

9. ENERGY CONSERVATION

9.1. Give details of the power requirements, source of supply, backup source etc. What is the energy consumption assumed per square foot of built-up area? How have you tried to minimize energy consumption?

9.2. What type of, and capacity of, power back-up to you plan to provide?

9.3. What are the characteristics of the glass you plan to use? Provide specifications of its characteristics related to both short wave and long wave radiation?

9.4. What passive solar architectural features are being used in the building? Illustrate the applications made in the proposed project.

9.5. Does the layout of streets & buildings maximise the potential for solar energy devices? Have you considered the use of street lighting, emergency lighting and solar hot water systems for use in the building complex? Substantiate with details.

9.6. Is shading effectively used to reduce cooling/heating loads? What principles have been used to maximize the shading of Walls on the East and the West and the Roof? How much energy saving has been effected?

9.7. Do the structures use energy-efficient space conditioning, lighting and mechanical systems? Provide technical details. Provide details of the transformers and motor efficiencies, lighting intensity and air-conditioning load assumptions? Are you using CFC and HCFC free chillers? Provide specifications.

9.8. What are the likely effects of the building activity in altering the micro-climates? Provide a self assessment on the likely impacts of the proposed construction on

---

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

creation of heat island & inversion effects?

9.9. What are the thermal characteristics of the building envelope? (a) roof; (b) external walls; and (c) fenestration? Give details of the material used and the U-values or the R values of the individual components.

9.10. What precautions & safety measures are proposed against fire hazards? Furnish details of emergency plans.

9.11. If you are using glass as wall material provides details and specifications including emissivity and thermal characteristics.

9.12. What is the rate of air infiltration into the building? Provide details of how you are mitigating the effects of infiltration.

9.13. To what extent the non-conventional energy technologies are utilised in the overall energy consumption? Provide details of the renewable energy technologies used.

10. Environment Management Plan

The Environment Management Plan would consist of all mitigation measures for each item wise activity to be undertaken during the construction, operation and the entire life cycle to minimize adverse environmental impacts as a result of the activities of the project. It would also delineate the environmental monitoring plan for compliance of various environmental regulations. It will state the steps to be taken in case of emergency such as accidents at the site including fire.

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

APPENDIX III

(See paragraph 7

GENERIC STRUCTURE OF ENVIRONMENTAL IMPACT ASSESSENT DOCUMENT

S.NO	EIA STRUCTURE	CONTENTS
1.	Introduction	• Purpose of the report • Identification of project & project proponent • Brief description of nature, size, location of the project and its importance to the country, region • Scope of the study – details of regulatory scoping carried out (As per Terms of Reference)
2.	Project Description	• Condensed description of those aspects of the project (based on project feasibility study), likely to cause environmental effects. Details should be provided to give clear picture of the following: • Type of project • Need for the project • Location (maps showing general location, specific location, project boundary & project site layout) • Size or magnitude of operation (incl. Associated activities required by or for the project • Proposed schedule for approval and implementation • Technology and process description • Project description. Including drawings showing project layout, components of project etc. Schematic representations of the feasibility drawings which give information important for EIA purpose • Description of mitigation measures incorporated into the project to meet environmental standards, environmental operating conditions, or other EIA requirements (as required by the scope) • Assessment of New & untested technology for the risk of technological failure

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

3.	Description of the Environment	• Study area, period, components & methodology • Establishment of baseline for valued environmental components, as identified in the scope • Base maps of all environmental components
4.	Anticipated Environmental Impacts & Mitigation Measures	• Details of Investigated Environmental impacts due to project location, possible accidents, project design, project construction, regular operations, final decommissioning or rehabilitation of a completed project • Measures for minimizing and / or offsetting adverse impacts identified • Irreversible and Irretrievable commitments of environmental components • Assessment of significance of impacts (Criteria for determining significance, Assigning significance) • Mitigation measures
5.	Analysis of Alternatives (Technology & Site)	• In case, the scoping exercise results in need for alternatives: • Description of each alternative • Summary of adverse impacts of each alternative • Mitigation measures proposed for each alternative and • Selection of alternative
6.	Environmental Monitoring Program	• Technical aspects of monitoring the effectiveness of mitigation measures (incl. Measurement methodologies, frequency, location, data analysis, reporting schedules, emergency procedures, detailed budget & procurement schedules)
7.	Additional Studies	• Public Consultation • Risk assessment • Social Impact Assessment. R&R Action Plans
8.	Project Benefits	• Improvements in the physical infrastructure • Improvements in the social infrastructure

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

		• Employment potential –skilled; semi-skilled and unskilled • Other tangible benefits
9.	Environmental Cost Benefit Analysis	If recommended at the Scoping stage
10.	EMP	• Description of the administrative aspects of ensuring that mitigative measures are implemented and their effectiveness monitored, after approval of the EIA
11	Summary & Conclusion (This will constitute the summary of the EIA Report)	• Overall justification for implementation of the project • Explanation of how, adverse effects have been mitigated
12.	Disclosure of Consultants engaged	• The names of the Consultants engaged with their brief resume and nature of Consultancy rendered

APPENDIX III A

(See paragraph 7)

CONTENTS OF SUMMARY ENVIRONMENTAL IMPACT ASSESSMENT

The Summary EIA shall be a summary of the full EIA Report condensed to ten A-4 size pages at the maximum. It should necessarily cover in brief the following Chapters of the full EIA Report: -

1. Project Description
2. Description of the Environment
3. Anticipated Environmental impacts and mitigation measures
4. Environmental Monitoring Programme
5. Additional Studies
6. Project Benefits
7. Environment Management Plan

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

APPENDIX IV

(See paragraph 7)

PROCEDURE FOR CONDUCT OF PUBLIC HEARING

1.0 The Public Hearing shall be arranged in a systematic, time bound and transparent manner ensuring widest possible public participation at the project site(s) or in its close proximity District -wise, by the concerned State Pollution Control Board (SPCB) or the Union Territory Pollution Control Committee (UTPCC).

2. 0 **The Process:**

2.1 The Applicant shall make a request through a simple letter to the Member Secretary of the SPCB or Union Territory Pollution Control Committee, in whose jurisdiction the project is located, to arrange the public hearing within the prescribed statutory period. In case the project site is covering more than one District or State or Union Territory, the public hearing is mandated in each District, State or Union Territory in which the project is located and the applicant shall make separate requests to each concerned SPCB or UTPCC for holding the public hearing as per this procedure.

2.2 The Applicant shall enclose with the letter of request, at least 10 hard copies and an equivalent number of soft (electronic) copies of the draft EIA Report with the generic structure given in Appendix III including the Summary Environment Impact Assessment report in English and in the official languageof the state/local language, prepared strictly in accordance with the Terms of
Reference communicated after Scoping (Stage-2). Simultaneously the applicant shall arrange to forward copies, one hard and one soft, of the above draft EIA Report along with the Summary EIA report to the following authorities or offices, within whose jurisdiction the project will be located:

(a) District Magistrate/District collector/Deputy commissioner/s
(b) Zila Parishad or Municipal Corporation or Panchayats Union
(c) District Industries Office
(d) Urban Local Bodies (ULBs) / PRIs Concerned / Development authorities.
(d) Concerned Regional Office of the Ministry of Environment and Forests

2.3 On receiving the draft Environmental Impact Assessment report, the abovementioned authorities except the Regional Office of MoEF, shall arrange to widely publicize it within their respective jurisdictions requesting the interested persons to send their comments to the concerned regulatory authorities. They shall also make available the draft EIA Report for inspection electronically or otherwise to the public during normal office hours till the Public Hearing is over.

2.4 The SPCB or UTPCC concerned shall also make similar arrangements for giving publicity about the project within the State/Union Territory and make available the Summary of the draft Environmental Impact Assessment report (Appendix III A) for

---

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

inspection in select offices or public libraries or any other suitable location etc. They shall also additionally make available a copy of the draft Environmental Impact Assessment report to the above five authorities/offices as given in para 2.2.

3.0 Notice of Public Hearing:

3.1 The Member-Secretary of the concerned SPCB or UTPCC shall finalize the date, time and exact venue for the conduct of public hearing within 7(seven) days of the date of receipt of the draft Environmental Impact Assessment report from the project proponent, and advertise the same in one major National Daily and one Regional vernacular Daily / Official State Language. A minimum notice period of 30(thirty) days shall be provided to the public for furnishing their responses;

3.2 The advertisement shall also inform the public about the places or offices where the public could access the draft Environmental Impact Assessment report and the Summary Environmental Impact Assessment report before the public hearing. In places where the newspapers do not reach, the Competent Authority should arrange to inform the local public about the public hearing by other means such as by way of beating of drums as well as advertisement / announcement on radio / television.

3.3 No postponement of the date, time, venue of the public hearing shall be undertaken, unless some untoward emergency situation occurs and then only on the recommendation of the concerned District Magistrate/District collector/Deputy Commissioner, the postponement shall be notified to the public through the same National and Regional vernacular dailies and also prominently displayed at all the identified offices by the concerned SPCB or Union Territory Pollution Control Committee;

3.4 In the above exceptional circumstances, fresh date, time and venue for the public consultation shall be decided by the Member – Secretary of the concerned SPCB or UTPCC only in consultation with the District Magistrate/District collector/Deputy Commissioner and notified afresh as per procedure under 3.1 above.

4.0 Supervision and Presiding over the Hearing:

4.1 The District Magistrate/District collector/Deputy Commissioner or his or her representative not below the rank of an Additional District Magistrate assisted by a representative of SPCB or UTPCC, shall Supervise and preside over the entire public hearing process.

5.0 Videography

5.1 The SPCB or UTPCC shall arrange to video film the entire proceedings. A copy of the videotape or a CD shall be enclosed with the public hearing proceedings while Forwarding it to the Regulatory Authority concerned.

6.0 Proceedings

6.1 The attendance of all those who are present at the venue shall be noted and annexed with the final proceedings.

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

6.2 There shall be no quorum required for attendance for starting the proceedings.

6.3 A representative of the applicant shall initiate the proceedings with a presentation on the project and the Summary EIA report.

6.4 Persons present at the venue shall be granted the opportunity to seek information or clarifications on the project from the Applicant. The summary of the public hearing proceedings accurately reflecting all the views and concerns expressed shall be recorded by the representative of the SPCB or UTPCC and read over to the audience at the end of the proceedings explaining the contents in the local/vernacular language and the agreed minutes shall be signed by the District Magistrate/District collector/Deputy Commissioner or his or her representative on the same day and forwarded to the SPCB/UTPCC concerned.

6.5 A Statement of the issues raised by the public and the comments of the Applicant shall also be prepared in the local language or the Official State language, as the case may be, and in English and annexed to the proceedings:

6.6 The proceedings of the public hearing shall be conspicuously displayed at the office of the Panchyats within whose jurisdiction the project is located, office of the concerned Zila Parishad, District Magistrate/District collector/Deputy Commissioner, and the SPCB or UTPCC . The SPCB or
UTPCC shall also display the proceedings on its website for general information. Comments, if any, on the proceedings which may be sent directly to the concerned regulatory authorities and the applicant concerned.

7.0 **Time period for completion of public hearing**

7.1 The public hearing shall be completed within a period of 45 (forty five) days from date of receipt of the request letter from the Applicant. Thereafter the SPCB or UTPCC concerned shall sent the public hearing proceedings to the concerned regulatory authority within 8(eight) days of the completion of the public hearing.Simultaneously, a copy will also be provided to the project proponent.The applicant may also directly forward a copy of the approved public hearing proceedings to the regulatory authority concerned along with the final Environmental Impact Assessment report or supplementary report to the draft EIA report prepared after the public hearing and public consultations incorporating the concerns expressed in the public hearing along with action plan and financial allocation, item-wise, to address those concerns.".

7.2 If the SPCB or UTPCC fails to hold the public hearing within the stipulated 45(forty five) days, the Central Government in Ministry of Environment and Forests for Category 'A' project or activity and the State Government or Union Territory Administration for Category 'B' project or activity at the request of the SEIAA, shall engage any other agency or authority to complete the process, as per procedure laid down in this notification.

APPENDIX –V

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

(See paragraph 7)

PROCEDURE PRESCRIBED FOR APPRAISAL

1. The applicant shall apply to the concerned regulatory authority through a simple communication enclosing the following documents where public consultations are mandatory:

- Final Environment Impact Assessment Report [20(twenty) hard copies and 1 (one) soft copy)]
- A copy of the video tape or CD of the public hearing proceedings
- A copy of final layout plan (20 copies)
- A copy of the project feasibility report (1 copy)

2. The Final EIA Report and the other relevant documents submitted by the applicant shall be scrutinized in office within 30 days from the date of its receipt by the concerned Regulatory Authority strictly with reference to the TOR and the inadequacies noted shall be communicated electronically or otherwise in a single set to the Members of the EAC /SEAC enclosing a copy each of the Final EIA Report including the public hearing proceedings and other public responses received along with a copy of Form -1or Form 1A and scheduled date of the EAC /SEAC meeting for considering the proposal.

3. Where a public consultation is not mandatory, the appraisal shall be made on the basis of the prescribed application Form 1 and EIA report, in the case of all projects and activities other than Item 8 of the Schedule. In the case of Item 8 of the Schedule, considering its unique project cycle, the EAC or SEAC concerned shall appraise all Category B projects or activities on the basis of Form 1, Form 1A and the conceptual plan and make recommendations on the project regarding grant of environmental clearance or otherwise and also stipulate the conditions for environmental clearance."

4. Every application shall be placed before the EAC/SEAC and its appraisal completed within 60 days of its receipt with requisite documents / details in the prescribed manner.

5. The applicant shall be informed at least 15 (fifteen) days prior to the scheduled date of the EAC /SEAC meeting for considering the project proposal.

6. The minutes of the EAC /SEAC meeting shall be finalised within 5 working days of the meeting and displayed on the website of the concerned regulatory authority. In case the project or activity is recommended for grant of EC, then the minutes shall clearly list out the specific environmental safeguards and conditions. In case the recommendations are for rejection, the reasons for the same shall also be explicitly stated.

Note: The principal rules were published in the Gazette of India, Extraordinary, Part II, Section 3, Sub-section (ii) vide notification number S.O. 1533 (E), dated 14th September, 2006 and amended vide S.O. 1737 (E), dated the 11th October, 2007.

APPENDIX VI

(See paragraph 5)

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

COMPOSITION OF THE SECTOR/ PROJECT SPECIFIC EXPERT APPRAISAL COMMITTEE (EAC) FOR CATEGORY A PROJECTS AND THE STATE/UT LEVEL EXPERT APPRAISAL COMMITTEES (SEACs) FOR CATEGORY B PROJECTS TO BE CONSTITUTED BY THE CENTRAL GOVERNMENT`

1. The Expert Appraisal Committees (EAC(s) and the State/UT Level Expert Appraisal Committees (SEACs) shall consist of only professionals and experts fulfilling the following eligibility criteria:

Professional: The person should have at least (i) 5 years of formal University training in the concerned discipline leading to a MA/MSc Degree, or (ii) in case of Engineering /Technology/Architecture disciplines, 4 years formal training in a professional training course together with prescribed practical training in the field leading to a B.Tech/B.E./B.Arch. Degree, or (iii) Other professional degree (e.g. Law) involving a total of 5 years of formal University training and prescribed practical training, or (iv) Prescribed apprenticeship/article ship and pass examinations conducted by the concerned professional association (e.g. Chartered Accountancy),or (v) a University degree , followed by 2 years of formal training in a University or Service Academy (e.g. MBA/IAS/IFS). In selecting the individual professionals, experience gained by them in their respective fields will be taken note of.

Expert: A professional fulfilling the above eligibility criteria with at least 15 years of relevant experience in the field, or with an advanced degree (e.g. Ph.D.) in a concerned field and at least 10 years of relevant experience.

Age: Below 70 years. However, in the event of the non-availability of /paucity of experts in a given field, the maximum age of a member of the Expert Appraisal Committee may be allowed up to 75 years

2. The Members of the EAC shall be Experts with the requisite expertise and experience in the following fields /disciplines. In the event that persons fulfilling the criteria of "Experts" are not available, Professionals in the same field with sufficient experience may be considered:

- **Environment Quality Experts**: Experts in measurement/monitoring, analysis and interpretation of data in relation to environmental quality

- **Sectoral Experts in Project Management**: Experts in Project Management or Management of Process/Operations/Facilities in the relevant sectors.

- **Environmental Impact Assessment Process Experts**: Experts in conducting and carrying out Environmental Impact Assessments (EIAs) and preparation of Environmental Management Plans (EMPs) and other Management plans and who have wide expertise and knowledge of predictive techniques and tools used in the EIA process

- **Risk Assessment Experts**

- **Life Science Experts in floral and faunal management**

- **Forestry and Wildlife Experts**

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

- **Environmental Economics Expert with experience in project appraisal**

3. The Membership of the EAC shall not exceed 15 (fifteen) regular Members. However the Chairperson may co-opt an expert as a Member in a relevant field for a particular meeting of the Committee.

4. The Chairperson shall be an outstanding and experienced environmental policy expert or expert in management or public administration with wide experience in the relevant development sector.

5. The Chairperson shall nominate one of the Members as the Vice Chairperson who shall preside over the EAC in the absence of the Chairman /Chairperson.

6. A representative of the Ministry of Environment and Forests shall assist the Committee as its Secretary.

7. The maximum tenure of a Member, including Chairperson, shall be for 2 (two) terms of 3 (three) years each.

8. The Chairman / Members may not be removed prior to expiry of the tenure without cause and proper enquiry.

I; II; III (i), (ii); IV (a), (b); V (i), (ii), (iii)(a), (b), (c), (iv), (v), (vi) (a), (b), (vii), (viii) (a), (b), (ix), (x), (xi), (xii) (a), (b) , (xiii), (xiv) (a), (b), (xv) (a), (b), (xvi) (a), (b), (xvii); VI (a), (b); VII & VIII of the Notification, S.O. 3067(E) dated 01.12.2009 of the Ministry of Environment and Forests, (Published in the Gazette of India, Extraordinary, Part-II, and Section 3, Sub-section (ii), No. 2002] New Delhi, Tuesday, November 1, 2009; an amendment to EC notification S.O.1533(E) dated 14.09.2006

ANNEXURE-3

Annexure B

तार :
Telegram : PARYAVARAN,
NEW DELHI
दूरभाष :
Telephone : 2436 2827
टेलेक्स :
Telex : W-66185 DOE IN
FAX : 4360678

भारत सरकार
पर्यावरण एवं वन मंत्रालय
GOVERNMENT OF INDIA
MINISTRY OF ENVIRONMENT & FORESTS
पर्यावरण भवन, सी. जी. ओ. कॉम्प्लेक्स
PARYAVARAN BHAVAN, C.G.O. COMPLEX
लोदी रोड, नई दिल्ली-110003
LODHI ROAD, NEW DELHI-110003

No.J-12011/22/2005-IA.I

03.08.2005

The President,
Athena Projects Private Ltd.
191, Jor Bagh,
New Delhi-110003.

Subject:- Teesta Stage –III Hydro Electric Project (1200 MW) in North Sikkim district – Site clearance for Investigation and Survey - reg.

Sir,

This has reference to your letter No. ASG/GOI-MoEF/50418, dated 08.03.2005, 29.06.2005 and 11.07.2005 on the above subject. It has been noted that the project is a run of the river scheme on Teesta river. The dam site is located near village Chungthang in district North Sikkim & power house sites located on the right bank of the river near village Sanklan. Total land requirement is about 240 ha. Out of that 125 ha. is forest land.

2. The above proposal has been examined taking into consideration the submitted project documents. The Ministry of Environment & Forests hereby accords site clearance as per the provisions of EIA notification, 1994 subject to strict compliance of the following terms and conditions –

i) Comprehensive EIA (one year data) report comprising the detailed report on ecological study, catchment area treatment plan (SYI method) along with index map and financial implications, seismicity, disaster management plan, loss of minerals, migration path of the wild & aquatic animals, impact due to

Continued...

construction of infrastructure required for the construction of projects such as roads, opening up of new quarries etc. should be undertaken and submitted to the Ministry through State Government within 18 months of issue of this letter.

ii) Clearance is only for undertaking investigations at the above-mentioned site and for collection of environmental data for preparation of comprehensive EIA report and management plans. This should not in any way be construed as commitment for environmental clearance.

iii) Clearance under Forest (Conservation) Act 1980 should be separately obtained.

iv) No civil work of permanent nature on the project shall be initiated in anticipation of the final approval of the Ministry. The Project Authority would have to apply for environmental clearance by submitting environmental data and plans.

v) Ministry of Environment & Forests shall assess the proposal on its merit before taking a final view.

vi) The fund requirements for environmental aspects should be included in the budget of the project for evaluation of economic feasibility of the project.

vii) Ministry reserves the right to suggest additional measures for environmental protection during the investigation stage, if found necessary.

Yours faithfully,

(Dr. S. Bhowmik)
Additional Director

Copy to:-

1. Secretary, Ministry of Power, Shram Shakti Bhawan, Rafi Marg, New Delhi.
2. Secretary, Department of Power, Govt. of Sikkim Secretariat, Gangtok.
3. Secretary, Deptt. of Forest, Govt. of Sikkim, Secretariat, Gangtok.
4. Adviser (Power), Planning Commission, Yojana Bhavan,New Delhi.
5. Regional Office, MOEF, Shilong.
6. Guard File

(Dr.S. Bhowmik)
Additional Director

ANNEXURE – 4

172

Government of India
Ministry of Environment and Forests
(IA-I Division)

Sub: Summary Record of discussion of the 44th meeting of the Expert Committee for River Valley and Hydroelectric projects held on 28th June , 2006 in Paryavaran Bhavan, New Delhi.

The list of participants is appended.

At the outset Chairman welcomed all the members . He also congratulated Dr. A.K. Bhattacharya for his appointment as emiratus Scientist in Water Technology Centre, IARI.

Item No. 1

Confirmation of the minutes of the last EC meeting.

The minutes of the 43rd meeting of Expert Committee for River Valley and Hydroelectric projects were confirmed after following modification –

- On page-6, under Pare(Dikrong) HEP, line-5 instead of river Ranganadi, read river Pare.
- On page-11 under Jorethang Loop HEP, after line 14 the following sentence to be added.
  "However written reply of Dr. Basu's comment is to be given by the P.A.

Item No.2

Consideration of the projects

1. **Sorang HEP(100 MW) in Himachal Pradesh by M/s Himachal Sorang Power Pvt. Ltd.**

Shri P.M. Nanda, General Manager(Power) attended the meeting along with Consultant and other officials. He delivered a brief presentation on the proposal. The Committee noted that Sorang HEP is a run of the river scheme. The water will be diverted through trench weir from Sorang Khad. No impounding of water will be done at the intake site hence no reservoir will be formed. Total land requirement is 20.58 ha. Out of which 14.48 ha. is forest land. Rupi-Bhaba wild life Sanctuary is only 650 m away. No displacement of

173

human population is involved. State Got. Has forwarded the project for environmental clearance.

After carefully examining all the environment related issues the Committee desired to have the following information /clarification –

i) The Statement – No type of herbs were found in the area is not correct. This may be rechecked. Similarly 'No major fauna was observed during survey' needs to be corrected.

ii) Full listing of flora & fauna to be given. Density of vegetation, their distribution, abundance, indices also have to be furnished.

iii) Rupi-Bhaba Wildlife Sanctuary is only 650 m away. Comments of the State Chief Wildlife Warden regarding impact on wildlife during construction to be submitted.

iv) Commitment of HPSEB regarding supplying of construction power to be given.

v) The scheme is in seismic zone V. Seismic design parameters approved by National Committee of seismic Design Parameters, CWC should be used for construction of structures.

2. **Teesta-III HEP(1200 MW) in Sikkim by M/s Teesta Urja Ltd.**

Shri K. Seethayya, Adiser of the company delivered a brief presentation on the proposal which was followed by the consultant. The Committee noted that the proposal is for construction of a concrete face rock fill dam of 60m height across Teesta river at about 400m downstream of confluence of river Lachen chu and Lachung chu near village Chungthang to create a gross storage of 5.08 Mm3 at full reservoir level of 1585m. The power house will be underground with an installed capacity of (6x200) 1200 MW. The power house site is 800m upstream of confluence of the river Teesta and Talung chu near village Sanklan..

Total land requirement is 196.967 ha. Out of which 80.288 ha. is forest land. Khangchendzonga National Park is one km away from the project site. Between Teesta reservoir level & Khangchendzonga National Park the separating ridge is at 225 m height. Teesta river & Khangchendzonga National Park are in two different basins. The site is within the buffer zone of biosphere reserve. The submergence area at FRL is about 22 ha. No

homestead is being displaced. However, 156 families are likely to lose their land partially in nine project affected villages. R&R package has been prepared based on NPRR-2003. A budget of Rs.130 million has been kept for this purpose. Public hearing was held on 8th June, 2006.

After carefully examining all the environment related issues the Committee desired to have the following information /clarification –

i) Basis for selection for the quadrant sizes.

ii) IVI calculation needs to be rechecked.

iii) On page-47 & 66 areas of water body figures are confusing and contradictory. These need to be rechecked.

iv) The meaning of wild crop plant species may be clarified.

v) Pinus is singularly absent from the list of the plants, which should be a component of conifers. Please check.

vi) It is stated in the questionnaire(p-12) that no endangered species are reported. However, lagerstroemia minuticarpa which is supposedly endangered is available in the area. Please clarify the status.

vii) The report states that a study to establish design seismic parameters is being carried out by DEQ, IIT Roorkee. Please verify whether the report has been received.

viii) As the dam is large dam the recommended seismic design parameters need approval of NCSDP. The approved design earthquake parameters shall be used for final design. Did NCSDP's approval is obtained on the parameters recommended?

ix) In EIA report it is suggested that community kitchens shall use LPG or diesel as fuel. Diesel shall not be used for these kitchens.

x) In the questionnaire for environmental clearance it is stated that about 20km away from dam a landslide area(Zena land slide) exists. Are steps being taken to stabilize the area?

xi) Khangchendzonga National Park is one km away from the project site. Comments of State Chief Wildlife Warden regarding impact on wildlife during construction to be submitted.

174

3. Pare (Dikrong) HEP(110 MW) in Arunachal Pradesh by M/s NEEPCO.

This proposal was considered by the expert committee at its earlier meeting held on 17.5.06. As decided by the Committee, a sub group visited the proposed site on 11th June, 2006. The site visit report was accepted by the Committee except observation on the number. of rooms for H.S. school. The Committee felt that 20 rooms are adequate. The issues raised in the site visit report need to be clarified by the project authority.

4. Temghar irrigation project in Maharashtra.

This proposal has been considered by the expert committee on 19.2.04, 15.2.2006. The furnished clarifications sought by the committee at its last meeting were considered by the committee and found satisfactory. As such recommended clearance. The committee also noted that this is an ongoing project and about 95% of work has been completed. As under EIA notification 1994, only new projects are to be considered for E.C. Decision on granting environmental clearance to this project was left to the Ministry.

5. Indira Sagar lift irrigation project in Andhra Pradesh.

This project was considered by the expert committee at its earlier meeting held on 17.5.06. The committee had recommended environmental clearance subject to submission of certain clarifications. The clarifications received from the project authority were considered by the Committee, which were found satisfactory. The committee recommended environmental clearance.

Item No.3

Any other item with permission of the chair.

Rajiv Sagar lift irrigation project in Andhra Pradesh.

This project could not be included in the agenda as detailed feasibility report was not received. The same was submitted during the meeting. The project authority was allowed to give presentation on the proposal.

Shri Satish Chandra, Secretary, Govt. of Andhra Pradesh delivered a brief presentation which was followed up by the consultant. The committee noted that the project is a lift cum-gravity canal project. It is proposed to lift water from the river Godavari(+45 00 m) during monsoon(lifting for 150 days). The intake structure for lift is on right bank of the river Godavari near

178

village Pamulapally in Aswapuram Mandal of Khammam district. The scheme provides irrigation facilities to the areas between EL+45m to +216 m covering a command area of 81,000 ha(2,00,000 acres). The command area is falling in Khammam district. The scheme also envisages supplying drinking water to the enroute villages.

Total land requirement is 1980.87 ha. out of which 345 ha. is forest land. 165 ha forest land will be submerged due to construction of two new balancing reservoir, already existing. Three balancing reservoirs ~~will be utilized~~ . No human population will be displaced due to this project and no R&R problem exists as there are no PAPs.

After carefully considering all the environment related issues, the committee recommended environment clearance for the project.

Grading of the Projects: Sorang – 60%
Teesta - 70%
Rajiv Sagar - 65%

Next meeting of the committee will be held on 19th July, 2006.

The meeting ended with thanks to the Chair.

ANNEXURE-5

195

Government of India
Ministry of Environment and Forests
(IA-I Division)

Sub: Summary Record of discussion of the 45th meeting of the Expert Committee for River Valley and Hydroelectric projects held on 19th July , 2006 in Paryavaran Bhavan, New Delhi.

The list of participants is appended.

At the outset Chairman welcomed all the members. Thereafter he informed the committee that Secretary (E&F) had taken an interactive meeting with all Chairmen and Member Secretaries of the various Expert Committees of Impact Assessment Division,on 4th July, 2006. In the meeting, Secretary expressed his concern about the large number of projects pending for environmental clearance and mentioned that the Committees would have to devise mechanisms for speedy appraisal of the projects. Chairman listed out the important decisions taken/suggestions made in the meeting. These include:

- Only relevant information for the issue of Environmental clearance may be asked from the project proponent.
- Seeking supplementary information may be avoided in cases where Committee recommends environmental clearance.
- Committee may avoid asking for new information in every meeting. Where the project proponent does not submit the proposal with relevant information, Committee may recommend rejection of the proposal.
- When rejection is recommended, the reasons should be clearly listed. Ministry would 'reopen' the case only if reasons for rejection are rectified by the proponent.
- All clearances under other statutory agencies can run parallel. Therefore, unless found essential to do otherwise, Committee can form its view on the project based on the documents prescribed as per procedures and provisions under the EIA Notification. There may be a general disclaimer that the environmental clearance will be valid when due clearances/approvals have been obtained from all concerned authorities.
- Member Secretary will prepare an information-matrix on the projects included in the agenda indicating the documents needed/submitted with preliminary remarks on the quality of documents submitted, for ready reference of Committee members.
- Ministry will consider putting in place a mechanism to involve Committee members in post project monitoring.
- Ministry has increased the sitting fees from Rs.600/- to Rs.1000/- and is working with Finance Department for revision of other allowances and facilities for the members of EACs.

196

Item No. 1

Confirmation of the minutes of the last EC meeting.

The minutes of the 44th meeting of Expert Committee for River Valley and Hydroelectric projects were confirmed after following modification –

Item No.2

Teesta –III HEP(1200 MW) in Sikkim.

2nd para 5th line – Read – ...National Park are in another Sub-basin of Teesta basin; instead of " ... National Park are in two different basins."
3rd para point No. (i) – Read- Quadrat in stead of Qudrant.

Under Rajiv Sagar Lift Irrigation project.

3rd para, 3rd line – read – balancing reservoir. Three balancing reservoir already existing.

Consideration of the projects:

1. Teesta stage-III HEP(1200 MW) in Sikkim by M/s Teesta Urja Ltd.

This project was considered by the expert committee at its meeting held on 28th June, 2006. The Committee had sought certain clarification on different issues. The clarifications submitted by the project authority were considered by the Committee. In addition to this representations submitted by Shri Tseten Lepcha were also considered.

Considering the landslide prone areas in general the committee requested the project authority to do tunneling with great care under close supervision. Reply of project proponent in response to Shri Lepcha's representation as well as the clarifications to committee's observation were found satisfactory. The committee recommended environmental clearance to the project.

2. Teesta stage -VI HEP(500 MW) in Sikkim by Lanco Energy Pvt. Ltd.

Shri Murali, Vice President of the company gave a brief presentation on the proposal which was followed by the consultant. The committee noted that a barrage of 18m height from the river bed level is proposed at Sirwani in South Sikkim district to generate 500 MW electricity. The proposed scheme is run of the river and the barrage will submerge 36 ha of land. 111 families will be losing a part of their agricultural land.

197

Catchment area treatment will be completed in five years and another two years will be required for maintenance construction of the barrage is likely to be completed within five years. Entire project area surveyed during three seasons i.e October-November in 2005, February-March in 2006 and May-June, 2006.

After critically examining all the environment related issues the committee desired to have the following information –

i) Year wise physical target for CAT should be identified on an index map.

ii) FCC of the project area to be submitted.

ii) Grievance redressal committee should consist at least one member from project affected families.

iv) The proposal for creation of a fish ladder for migration of fishes or a fish farm only for Mahseer is confusing, as the river stretch is dominated by other fishes like snow trout, catli, Labeo dero and Barilius bendelisis. Howe a fish farm only for Mahseer can help conservation of other fishes may be explained.

v) Regarding seismicity comments(Copy of which is given to PA) given by Prof. Basu should be clarified.

vi) In the EIA (page-47) it is written that a full fledged research of limnlogical studies be carried out to have the basic facts on the present status of our riverine systems before and after barrage constructions or impoundments in such project. However, no monetary allocation for the same has been indicated in the EMP.

vii) On page 137 of EIA report it is stated ' the water discharge from all these streams may not be sufficient to sustain aquatic organism downstream of the barrage site. But EMP report does not indicate any appropriate measures to ensure the biological health of the river in this stretch.

viii) During presentation it was informed that 10% of water will be released during lean season to maintain the aquatic life in the river. Water availability during lean season is 80 cumec. Quantity of water required for running all the units is 530 cumec. How 10% water will be released during lean season may be explained?

(ix) On page-29 of presentation material it is stated – land acquisition will be done by land revenue dept., GOS as per Sikkim law. Copy of this law may be submitted.

x) In the addendum relative density has been wrongly calculated. This may be corrected.

xi) It is stated in the Executive summary of DPR, on page 80, under column 12.7.5 that "there are not many wildlife in the project sites. As such no specific

management plan to protect wildlife needs to be prepared". In EMP on page 57, under management plan, it is stated 'as per the findings, thee are no rear or endangered plants or animals species likely to be affected by the proposed project activities".

Though as per the above statements none of the rear & endangered floe or fauna are affected, even a biodiversity conservation has been proposed for the critical areas. These critical areas should be identified and intimated. How this conservation is different than CAT and CA may also be clarified.

xii) Different plot sizes for quadrat have been used for trees, shrubs & herbs which are not correct for floral species of Sikkim. Quadrat varies from place to place depending on the nature of vegetation. This needs to be relooked.

xiii) Page 73 of EIA: It is not clear whether soil N, P&K area of available value or total value. Moreover, organic carbon should have been reported instead of organic matter. 50 report the N P.K as available N,P and K in kg/ha.

xiv) Page 131 on surface water quality. Important water parameters like chloride , nitrate, fluoride, heavy metals like Zn, Cd, As, Hg are not reported in water analysis.

xv) Page 131: BOD of surface water exceeds the permissible limits of even C-grade drinking water. This has an environmental implication since near about 25% of drinking water comes from existing springs. Remedial measures have to be indicated.

xvi) Nomenclatuarally the presentation of flora and faunal taxa is extremly poor. Full listing of flora (including lower form) & fauna to be given. Density of vegetation, their distribution, abundance indices also has to be furnished. The whole account needs to be thoroughly revised by competent authorities, and provided with reference of both primary and secondary sources.

xvii) On page 14 of presentation material the nature of soil is indicated as sandy loam to fine loamy. But water holding capacity is shown as 53.6 % - 55.3 %. Sandy loam soil can mot have this much water holding capacity.

The committee decided to depute a sub-group to visit the proposed site for on the spot examination. The following members were nominated for the site visit:

(1) Prof.P. G.Sastry (2) Prof. S. Chanda (3) Prof. S. Basu (4) Dr. S. Bhowmik.(5) Shri R. K. Khanna, CWC.

199

3. **Sorang HEP (100 MW) in Himachal Pradesh by Himachal Sorang Power private Ltd.**

This project was considered by the expert committee at its meeting held on 28th June, 2006. The Committee had sought certain clarification on different issues. The clarifications submitted by the project authority were considered by the Committee. The clarifications were found satisfactory. However as Rupi-Bhaba Wildlife Sanctuary is in a close proximity of the project area , the committee should not use diesel generator for construction power. As such they were requested to submit commitment from the official of State Electricity Board for supplying 3 MW power. The project proponent informed that they have applied for commitment from HPSEB. Decision in this regard may be taken by HPSEB in their meeting, scheduled to be held, sometime in August 2006. Thereafter commitment of HPSEB may be submitted.

The committee recommended environmental clearance with the condition that Ministry may process the proposal for clearance after receipt of the above said commitment letter.

Grading –

Teesta Stage – VI HEP :-

EIA/EMP report prepared by Forest, Environment and wildlife management department , Govt. of Sikkim – 55%

As 3rd Wednesday of August is holiday, it was decided to hold the next meeting on 23rd August 2006.

The meeting ended with vote of thanks to the Chair.

The minutes have been confirmed by the Chairman.

Dr.P.G.Sastry
Chairman

250

List of participants attended the 45th meeting of Environmental Expert Committee for River Valley and Hydroelectric projects held on 19th July, 2006 in Paryavaran Bhawan.

Sl.No.	Name	
1.	Dr. P.G. Sastry	Chairman
2.	Prof. S. Chanda	Member
3.	Dr. A. Sarkar	"
4.	Prof. Susanta Basu	"
5.	Prof. SPS Kushwaha	"
6.	Dr. O. P. Sisodia	"
7.	E. Karunanithy	"
8.	R.S. Bharathi	"
9.	Sh. R.K. Khanna	"
10.	Dr. S Bhowmik	Member Secretary
11.	Dr. Harendra Kharkwal	MOEF

Teesta Stage-III(1200 MW), Sikkim.

1.	K. Seethayya	Adviser
2.	P.D.P. Rao	
3.	Rajendra Singh	
4.	K.V.Rao	
5.	Dr. R.K.Singh	Sr. scientist, WAPCOS
6.	Meela Srikant	
7.	Anil kumar	
8.	R. Sasikumaran Nair	Liason Officer
9.	Pradeep Sharma	Environmetalist
10.	Jayachandra Kharadelwal	Sr. env. Engineer
11	Dr. A. K. Sharma	Dy.C.S. WAPCOS
12.	R.B.Singh	Liasion Officer
13	Sunil kumar Tamrakar.	

Teesta Stage-VI(500 MW), Sikkim

1.	Murli Subramaniam	Vice President
2.	Rb.Sriganesh	G.M.(Fin & Accts)
3.	P. Senthil Kumar	
4.	C.S. Rao	
5.	Brijendra Sharma	
6.	V.P.S. Chauhan	
7.	D.V. Rao	
8.	Ravina	
9.	M. Arun	
10.	Dimpy sharma	
11.	B.K. Sharda	
12.	R.K. Pradhan	
13.	S.K. Rai	

Sorang HEP, Himachal Pradesh.

1.	P.M.Nanda	General Manager(Power)
2.	Anup Banyal	
3.	Kota Shankar Sharma	Adviser

35765/2017/IT

262

ANNEXURE-6

No. J-12011/26/2006-IA.I
Government of India
Ministry of Environment & Forests

Paryavaran Bhawan,
C.G.O. Complex, Lodi Road,
New Delhi-110003

Dated: 4th August, 2006

Sh. Y. N. Apparao,
M/s Teesta Urja Limited,
119, Jor Bagh ,
New Delhi – 110003.

Subject: Teesta Hydroelectric Project Stage-III (1200 MW) in North District, Sikkim – Environmental Clearance reg.

Sir,

This has reference to your letter No. TUL/MoEF/060617, dated 17.06.2005 and subsequent letters No.TUL-VII/MoEF/060714, TUL/MoEF/060714, TUL/ MoEF/060719 dated 14.07.2006 & 19.07.2006 respectively on the subject.

2. The above referred proposal was considered by the Expert Committee for River Valley & Hydroelectric projects at its meeting held on 28.06.2006 & reconsidered on 19.07.2006.

3. The Teesta Hydroelecric Project (1200 MW) envisages construction of a concrete face rock fill dam of 60m height across Teesta river at about 400m downstream of confluence of river Lachen chu and Lachung chu near village Chungthang and the underground power house at 800m upstream of confluence of the river Teesta and Talung chu near village Sanklan, North Sikkim district, Sikkim. Total land requirement is 196.967 ha. Out of which 80.288 ha. is forest land. Forest Clearance is yet to be obtained. No human population will be displaced. However, 156 families are likely to lose their land partially in nine project affected villages. R&R package has been prepared based on NPRR-2003. Public hearing was held on 8th June, 2006. The estimated cost of the project is Rs. 5705.55 crores.

Generated from eOffice by ISHANVI MAKHAIK, Asso legal(IM)-IA-I, ASSOCIATE (LEGAL) - C, MOEFCC on 05/01/2024 12:12 PM

[redacted]/2017/IT

4. The Environmental Management Plan submitted by M/s Teesta Urja Limited has been examined. The Ministry of Environment and Forests hereby accords environmental clearance as per the provisions of Environmental Impact Assessment Notification, 1994, subject to strict compliance of the terms and conditions as follows:

Part A: Specific Conditions

i) 1953.3 ha. degraded catchment area needs to be treated. The Catchment Area Treatment Plan as has been proposed should be completed in four years. The plan is reproduced below:

Treatment Measures	Units	Year -I	Year –II	Year-III	Year -IV
Afforestation	ha.	263	263	113	113
Plantation (Medicinal / bamboo)	ha.	145	145	63	63
Pasture Development	ha.	188	188	81	81
Social Forestry	ha.	14	14	6	6
Fuel wood and fodder grass	ha.	56	56	24	24
Nursery development	No.	4	4	2	-
Barbed wire fencing	Km	3	3	2	2
Step drain / catch water drains	m	175	175	75	75
1:2:4 Stone masonry	m^3	25	25	13	12
Contour bunding	ha.	17	17	8	7

ii) Considering the landslide prone areas, the tunneling should be done with great care under close supervision.

iii) Clearance from National Committee of Seismic Design Parameters (NCSDP) of CWC should be obtained.

iv) Total 156 families from nine villages will be affected due to acquisition of land & affected families should be rehabilitated as per NPRR-2003.

v) A monitoring committee should be constituted which must include representatives of project affected persons from SC/ST category and a women beneficiary.

vi) All the assurances/ commitments given by the project authority in the Public Hearing must be honoured in letter and spirit.

Generated from eOffice by ISHANVI MAKHAIK, Asso legal(IM)-IA-I, ASSOCIATE (LEGAL) - C, MOEFCC on 05/01/2024 12:12 PM

vii) The Khangchendzonzga National Park is one km away from the project site The Wildlife Conservation Plan proposed for protection of Wildlife in protected area on page 10-1 to 10-13 of EMP, should be followed in toto.

viii) Forest Clearance should be obtained for acquiring 80.288 hectare forest land & submitted.

ix) The implementation of Fish Management Plan including provision of fish ladder should be carried out in consultation with the Fisheries Department, State Government of Sikkim and submitted to MOEF within three months from date of issue of this letter.

x) During the lean season minimum 3 cumecs water should be released downstream of the dam for sustenance of aquatic life.

xi) Any other clearance from any other organization if required should be obtained.

Part-B: General Conditions

(i) Adequate free fuel arrangement should be made for the labour force engaged in the construction work at project cost so that indiscriminate felling of trees is prevented.

(ii) Fuel depot may be opened at the site to provide the fuel (kerosene/wood/LPG). Medical facilities as well as recreational facilities should also be provided to the labourers.

(iii) All the labourers to be engaged for construction works should be thoroughly examined by health personnel and adequately treated before issuing them work permit.

(iv) Restoration of construction area including dumping site of excavated materials should be ensured by leveling, filling up of burrow pits, landscaping etc. The area should be properly treated with suitable plantation.

(v) Financial provision should be made in the total budget of the project for implementation of the above suggested safeguard measures.

vi) A Monitoring Committee for R & R should be constituted which must include representatives of project-affected persons from a woman beneficiary.

Generated from eOffice by ISHANVI MAKHAIK, Asso legal(IM)-IA-I, ASSOCIATE (LEGAL) - C, MOEFCC on 05/01/2024 12:12 PM

35765/2017/IT

vii) A Multidisciplinary committee should be constituted with representatives from various disciplines of forestry, ecology, wildlife, soil conservation, NGO etc. to oversee the effective implementation of the suggested safeguard measures.

viii) Six monthly monitoring reports should be submitted to the Ministry and its Regional Office, Shillong for review.

4. Officials from Regional Office MOEF, Shillong who would be monitoring the implementation of environmental safeguards should be given full cooperation, facilities and documents / data by the project proponents during their inspection.

5. The responsibility of implementation of environmental safeguards rests fully with the M/s Teesta Urja Limited & Government of Sikkim.

6. In case of change in the scope of the project, project would require a fresh appraisal.

7. The Ministry reserves the right to add additional safeguard measures subsequently, if found necessary and to take action including revoking of the clearance under the provisions of the Environment (Protection) Act, 1986, to ensure effective implementation of the suggested safeguard measures in a time- bound and satisfactory manner.

8. This clearance letter is valid for a period of five years from the date of issue of this letter for commencement of construction work.

9. A copy of the clearance letter will be marked to concerned Panchayat / local NGO, if any, from whom any suggestion/ representation has been received while processing the proposal.

10 State Pollution Control Board / Committee should display a copy of the clearance letter at the Regional Office, District Industries Center and Collector's office/ Tehsildar's office for 30 days.

11. The project proponent should advertise within seven days from the date

Generated from eOffice by ISHANVI MAKHAIK, Asso legal(IM)-IA-I, ASSOCIATE (LEGAL) - C, MOEFCC on 05/01/2024 12:12 PM

of issue of the clearance latter, at least in two local newspapers widely circulated in the region around the project, one of which shall be in the vernacular language of the locality concerned informing that the project has been accorded environmental clearance and copies of clearance letters are available with the State Pollution Control Board / Committee and may also be seen at Website of the Ministry of Environment and Forests at http:// www.envfor.nic.in

(Dr. S. Bhowmik)
Additional Director

Copy to:

1. The Secretary, Ministry of Power, Shram Shakti, Bhawan, Rafi Marg, New Delhi-110001.
2. Principal Chief Engineer cum Secretary, Energy & Power department, Government of Sikkim, Gangtok, Sikkim- 737102
3. The Secretary, Department of Forest, Environment & Wildlife Management, Deorali – Gangtok-737102..
4. The Secretary, Ministry of Water Resources, Shram Shakti Bhawan, Rafi Marg, New Delhi-110001.
5. The Adviser (Power), Planning Commission, Yojna Bhawan, New Delhi - 110001.
6. The Chief Engineer, Project Appraisal Directorate, Central Electricity Authority, Sewa Bhawan, R.K. Puram, New Delhi-110066.
7. Chief Conservator of Forests, Ministry of Environment & Forests, Regional Office Sillong, Sikkim.
8. Member Secretary, State Pollution Control Board, Sikkim, Department of Forest, Environment & Wildlife Management, Deorali – Gangtok-737102.
9. EI- Division, Ministry of Environment & Forests, New Delhi-110003.
10. Guard file.

(Dr. S. Bhowmik)
Additional Director

Generated from eOffice by ISHANVI MAKHAIK, Asso legal(IM)-IA-I, ASSOCIATE (LEGAL) - C, MOEFCC on 05/01/2024 12:12 PM

ANNEXURE-7

GOVERNMENT OF INDIA
MINISTRY OF ENVIRONMENT,FOREST & CLIMATE CHANGE
NORTH EASTERN REGIONAL OFFICE
LAW-U-SIB, LUMBATNGEN,SHILLONG-793021
Tel. 0364-2537395; Fax. 0364-2536041
E-mail: moefro.shillong@gov.in, vp.upadhyay@nic.in

FILE NO.RO-NE/E/IA/SK/HEP/60/820-21 DATED 16.06.2017

To,

The Chief Executive Officer,
Teesta Urja Limited,
2nd Floor, Vijay Building-17,
Barakhamba Road,Connaught Place,
New Delhi-110001,
Tel: 011-46592600/46529700.

Sub: Teesta Hydro Electric Project Stage-III(1200 MW) in North District Sikkim-reg.

The above project was monitored on 10.06.2017 by the undersigned in the month of June, 2017. The observations of the Regional Office are as follows:

1. The project should continuously collect the data at required intervals for the downstream discharge to ensure that the minimum discharge condition of 3 cumecs is fully complied.

2. A few labour camps on either side of the river bed downstream of the dam still exist. These are the areas which have been filled up by dumping solid waste and then constructing labour camps and workshops over these sites. As the construction work is over, these sites can be reclaimed by suitably raising plantation of local native species to make these areas aesthetically attractive with near natural landscape.

3. The project needs to fully restore the 4 ha dump area used for dumping solid waste from Adit –III. This site has been stabilized for which eco-restoration should be done.

4. The public hearing commitment and implementation report should be submitted to the Regional Office.

It is requested that the project may clarify all the above points relating to non-compliance of conditions and an action taken report may be submitted to this office within 30 days of the receipt of this letter.

Encl. As above

Yours faithfully,

Dr. V.P. Upadhyay
Scientist 'G'

Copy to,

Shri.G.Ramakrishnan (Head of Project),Near Community Centre, Development Area, Gangtok, East District Sikkim-737101.

Scientist 'G'

GOVERNMENT OF INDIA
MINISTRY OF ENVIRONMENT,FOREST & CLIMATE CHANGE
NORTH EASTERN REGIONAL OFFICE
LAW-U-SIB, LUMBATNGEN,SHILLONG-793021
Tel. 0364-2537395; Fax. 0364-2536041
E-mail: moefro.shillong@gov.in, vp.upadhyay@nic.in

File No.RO-NE/E/IA/SK/HEP/60/ 820-21 Dated 15.06.2017

Monitoring Report on status of compliance of environment clearance and environmental management

1.	Name of the Project	:	TEESTA STAGE-III(1200 MW) HEP,North Sikkim.
2.	No. & Date of EC	:	J-12011/26/2006-IA. DATE 4th August,2006
3.	Address of Correspondence	:	Mr.G.Ramakrishnan(Head of the Project) Near Community Centre, Development Area ,Gangtok East- District, Sikkim-737101.
5.	Date of Monitoring	:	10.06.2017

STATUS OF COMPLIANCE :

The Teesta Hydro Electric Stage –III Project of 1200 MW has been completed and official commissioning date was informed as Feb-March,2017. The project has a 60 mtr height of rock fill dam at confluence of river Lachen and Lachung near village Chungthang.The Power House is underground and is 800 mtr up stream of confluence of river Teesta and Talung- chu near village Sanklan in North Sikkim District. The status of compliance is as follows:

SPECIFIC CONDITIONS

STIPULATION I

Catchment area treatment for an area of 1953.3 ha is to be carried out as per MoEF stipulations.

STATUS OF COMPLIANCE

The project has deposited Rs.1002,70,000 with the State Forest Department.CAT plan is being implemented by State Forest Department through different forest divisions and regular follow up is being done by the project authorities to review the status of implementation of CAT Plan.

STIPULATION II

Considering the Landslide prone area tunneling should be done with great care.

STATUS OF COMPLIANCE

All the construction activities are over and it was stated that the tunneling was completed with the help of control blasting and pre-splitting method.

STIPULATION III

Clearance from National Committee of Seismic design Parameter of CWC shall be obtained.

STATUS OF COMPLIANCE

It was stated that the Seismic Design Parameters for Teesta-III HEP has been approved by NCSDP in its XIXth meeting held on 11th April 2008 at CWC, New Delhi. The area falls in Seismic Zone IV and site specific study was carried out by IIT Roorkie.

STIPULATION IV

156 family shall be rehabilitated as per NPRR-2003.

STATUS OF COMPLIANCE

The number of families under R & R Scheme has increased from 156 to 265. There was no homestead displacement. The project deposited Rs.174648404 as part of R & R and local area development plan with State Government. Sikkim Government constituted a monitoring committee for re-settlement and rehabilitation to oversee the implementation as supervisory body under the chairmanship of Commissioner land revenue and disaster management and implementation body under chairmanship of District Collector North Sikkim. It was stated that the administrator R & R committee has disbursed the PAF grant and Tribal grant to the 265 project affected families.

STIPULATION V

Monitoring committee shall be constituted which must include representative from affected person from SC/ST category and a women beneficiary.

STATUS OF COMPLIANCE

As stated above,R & R committee has been constituted for the proper monitoring and implementation of R & R plan vide notification no. 48/301/II/LR&DMD(S) dated 22nd July 2008. The R & R included 100 % project affected families from ST category only.

STIPULATION VI

All the assurance/commitment must be honored in letter and spirit.

STATUS OF COMPLIANCE

It was stated that the condition was complied.**The public hearing commitment and implementation report should be submitted to the Regional Office.**

STIPULATION VII

Wildlife conservation plan as per page 10-1 to 10-13 in EMP shall be followed

STATUS OF COMPLIANCE

The project deposited a sum of Rs. 1.147 Crore as part of EMP, Rs. 5.25 Lakh as part of Forest Clearance (CAMPA Fund) for implementation of Wildlife Conservation Plan. Kanchenzonga National Park (KNP) Division.The components included implementing the

plan by establishing Check post, footpath construction, constructing water holes, planting fruit bearing tree as a part of habitat improvement, etc.

STIPULATION VIII

Forest Clearance shall be obtained for acquiring 80.288 Hectare forest land and submitted.

STATUS OF COMPLIANCE

The MoEF & CC accorded Forest Clearance vide letter F.No.8- 142/2006-FC dated 2nd November 2007 for diversion of 83.0405 ha forestland for project activities which included 25.4190 ha submergence area. In addition to forest land, the project had acquired 7.7699 ha revenue land and 123.0757 ha private land for the project purpose.

STIPULATION IX

Fish Management Plan in consultation with Fisheries department. GOS shall be submitted within 3 month from date of issue of this letter.

STATUS OF COMPLIANCE

This condition has been complied. The Fish Management Plan included the construction of Trout Hatchery cum rearing farm at Rabum in North Sikkim with an estimated cost of Rs. 1,13,47,346/- only including recurring cost of Rs. 20 Lakhs for operation and maintenance for four years. Total financial disbursement to State Fisheries Department of Rs 93,47,346 has been made. It was also informed that O&M cost of Rs. 10 Lakh also has also been disbursed additionally for first two years. The hatchery is functional in the area.

STIPULATION X

Minimum 3 cumecs water shall be released during lean season.

STATUS OF COMPLIANCE

It was stated that the above condition will be complied with.**The project should continuously collect the data at required interval for the downstream discharge to ensure that the above condition is fully complied.**

STIPULATION XI

Any other clearance from other organization shall be obtained if required

STATUS OF COMPLIANCE

It was stated that the condition is being complied.

PART-B (GENERAL CONDITIONS)

STIPULATION I

Adequate free fuel arrangement should be made for the labour force engaged in the construction work at project cost so that indiscriminate felling of trees is prevented.

STIPULATION II

Fuel depot may be opened at the site to provide the fuel (kerosene/wood/LPG). Medical facilities as well as recreational facilities should also be provided to the labourers.

&

STIPULATION III

All the labourers to be engaged for construction works should also be thoroughly examined by health personnel and adequately treated before issuing them work permit.

STATUS OF COMPLIANCE

The project has been commissioned. It was stated that construction workers were provided with LPG connection for community kitchen. In addition, Diesel bhatties were also provided in community kitchens. The project is operating 7 dispensaries with bed facilities at various project sites to provide medical support to labourers and other project staff. It was also informed that initial complete health screening is being done by company's doctors before deployment of workers occupational health monitoring is also being ensured.

During visit, it was observed that a few labour camps on either side of the river bed downstream of the dam are still existing. These are the areas which have been filled up by dumping solid waste and then constructing labour camps and workshops over these sites. As the construction work is over, these sites can be reclaimed by suitably raising plantation of local native species to make these areas aesthetically attractive with near natural landscape.

STIPULATION IV

Restoration of construction area including dumping area with levelling, filling up of burrow pits, landscaping etc. area should be properly treated with suitable plantation.

STATUS OF COMPLIANCE

The project has utilized its significant quantity of solid waste during construction activities for constructing rock fill dam and also in underground tunnels. The muck generated during power house construction was dumped in 10 ha area which has been successfully restored. **The project needs to fully restore the 4 ha dump area used for dumping solid waste from adit –III. This site has been stabilized for which eco-restoration should be done.**

STIPULATION V

Financial measure shall be made in the total budget for safeguard measures.

STATUS OF COMPLIANCE

A total of 208,52,62,780 has been spent by the project of which Rs.12287316 was deposited with Forest department towards forest Protection,Rs.5700000 towards Bio-diversity conservation,Rs.11995000 towards Wildlife Habitat Management.

STIPULATION VI

A monitoring committee for R&R should be constituted which must include representatives of project-affected persons from a women beneficiary.

STATUS OF COMPLIANCE

As stated above, in the report, R & R committee was constituted vide notification no. 48/30 I/II/LR&DMD (S) dated 22nd July 2008 by Land Revenue & Disaster Management Department, Government of Sikkim. The committee included Mrs. Rizangmu Lepcha (PAP) as women beneficiary member of the committee.

STIPULATION VII

A multidisciplinary committee should be constituted with representatives from various disciplines of forestry, ecology, wildlife, soil conservation, NGO etc. to oversee the effective implementation of the suggested safeguard measures.

STATUS OF COMPLIANCE

The Ministry of Environment Forest & Climate Change constituted a Multidisciplinary Monitoring Committee (MDC) with Dr. P G Sastry, Ex-Chairman of EAC along with members from disciplines like Forestry, Wildlife, Pollution Control, District Authorities and NGO.The committee had visited the site in Sep,2016 and as per the observation, compliance of conditions was found satisfactory.

STIPULATION VIII

Six monthly monitoring reports should be submitted to the Ministry and its regional Office, Shillong for review.

STATUS OF COMPLIANCE

The project has been submitting Six monthly reports to the Ministry along with a copy to the Regional Office.

STIPULATION IX

Officials from Regional Office MoEF, Shillong who would be monitoring the implementation of environmental safeguards should be given full cooperation, facilities and documents/ data by the project proponents during their inspection.

STATUS OF COMPLIANCE

The condition is being complied.

Comment:

1. **The project should continuously collect the data at required intervals for the downstream discharge to ensure that the minimum discharge condition of 3 cumecs is fully complied.**

2. A few labour camps on either side of the river bed downstream of the dam still exist. These are the areas which have been filled up by dumping solid waste and then constructing labour camps and workshops over these sites. As the construction work is over, these sites can be reclaimed by suitably raising plantation of local native species to make these areas aesthetically attractive with near natural landscape.

3. The project needs to fully restore the 4 ha dump area used for dumping solid waste from Adit –III. This site has been stabilized for which eco-restoration should be done.

4. The public hearing commitment and implementation report should be submitted to the Regional Office.

(Dr.V.P.Upadhyay)
Scientist 'G'

L-11011/01/2024-IA-I(RV) ANNEXURE-8

I/62160/2024

F. No.L-11011/01/2024-IA-I (RV)
Ministry of Environment, Forest & Climate Change
Government of India
(Impact Assessment Division)

2nd Floor, Vayu Wing,
Indira Paryavaran Bhawan,
Jor Bagh Road,
New Delhi-110003
Tele: 011-20819283
E-mail: saurabh.upadhyay@gov.in

Date: 8th January, 2024

To

Deputy Director General of Forests (C),
Ministry of Env., Forest and Climate Change,
Regional Office (EZ), A/3, Chandersekharpur,
Bhubaneswar-751023 (Odisha)
Email- roez.bsr-mef@nic.in

Sub: OA No. 171 of 2023 titled as Re.: News Item appeared in East Mojo On 05.10.2023 titled "Sikkim: Here's why the Chungthang Hydro-dam breach is a BIG DEAL" before the Hon'ble National Green Tribunal, Kolkata - reg.

Sir,

This is with reference to the above mentioned subject matter which has been registered as Original Application in suo-motu exercise of power on the basis of the newspaper item published in "East Mozo" dated 05.10.2023 titled "**Sikkim: Here's why the Chungthang Hydro-dam breach is a BIG DEAL".**

2. As per the said newspaper report, the glacial lake out-burst of South Lhonak Lake in North Sikkim, had caused flood in Teesta River leading to several death and destruction. In this incident, about 5.08 million cubic meters of water was released from hydro reservoir affecting mountains and communities. As per the reports, major flooding in Chungthang caused significant damage to public properties and structures on river bed. There was a breach of stringent safety measures and there is a potential risk associated with some of the large-scale infrastructure projects, which require robust disaster preparedness.

3. M/s Teesta Urja Limited had submitted the proposal named Teesta Hydroelectric Project (1200 MW), which envisages construction of a concrete face rock fill dam of 60m height across Teesta river at about 400m downstream of confluence of river Lachen chu and Lachung chu near village Chungthang to create a gross storage of5.08 Mm 3 at full reservoir level of 1585m. The MoEF&CC accorded the Environmental Clearance to the project on 04.08.2006, subject to implementation of certain conditions.

4. In light of the above, you are requested-

- To conduct a Site Inspection in order to verify the compliance status of the conditions stipulated in the EC letter granted to the said project and submit a factual status report to the MoEF&CC forthwith.
- Provide the latest Multi-disciplinary committee report to examine the effective implementation of the suggested safeguard measures

L-11011/01/2024-IA-I(RV)

I/62160/2024

- Provide the compliance/implementation status of the Environment Management Plan and Disaster Management Plan, especially w.r.t dam safety measures, disaster management and risk assessment.

5. Further, related documents along with the latest order dated 28.11.2023 of the Hon'ble Tribunal is enclosed for reference. Considering the urgency involved due to the directions of the Hon'ble Tribunal to submit a response in a time bound manner therefore, you are requested to provide the aforesaid latest by **30.01.2024**.

6. This issues with the approval of the competent authority.

Dr Saurabh Upadhyay
Scientist (

Encl. as above

Copy to:

1. Head of the office, Ministry of Env., Forest and Climate Change, Regional Office, Kolkata IB – 198, Sector-III, Salt Lake City, Kolkata - 700106
2. Director, Compliance and Monitoring Division, Vayu Wing, Indira Paryawaran Bhawan, MoEF&CC, New Delhi/ AD(MKS)/ Guard file

Signed by
Saurabh Upadhyay
Date: 08-01-2024 17:54:31

भारत सरकार/Government of India
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय
Ministry of Environment, Forest & Climate Change
क्षेत्रीय कार्यालय, भुवनेश्वर/ Regional Office, Bhubaneswar
उप-कार्यालय, कोलकाता/ Sub-Office, Kolkata
IB-198, Sector – III, Salt Lake City, Kolkata-700106
Phone: 033-2335-0902, E-mail: iro.kolkata-mefcc@gov.in

सत्यमेव जयते

File No: RO-NE/E/IA/SK/HEP/60/38 Date: 09.02.2024

To,

Dr. Saurabh Upadhyay,
Scientist "C",
Monitoring Cell, Impact Assessment Division,
Ministry of Environment, Forest and Climate Change,
Indira Paryavaran Bhawan,
Jorbagh Road, Aliganj,
New Delhi - 110003.
(E mail: saurabh.upadhyay@gov.in)

Sub: OA no. 171 of 2023 titled as Re.: News Item appeared in East Mojo on 05.10.2023 titled "Sikkim: Here's why the Chungthang Hydro-dam breach is a BIG DEAL" before the Hon'ble National Green Tribunal, Kolkata-reg

Ref: 1. Ministry's letter no. L-11011/01/2024-IA-I(RV) dated 08.01.2024,
2. Ministry's EC letter no. J-12011/26/2006-IA-I dated 04.08.2006.

Sir,

I am directed to draw your kind attention to the subject and reference letter cited above and to state that the site inspection of the project (M/s. Teesta Urja Limited) was conducted by Dr. Shahida P. Quazi, Scientist 'E', Sub-office Kolkata, Regional Office Bhubaneswar on 16.01.2024 and 17.01.2024.

The Factual report (Annexure A), Certified Compliance Report (Annexure B), Observations & Recommendations of Multidisciplinary Committee (MDC) of MoEF&CC (Annexure C), Compliance Status of Environmental Monitoring Programme during Project Operation Phase (Annexure D) and Compliance of Disaster Management Plan (Annexure E) is enclosed here with for your kind information and further needful action.

This is issued with the approval of the competent authority.

Yours faithfully,

Enclosure: As above

S. Shahida Parvin

डॉ. शाहिदा पी काज़ी/ Dr. Shahida P. Quazi
वैज्ञानिक-ई / Scientist-E

~~85~~

ANNEXURE-A

Factual Status Report of Teesta Hydroelectric Project (1200 MW)

The site inspection of the project (M/s. Teesta Ujra Limited) was conducted by Dr. Shahida P. Quazi, Scientist 'E', Sub-office Kolkata on 16.01.2024 and 17.01.2024. During inspection, Smt. Kusum Gurung (Joint Director, SPCB, Sikkim), Shri Bijay, (Block Officer, Mangan (T) Range), Shri Pema Lachungpa (Range Officer, Chungthang (T) Range), Shri Samten (Block Officer, Clungthang (T) Range), Shri Ongay Lepcha, (Block Officer, Dzongu (T) Range) were present. Further, Shri Palden Bhutia (DGM, Sikkim Urja Ltd.) and Shri Krishna Kr. Sharma (Manager, Sikkim Urja Ltd.) were also present from the project side. Based on the site inspection and documents submitted, observations made are submitted below:

OBSERVATIONS:

1. Ministry accorded Environmental Clearance to M/s. Teesta Ujra Limited for construction of a concrete face rock fill dam across Teesta River vide letter no. J-12011/26/2006-IA.I dated 04.08.2006.

2. PAs have received renewed Consent to Operate vide letter no. 2329/SPCB dated 20.09.2023 with validity till 31.03.2024.

3. During monitoring on 16.01.2024, it was observed that PAs have engaged workers for clearing the silt/ mud that had deposited in the Power House **(Photos: A1-A7).** Certain portion of the Power house was still inaccessible due to silt deposition. PAs informed that the underground power houses were flooded with water during the flood and on inspection by expert climbers on 26.10.2023, it was observed that silt had deposited in the Mat Access Tunnel & Cable Access Tunnel (3-4 ft), about 2-3 ft in machine hall and MIV floor was seen with silt laden water.

4. The Tail Race Tunnel could not be monitored due to inaccessible conditions. The undersigned along with other Officials were able to visit the river bed only. PAs informed that that the Tail Race Tunnel was full of silt laden water and the outlet mouth of TRT is buried under the river bed (10m blow the river bed) **(Photos: A8-A10)**

5. For the Dam site, it was observed that the Dam has been washed away **(Photos: A11 to A-19).** The colony has also been washed away.

Q. Shahida Parvin

(डॉ. शाहिदा परवीन काज़ी / Dr. Shahida Parvin Quazi)
वैज्ञानिक-ई / Scientist-E

Power House Site of Teesta Hydroelectric Project Stage-III (1200 MW) by M/s. Teesta Urja Limited on 16.01.2024.

1

2

3

4

5

6

7

Tail Race Tunnel Site of Teesta Hydroelectric Project Stage-III by M/s. Teesta Urja Limited on 16.01.2024.

8

9

10

Dam Site of Teesta Hydroelectric Project Stage-III (1200 MW) by M/s. Teesta Urja Limited on 17.01.2024

11

12

13

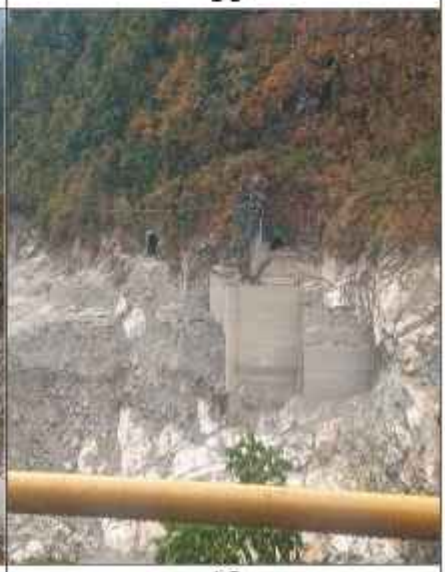
14

15

16

17

18



19

ANNEXURE-B

सत्यमेव जयते

भारत सरकार/Government of India
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय
Ministry of Environment, Forest & Climate Change
क्षेत्रीय कार्यालय, भुवनेश्वर/ Regional Office, Bhubaneswar
उप-कार्यालय, कोलकाता/ Sub-Office, Kolkata
IB-198, Sector – III, Salt Lake City, Kolkata-700106
Phone: 033-2335-0902, E-mail: iro.kolkata-mefcc@gov.in

LiFE Lifestyle for Environment

प्रमाणित अनुपालन रिपोर्ट/ Certified Compliance Report

SN	Item	Details
1.	परियोजना का प्रकार **Type of Project**	Hydroelectric Project (HEP)
2.	परियोजना का नाम **Name of Project**	Environmental Clearance for the Teesta Hydroelectric Project Stage-III (1200 MW) in North District, Sikkim by M/s. Teesta Urja Limited-reg.
3.	परियोजना प्राधिकरण का पता **Address of project authorities**	M/s. Teesta Urja Limited, 119, Jor Bagh, New Delhi- 110003. (e-mail: kks@sikkimurjalimited.in , pb@sikkimurjalimited.in , snsd@sikkimurjalimited.in)
4.	पर्यावरणीय स्वीकृति पत्र सं0 तथा तिथि **Env. Clearance Letter No. & Date**	J-12011/26/2006-IA.I dated 04.08.2006
5.	क्षेत्रीय कार्यालय संचिका सं0 **Regional Office File No.**	RO-NE/E/IA/SK/HEP/60
6.	स्थल दौरा तिथि **Date of Site Visit**	16.01.2024 and 17.01.2024
7.	परियोजना की स्थिति **Status of Project**	Non Operational
8.	उपलब्ध कर्मचारी **Persons available**	1. Smt. Kusum Gurung, J.D. SPCB 2. Shri Bijay, Block Officer, Mangan (T) Range 3. Shri Pema Lachungpa, Range Officer, Chungthang (T) Range 4. Shri Samten, Block Officer, Clungthang (T) Range 5. Shri OngayLepcha, Block Officer, Dzongu (T) Range 6. Shri Palden Bhutia, DGM, Sikkim Urja Ltd. 7. Shri Krishna Kr. Sharma, Manager, Sikkim Urja Ltd.
9.	निगरानी अधिकारी **Monitoring Officer**	Dr. Shahida Parvin Quazi, Scientist- E

10. परियोजना की वर्तमान स्थिति/ Present status of the Project:

Ministry accorded Environmental Clearance to M/s. Teesta Ujra Limited for construction of a concrete face rock fill dam across Teesta River vide letter no. J-12011/26/2006-IA.I dated 04.08.2006. PAs informed that the project was commissioned on February 2017. PAs have received renewed Consent to Operate vide letter no. 2329/SPCB dated 20.09.2023 with validity till 31.03.2024.

During monitoring on 16.01.2024, it was observed that PAs have engaged workers for clearing the silt/ mud that had deposited in the Power House. Certain portion of the Power house was still inaccessible due to silt deposition. PAs informed that the underground power houses were flooded with water during the flood and on inspection by expert climbers on 26.10.2023, it was observed that silt had deposited in the Mat Access Tunnel & Cable Access Tunnel (3-4 ft), about 2-3 ft in machine hall and MIV floor was seen with silt laden water. PAs informed that the Tail Race Tunnel was full of silt laden water and the outlet mouth of TRT is buried under the river bed (10m blow the river bed). For the Dam site, it was observed that the Dam has been washed away. The colony has also been washed away. The project is non operational at present.

Dr. Shahida Parvin

11. अनुबंधित स्थितियाँ/ **Stipulated Conditions:**

J-12011/26/2006-IA.I dated 04.08.2006:

PART A: SPECIFIC CONDITIONS:

i. **1953.3 ha. degraded catchment area needs to be treated. The Catchment Area Treatment Plan as has been proposed should be completed in four years. The plan is reproduced below:**

Treatment Measures	Units	Year-I	Year-II	Year-III	Year-IV
Afforestation	ha.	263	263	113	113
Plantation (Medicinal/ bamboo)	ha.	145	145	63	63
Pasture Development	ha.	188	188	81	81
Social Forestry	ha.	14	14	6	6
Fuel wood and fodder grass	ha.	56	56	24	24
Nursery development	No.	4	4	2	-
Barbed wire fencing	Km	3	3	2	2
Step drain/ catch water drains	m	175	175	75	75
1:2:4 Stone masonry	m^3	25	25	13	12
Contour bunding	ha.	17	17	8	7

Status: PAs have informed that the CAT plan has been executed by State Forest Department for which a sum of Rs. 10.027 Crores has already been submitted by PAs and around 95% of the work has been completed so far with the provided fund from CAMPA. ***PAs need to submit the certificate for utilization of funds deposited under CAT plan.***

ii. **Considering the landslide prone areas, the tunneling should be done with great care under close supervision.**

Status: The project was commissioned on February 2017. PAs have informed that the tunneling had been executed with the help of controlled blasting and pre-splitting method.

iii. **Clearance from National Committee of Seismic Design Parameters (NCSDP) of CWC should be obtained.**

Status: PAs have informed that they have obtained the clearance from National Committee of Seismic Design Parameters (NCSDP) in its XIX meeting held on 11.04.2008 at CWC, New Delhi. On perusing the minutes of the XIX meeting of the National Committee on Seismic Design Parameters (NCSDP), it is observed that "the site specific study of the project was accordingly accorded conditional approval by the Committee. After the document as suggested by the Committee is received, the project would be put up to the Chairman of the NCSDP for formal clearance". PAs have submitted a copy of letter from Central Water Commission dated 1.10.2014, wherein it is stated that "in 27th meeting of NCSDP held on 23rd June 2014 the Member Secretary apprised the Committee that in compliance to the decision of the 22nd meeting of NCSDP held on 24th September 2010, the Teesta (stage III) H E project authorities have submitted the report on dynamic analysis of the Teesta (Stage III) dam. The committee noted the compliance by Teesta (Stage III), H E Project authorities".

iv. **Total 156 families from nine villages will be affected due to acquisition of land & affected families should be rehabilitated as per NPRR-2023.**

Status: Being complied. PAs have informed that the administrator R&R committee has disbursed the PAF grant and Tribal grant to total 265 project affected families as per NPRR, 2003.

B. Shahida Parveen

v. **A monitoring committee should be constituted which must include representatives of project affected persons from SC/ ST category and a women beneficiary.**

Status: Being complied. PAs have informed that the R&R committee has been constituted for the proper monitoring and implementation of R&R plan vide notification no. 48/301/II/LR&DMD(S) dated 22.06.2008. PAs have also submitted the copy of the constituted committee vide notification no. 48/301/II/LR&DMD(S) dated 22.06.2008.

vi. **All the assurances/ commitments given by the project authority in the Public Hearing must be honoured in letter and spirit.**

Status: Partially complied. ***PAs have not provided detailed compliance status with respect to the all the assurances/ commitments given by the project authority in the public Hearing.***

vii. **The Khangchendzonzga National Park is one km away from the project site. The Wildlife Conservation Plan proposed for protection of Wildlife in protected area on page 10-1 to 10-13 of EMP, should be followed in toto.**

Status: PAs have informed a sum of Rs. 5,25,000/- has been deposited for CA in forest land under Wildlife Habitat Management. An additional sum of Rs. 1,14,70,000.00/- has also been deposited to State Forest Department for implementation of Wildlife Conservation Plan. It has been stated that the plan is being implemented by State Forest Department.

viii. **Forest Clearance should be obtained for acquiring 80.288 hectare forest land & submitted.**

Status: Complied. The Ministry of Environment, Forest and Climate Change accorded Forest Clearance vide letter no. 8-142/2006-FC dated 2nd November, 2007.

ix. **The implementation of Fish Management Plan including provision of fish ladder should be carried out in consultation with the Fisheries Department, State Government of Sikkim and submitted to MOEF within three months from date of issue of this letter.**

Status: PAs in their six monthly compliance report had informed that "the Fisheries Department had proposed to construct Hatchery cum Fish farm with the total cost of 1.13 Cr and it has been completed and handed over". During monitoring the hatchery cum farm unit located along the river stretch of Teesta along Lachen-Chungthang Highway could not be inspected due to unapproachable road condition as informed by the State Forest Officer. A report has been submitted by the Directorate of Fisheries, Govt. of Sikkim **(Annexure B1)** through the Project Authorities. As per the report "a catastrophic disaster due to Glacial Lake Outburst of South Lhonak Lake on the early hours of 4th October 2023 resulted in numerous casualties and damages in Mangan District along the River basin of Teesta River" and "there has been a severe damage to hatchery cum farm unit located along the river stretch of Teesta along Lachen-Chungthang Highway". The report further states that "The entire raceway tank has been completely washed away. 20 no's of Brown Trout Brooders, 50 nos. of Rainbow Trout Brooders, 127 nos. of yearling, 10,200 nos. of advance Fingerling stocked in the farm has also been washed away. The water connectivity has also been damaged. The Hatchery unit cum quarter has also been damaged but it is repairable. 200 kgs of Trout Feed (1.8mm-2 bags, 3mm-2 bags, 6mm-3 bags) stocked in the farm has also been damaged".

x. **During the lean season minimum 3 cumecs water should be released downstream of the dam for sustenance of aquatic life.**

Status: Agreed with. It has been informed that E-flow discharge arrangement has been incorporated in the Dam body and as per the NGT order, 15% of the lean season charge is being released which is about 5.2 cumecs.

S. Shahida Parvin

xi. **Any other clearance from any other organization if required should be obtained.**

Status: Agreed with.

PART B: GENERAL CONDITIONS:

i. **Adequate free fuel arrangement should be made for the labour force engaged in the construction work at project cost so that indiscriminate felling of trees is prevented.**

Status: Not applicable at present. The project was commissioned on February 2017.

ii. **Fuel depot may be opened at the site to provide the fuel (kerosene/wood/LPG). Medical facilities as well as recreational facilities should also be provided to the labourers.**

Status: Not applicable at present. The project was commissioned on February 2017.

iii. **All the labourers to be engaged for construction works should be thoroughly examined by health personnel and adequately treated before issuing them work permit.**

Status: Not applicable at present. The project was commissioned on February 2017

iv. **Restoration of construction area including dumping site of excavated materials should be ensured by leveling, filling up of burrow pits, landscaping etc. The area should be properly treated with suitable plantation.**

Status: Being complied. PAs informed that restoration & landscaping activities were taken up at sites right from the commencement of the project construction. During monitoring, it was observed that the dumping sites have been restored.

v. **Financial provision should be made in the total budget of the project for implementation of the above suggested safeguard measures.**

Status: Being complied. PAs have submitted the expenditure incurred for the implementation of EMP up to 30th September 2023 as a part of six monthly compliance report.

vi. **A Monitoring Committee for R & R should be constituted which must include representatives of project-affected persons from a woman beneficiary.**

Status: Being complied. PAs have informed that the R&R committee has been constituted for the proper monitoring and implementation of R&R plan vide notification no. 48/301/II/LR&DMD(S) dated 22.06.2008 Land Revenue & Disaster Management Department, Government of Sikkim. It has been stated the Mrs. Rizangmu Lepcha (PAP) is elected as women beneficiary member of the committee. PAs have also submitted the copy of the constituted committee vide notification no. 48/301/II/LR&DMD(S) dated 22.06.2008.

vii. **A Multidisciplinary committee should be constituted with representatives from various disciplines of forestry, ecology, wildlife, soil conservation, NGO etc. to oversee the effective implementation of the suggested safeguard measures.**

Status: Being complied. It has been informed that Multidisciplinary Monitoring Committee comprising Ex-Chairman of EAC Dr. P G Sastry, along with other members from FRI, WII, State Forest Department, SPCB, etc. has been constituted by the MoEFCC, New Delhi and periodic monitoring of the project are being carried out. The MDC visited the project sites during September, 2016 and as per the observation compliance of conditions was found satisfactory.

Q. Shahida Parveen

viii. **Six monthly monitoring reports should be submitted to the Ministry and its Regional Office, Shillong for review.**

Status: Being complied. From available records, it is observed that PAs are regular in submitting six monthly compliance report.

12. पर्यवेक्षण / Observations:

J-12011/26/2006-IA.I dated 04.08.2006:

1. *PAs need to submit the certificate for utilization of funds deposited under CAT plan.* **(Specific Condition i)**

2. *PAs have not provided detailed compliance status with respect to the all the assurances/ commitments given by the project authority in the public Hearing.* **(Specific Condition vi)**

13. अनुशंसा / Recommendations:

This project can be put up in the following tick-marked category of compliance status.

- Compliance status could not be judged as the project was shut down / not in operational during the site visit.
- No non-compliances detected. No further action is required.
- ✓ ***Non-compliances detected. Letter issued to project authorities for taking corrective measures.***
- Serious non-compliances detected. Recommended to issue a Show-Cause Notice to Project Authorities.

S. Shahida Parvin

(डॉ. शाहिदा परवीन काज़ी / Dr. Shahida Parvin Quazi)
वैज्ञानिक-ई / Scientist-E

~~94~~

ANNEXURE- B1

Report on Damages to Trout Farm cum Hatchery Unit, Rabum , Lachen caused by Flash Flood on 4th October 2023

A catastrophic disaster due to Flash flood in the early hours of 4th October 2023 resulted in numerous casualties and damages in Mangan District along the River basin of Teesta River.

The damage done by the Lake outburst on the outskirt of Lachen could not be received on time due to lack of connectivity of roads and mobile network.

The information as received today i.e. 9th October 2023 by the district officials of Directorate of Fisheries, Mangan is that there has been a severe damage to hatchery cum farm unit located along the river stretch of Teesta along Lachen- Chungthang Highway.

The report of damage is as follows:

1. ***Trout farm cum hatchery unit , Rabum***

   The 4 nos. of raceway tank and major part of 10 nos. of raceways has been completely washed away. 20 nos of Brown Trout Brooders, 50 nos. of Rainbow Trout Brooders, 127 nos. of yearling, 10,200 nos. of advance Fingerling stocked in the farm has also been washed away. The water connectivity has also been damaged. The Hatchery unit cum quarter has also been damaged but it is repairable.

   200 kgs of Trout Feed (1.8mm-2 bags, 3mm- 2 bags, 6mm- 3 bags) stocked in the farm has also been damaged.

Weight wise loss of Brooders from Rabum Trout Farm-cum-Hatchery Unit:

Sl. No	Name of the Species	No. of Brooders	Average weight	Loss incurred in Kgs
1	Rainbow Trout	50 nos	1.5 Kg	75 Kgs
2	Brown Trout	20 nos	1.5 Kg	30 Kgs
			Total	**105 Kgs**

Loss of 105 kgs @800/kg = Rs. 84,000/-

Ugen Tseten Bhutia
Assistant Director (Mangan)
Directorate of Fisheries
Govt. of Sikkim

1

Loss of Yearling/Advance fingerlings:

Sl. No	Types	No. of yearling/fingerling	Average weight	Loss incurred in Kgs
1	Yearling	127	0.5	63.5
2	Advance Fingerling	10200	0.05	510
			Total	**573.5 Kgs**

Loss of 573.5Kgs @800/kg= Rs 4,58,800/-

- **Cost of rearing Rainbow Trout Brooder the stock till date:**
  - Cost of fingerling: 150 fingerling@20/fingerling= Rs 3000/-
  - Cost of rearing the lost stock of 1.5 kg average weight including cost of fingerling and feed: 150 nos x 3kg = 450 kg of feed
  - Loss incurred in feed = 450 kg @140/kg= Rs. 63,000/-
- **Rainbow trout yearling**
  - Cost of fingerling=300 fingerling@20/fingerling= Rs 6000/-
  - Feed required to gain avg. weight of 0.5kg = 300x1kg = 300 kg
  - Loss incurred in feed=300 kg @140/kg= Rs. 42,000/-

- **Rainbow trout advance fingerling:**
  - Cost of fingerling =20,000 fingerling@20/fingerling= Rs. 40,000/-
  - Feed required to gain 0.1 kg = 20,000 x 0.1 kg = 2000 kg/-
  - Loss incurred in feed =2000 kg @140/kg = Rs. 2,80,000/-

- **Total Cost of Fingerling=3000+6000+40,000=** Rs. 49,000/-
- **Total cost of loss incurred in feed =Rs.2,80,000+ Rs.42,000+Rs. 63,000=** [redacted]
- **Cost of loss of feed stocked in store =200kgs @140/kg =** Rs. 28,000/-

Total loss incurred = Rs. 10,04,800/-

Ugen Tseten Bhutia
Assistant Director (Mangan)
Directorate of Fisheries
Govt. of Sikkim

~~96~~

Damages sustained due to Flashflood at Rabum Trout Farm cum Hatchery, North Sikkim on 4th October 2023.

Photographs of Trout Farm before Flash Flood	Photographs of Trout Farm after Flash Flood

Ugen Tseten Bhutia
Assistant Director (Mangan)
Directorate of Fisheries
Govt. of Sikkim

Ugen Tseten Bhutia
Assistant Director (Mangan)
Directorate of Fisheries
Govt. of Sikkim

ANNEXURE-C

Observations and Recommendations of the Multidisciplinary Committee (MDC) of Ministry of Environment & Forests (MoEF)

for

1200 MW Teesta-III HEP, North Sikkim

The MDC meeting of 1200 MW Teesta-III HEP was held on 24th Sep & 25th Sep 2016 at the project site. On the first day, project developer appraised the committee members with a power point presentation on overall implementation status of various stipulations of EMP and Environmental Clearance. On 25th Sep 2016, committee visited Dam site and inspected various works around dam including Reservoir Rim treatment work. The committee also visited the site of Fish Farm, developed under Fish management plan at Rabum, North Sikkim. The committee also inspected the works being carried out by State Forest Department for components such as CAT, CA, Wildlife Management Plan, etc. In order to evaluate the progress made by the project proponent towards muck management, solid waste management and restoration & landscaping, various muck dumping areas at Adit-II, Power house site were also visited. In the evening, the committee members deliberated the progress made by the project proponent and other State Departments to implement the measures adopted for overall Environment Management of the project.

The elaborate status of various stipulations made by MoEF and the compliance activities being carried out by the project are detailed below:

SL. NO.	Activity	MoEF Stipulations	Action taken by Project Proponent	Remarks of the Committee
A)Management in Road Construction & Roadside Plantation				
1.	Road Construction	- The balanced cut and filled method should be adopted - The cut slopes should be protected by breast walls, catch water drains, etc. - Controlled blasting techniques should be adopted to avoid over-shattering of hill faces - The artificial drains should be linked	Roads have been constructed using cut and fill method. Road side protection measures like Plum concrete walls and Crate walls towards the valley side and similarly RRM walls, plum concrete walls, dry walls towards the hillside have been constructed.	The committee observed that the road construction works were found to be satisfactorily completed. All the stipulated measures were adopted by the project proponent. Protection of cut slopes, linking of artificial drainage to natural drainage

		to existing natural drainage system	Wherever, the huge boulders were encountered, controlled blasting techniques were applied. Drainage facility has been provided all along the project roads for safe disposal of rain water.	system is adopted. The blasting pattern adopted by the project indicate that unwanted shattering in the rock out crops is not there.
2.	Roadside Plantation	- During road construction, tree felling should be bare minimum - Depending on the availability of land and other resources, afforestation of the roadside land should be carried out	Roadside plantation was done extensively using various local species in order to propagate poly cultural diversity of plants. Necessary pasture development & soil moisture conservation measures are being taken up at various project components and its access roads. Degraded patches all along the project roads have been treated by Biological Measures i.e. seed dribbling and plantation etc.	The plantation done over the slopes and protection measures carried out were found adequate. The plantation carried out alongside the roads and on the slopes stands merged with the forest. The natural regeneration and plantation of slopes resulted in thick forest canopy.
B)Control of Pollution from Labour Camps				
1.	Measures as proposed in EMP	- Facilities of labour camps & sheds. - Provisions of community kitchen and free fuel. - Provision of drinking water supply - Sanitation facilities. - Solid waste management from labour camps.	Adequate numbers of semi-permanent structures at various project sites have been constructed for the workmen for residential purpose with the provisions of internal compartments, proper ventilations, light illumination, etc. Community kitchens had been established for the workmen engaged in the construction with the	The committee inspected the labour camps and found that all measures adopted for control of pollutions are sufficient. Overall solid waste management and hygiene maintenance is proper. The provision of

			provisions of free fuel arrangement. Adequate provision of LPG connections had been provided all over the project and in addition, diesel bhatties had also been provided to run the community kitchens. At each labour colony, RO plants were established to provide clean drinking water to the workmen and in addition, geyser tanks were also established at each colony to provide warm water during winter season. About 40 nos. of community toilets were made available with proper septic tanks for the workmen. The Solid Waste Collection vats were constructed and Dustbins were also placed at all project sites to collect waste materials from labour camps. The discharge generated in the community kitchens was disposed off in soak pits.	community kitchens provided to the workers is appreciated.
C)Muck Management & River Protection Plan				
1.	Protection & restoration of Dumping Sites as proposed in EMP	- Engineering measures like wire crate walls, boulder crate wall, RCC & catch water drain - Budgetary provision of Rs. 100.78 Crores kept for Muck management plan. - Restoration by biological measures to	Total 6 nos. of Muck Disposal Sites were identified for disposal of muck. The excavated muck generated from the underground structures was dumped in the respective dumping yards by providing proper retaining structures like crate walls, RRM walls,	The disposal of muck in designated dump yards is satisfactory as the muck is retained effectively by making engineering structures such as crate walls, concrete plugs, retaining walls, etc.

		be adopted like plantation of suitable tree species & soil binding species, plantation of ornamental plants & barbed wire fencing.	concrete plugs, etc. More than 80 % muck generated from all the components of the project was utilised for making aggregate and sand for concreting of various structures. The muck generated at Dam complex had been utilised for placing in CFRD. With the completion of construction works at various sites, the restoration and landscaping of the disposal yards have been carried out by engineering measures like walls, benches and slope maintenance & bio-engineering works like Jute matting, grid beams & plantation. Till date an amount of Rs. 85.85 Crores have been utilised to maintain the muck disposal around the project.	The utilization of tunnel muck for raising CFRD and extraction of sand and aggregate for concreting of the project components from the muck has resolved the problem of muck disposal to a considerable extent and is a noteworthy effort. The restoration & landscaping works in the disposal yards are found satisfactory. The committee noted that the seeding / plantation carried over the muck disposal yards has regenerated and merged with the surrounding forest.
D)Green Belt Development				
1.	Green belt development as proposed in EMP	- Should develop greenbelt around the perimeter of various project appurtenances, selected stretches along the periphery of submergence area, etc. - An area of about 30 ha is proposed to develop under this plan	As a part of Green Belt development, a nursery in bend-9 of Powerhouse road has been raised to cater the need of greenbelt plantation. Up till now more than 15000 saplings of local species have been transplanted on different slopes on the PH road, adit access roads, muck dumping yards, etc. In the periphery of the Reservoir Rim, after completion of engineering works, plantation of	Green belt plantation along the roads and slopes was found extensive and forest cover developed adequately.

			suitable species will be carried out.	
E)Biodiversity Conservation Plan & Wildlife Management Plan				
1.	Biodiversity Conservation Plan & Wildlife Management Plan as per EMP	- Conservation of threatened species in and around the reservoir area at a cost of 50 Lakhs as a part of biodiversity conservation plan. - As a part of Wildlife management plan, various conservation measures are to be adopted like recovery & improvement of wildlife habitat, translocation of displaced wildlife to the KNP, infrastructure development, special conservation of habitat vulnerable species, patrolling & surveillance, anti-poaching and hunting operational measures, eco-development & community participation, awareness, education & sensitization of fringe population, etc.	An amount of Rs.57.00 Lakh has been deposited with State Forest Department towards the conservation of *Hedychium spicatum* (medicinal plant) and *Cyathea spinulosa* species. The Forest Department has developed a nursery over an area of 6.3 Ha in the upstream of the reservoir along River Lachung. Rs. 119.90 lakhs towards execution of Wildlife Management Plan as per the stipulated conditions of EMP and Forest Clearance had been deposited in CAMPA fund. KNP division of State Forest Department have created inspection paths, check post, watch & ward towers, pot holes & some fencing works in various parts of the KNP. Plantation with regard to habitat improvement of wildlife in KNP area has been done. None of the cases pertaining to translocation of displaced wildlife has been found. An amount of Rs. 72.75 Lakhs against Rs. 176 Lakhs for Biodiversity Conservation and Wildlife Conservation measures has so far been utilized.	The works related to Biodiversity conservation and wildlife management plan were found to be progressing well. The MDC recommends early release of fund deposited with CAMPA because the project is being commissioned now. The balance of funds amounting to Rs. 99.25 Lakhs requires to be released from the CAMPA funds to complete the activity of Biodiversity and Wildlife Conservation at the earliest.

~~103~~

F)Fish Management Plan				
1.	Fish Management Plan as per EMP & EC stipulations	- Release of minimum flow - Implementation of supplementary stocking programme by developing hatcheries through State Fisheries Department, Government of Sikkim with a budget allocated of Rs. 65 Lakhs. - An amount of Rs. 10 Lakhs has kept for the provision of Fish Ladder.	An arrangement to release of minimum flow has been made during the designing of Dam structure. A structure within the Dam body has been created to release 3 cumec (as per EC stipulation) of water throughout the year. The Fish Management Plan as proposed in the EMP was examined in detail by the State Fisheries Department, subsequently the State Fisheries Department has revised the Fish Management Plan with due consideration to the ground situation and requirements. The revised Fish Management Plan rules out the possibility of fish ladder in view of height of dam (60 m) from technical as well as operational point. State Fisheries Department constructed a Trout Hatchery cum Rearing Farm at Rabum in North Sikkim at a cost of Rs. 1,13,47,346/-, including recurring cost of Rs. 20 Lakhs for operation and maintenance for five years against the approved EMP provision of Rs. 70 lacs. As on date, the hatchery has been commissioned and made operative for rearing fish fingerlings.	The committee visited the Fish Hatchery at village Rabum and found that elaborate arrangements were made for propagation, multiplication and conservation of Rainbow Trout & Brown trout species. The committee observed that the fish growth is very good as some of the fishes have grown upto 2kg in weight. The conservation methods adopted have boosted the breeding, multiplication and conservation. The fingerlings are ready for release in upstream and downstream sections of river Teesta. It is also apt to state that creation of hatchery has definitely facilitated the availability of fingerlings to local inhabitants also to carry out fisheries related activities in their backyard. The effort was appreciated by the committee and is recommended to be continued.

G)Air, Water & Noise Pollution Management				
1.	Monitoring of Air, Water & Noise on regular basis proposed as per EMP	- During the construction phase, regular monitoring of the parameters like air, water, noise, erosion & siltation, meteorological, etc., need to be carried out.	The monitoring is being conducted regularly by a third party lab M/s Envirotech East Pvt. Ltd. A full-fledged Environmental Laboratory has also been established at Chungthang for internal monitoring. State Pollution Control Board (SPCB) Sikkim also conducts monitoring on regular basis. Result suggests that all the parameters are under control as per permissible limits.	The analysis of various parameters over the years indicate that all the parameters are within prescribed limits. The committee recommends to continue the analysis of various parameters in the O&M stage also to monitor the overall impact of pollution indicators.
2.	Mitigating Measures	- To control the emission of fugitive dust especially due to crusher operation, dust suppression system should be adopted. - Regular spraying of water to be carried out to suppress the fugitive emissions from earth movers, vehicular traffic, etc. - To control the water pollution especially water discharge from tunnel, sedimentation tanks of requisite sizes to settle the sediment loads in the water before discharging it to nearby drains or river.	An arrangement to suppress the fugitive emission from crusher operation has been made by incorporating water sprinkling structure in the aggregate classifier of crusher. Project proponent is carrying out green belt development, regular sprinkling of water to control fugitive emission from movement of vehicles, muck disposal and construction activities. Settling tanks have been constructed to remove silt content from the discharged water from the project components.	Fugitive emissions were taken care of by water sprinkling, wet grinding of aggregate and by maintaining adequate dispersion of flu gases from the D.G.Sets.
H) Compensatory Afforestation & CAT Plan				
1.	Compensatory Afforestation	- Compensatory afforestation will be through State Forest Department as per	Rs. 21,540,150/- has been deposited towards the implementation of Compensatory	The CA activity was found completed in the year 2011-12.

	as per EC/Forest Clearance	the stipulations of Forest Clearance	Afforestation (CA) as part of Forest Clearance payments. Rs. 67,05,802/- has been deposited towards the implementation of CA in lieu of disposal of trees and poles from Private land to the State Forest Department. In all Rs. 282.45 Lakhs had been transferred to carry out compensatory afforestation over an area of 137 ha in Mangan, Dzongu & Chungthang Forest ranges. The CA was carried out in 40 ha (Mangan), 67 ha (Chungthang) & 30 ha (Dzongu) in the year 2011-12 at a cost of Rs. 118.39 Lakhs. An amount of Rs. 73.25 Lakhs was incurred on maintenance in above areas till March 2016. The maintenance will continue till the financial year 2016-17.	The committee recommends continuous maintenance till the stipulated period.
2.	CAT Plan for 1953.3 ha as per EMP	- The catchment area lies on the Lachen river catchment & Lachung River catchment needs treatment. - The measures to be adopted for Catchment Area Treatment plan are engineering and biological measures and budget allocated for the same is Rs. 10.027 Crores. - The engineering measures include step drains, barbed wire fencing, stone masonry & check dams. The biological measures include nursery development, afforestation, pasture development &	Rs. 10.027 crore had been deposited in CAMPA funds as part of EMP for the implementation of CAT works over an area of 1953.3 ha by State Forest Department. The implementation of CAT plan envisaged plantation works over an area of 1953.3 ha for activities of afforestation of local species, medicinal plants, bamboo plantation, pasture development, social forestry and fodder grass plantation by developing nurseries. For the purpose provision of watch and ward, fencing and administrative expenses were also	The MDC recommends strongly for the immediate release of the balance funds deposited with CAMPA for CAT works. The MDC further recommend that the remaining works of CAT be completed promptly by State Forest Department.

		social forestry.	provided. In the engineering measure component, provision for catch water drain, stone masonry & contour bunding were provided. As per the statement of State Forest Department (FCA Circle), an amount of Rs. 597.20 lakhs has been released from CAMPA fund for implementation of CAT works under Teesta-III project. Physically CAT works over an area of 1075 ha have so far been carried out. The remaining works over an area 878 ha will be carried in future. The details of CAT works till March 2016 are as follows: 1. Biological measures- - Nursery creation : 6 ha - Artificial regeneration : 200 ha - Aided nat. regeneration : 20 ha - Pasture development : 503 ha - Fodder plantation : 118 ha - Bamboo plantation : 111 ha - Broom plantation : 90 ha - Barbed wire fencing : 17 ha - Watch & ward : 7337 Mandays - Medicinal plantation : 10 ha - Maintenance 2. Engineering measures- - Contour bonding : 2 ha - CRSM wall : 10 Cu. M. - Catch water drain : 445 M - CCM wall : 580 Cu. M. - Crate wall : 501 Cu. M.	

I)Reservoir Rim Treatment Plan				
1.	Reservoir Rim Treatment Plan as per EMP	- Adequate protection measures need to be taken to protect the river banks around the reservoir area. - Biological and bio-engineering measures like crate walls, RCC retaining walls, breast walls, stream bank treatment, nala treatment/works, etc., are required to be adopted.	The work of the Reservoir Rim treatment planning and selection of material was assigned to an expert group called 'M/s Maccaferri Environmental Solutions Private Limited'. The work of Rim treatment around the submergence area have been completed by specialised Meccaferie gabion wall and RCC grid beams with Self Drilling Anchor (SDA). About Rs. 80 Cr being spent on this protective works.	The Reservoir Rim Treatment works are being carried out. The cladding wall in Section-C is to be expeditiously completed.
J) Forest Protection Plan				
1.	Forest Protection Plan as per EMP	- Provision of free fuel - To develop two (2) forest check posts with Range officer & guards. - Provision of adequate communication equipment and other facilities.	In order to prevent illegal felling of trees from the nearby Forest by the labourers, community kitchen facility was provided to all the labours. Free cooking fuels in terms of LPG connections and diesel bhatties were provided to run the community kitchens. Adequate LPG connections were purchased to run the community kitchens. Forest Protection Plan is being implemented by Forest Department at a cost of Rs. 81.46 Lakhs including the cost of checkpost construction, deployment of Range officer & guards, vehicular provisions, etc. Entire	Measures adopted by the Forest department under this plan which includes creation of check posts, creation of surveillance and inspection routes etc. were found satisfactory. The elaborate arrangements for free fuel supply and establishment of community kitchens by the project proponent were noteworthy measures which helped in Forest conservation as they abolished

			amount deposited by TUL as part of Forest &EMP payment. In addition to this, to restrict illegal tree felling and un-authorized movement of Forest produces, three (3) nos. of Check Posts were constructed at Theng village, Chungthang and Mangan which are presently under operation and administrative control of State Forest Department.	the need for firewood.
K)Public Health Delivery System				
	Public Health Delivery System	- Checking & control of areas of vectors related to various diseases, control measures for water-borne diseases. - Adequate vaccination and immunization facilities should be provided for workers at sites. - Developments of medical facilities - Health extension activities & infrastructural development - Regular health check ups.	Eight permanent Doctors were appointed for the project site with 23 nos. of nursing staff to provide medical assistant to labourer and staff working at site. Eight medical units were established at Dam site, Power House site, Shipgyer, Theng, Ramam and Saffoo Villages with onsite ambulance provision to give medical assistance to the site workers as well as the villagers. Complete health screening and periodic health check up of labourers were carried out on regular basis. Medical facility was provided to project employees as well as villagers free of cost.	The Committee expresses that the measures adopted for Public Health Delivery System were adequate and quite encouraging. The medical camps being organised from time to time and Health screening conducted in different villages is a noteworthy effort.

~~109~~

			BBF is regularly carrying out mobile OPDs in the affected villages for the local people. Specialized medical camps are being conducted regularly.	
L) Resettlement &Rehabilitation Plan				
1.	R&R Grants disbursed to Project affected Families (PAFs)	- Acquisition of land would have to be compensated in accordance with the Land Acquisition Act, 1894 and as per the provision of NPRR 2003. - Rehabilitation grant as per NPRR 2003 needs to be provided to Project Affected families. - Administrative arrangement for implementation of R&R measures by constituting R&R committee.	No resettlement was involved in the Project as no household was affected; only partial land holding were acquired from 265 PAFs. The land involved in the project had been acquired from the private land owners in accordance with Land Acquisition Act, 1894. As per the provisions of NPRR 2003, R&R Grants amounting Rs. 1,86,12,500 including PAF grant & tribal grant have been disbursed to PAFs through District Administration. Government of Sikkim vide Gazette Notification dated 22-07-2008 had constituted R&R committee for the implementation and monitoring of R&R plan including LADP.	The issues related to R&R are resolved as per regulations in vogue. The activity as per the stipulations made in the EC found to be completed.
2.	Local Area Development Programme (LADP)	- Vocational trainings should be provided to the PAFs. - Scholarship for students - Employment - Access roads to villages - Upgradation of education facilities - Social development activities	**Training:** A training institute "Teesta Industrial Training & Development Centre (TITDC)" was established at Mangan in the year 2006. The Institute is offering training under different disciplines for the unemployed youths from Project Affected Villages (PAVs) based on their educational qualification. The	The committee observes LADP works are taken up exhaustively. The stipulations made in Environment Clearance are being met with satisfactorily and in some of the areas extra measures are being taken up by

		- Training facilities for development of entrepreneurship to take up self employment - Mobile health vans - Economic opportunities like allotment of shops, petty contract, vehicle hiring, vendor permits, etc.	institute offers training in fields such as Computer system & AutoCAD applications, Electrician, Mechanical fitter, Carpentry, Surveying & Welding. Around 240 students have passed out in 6 batches. During the training, each student was given a scholarship of Rs. 2500/- per month for the entire duration of training period. **Scholarship for students & up-gradation of education facility:** In total 75 children ranging from Class I to Class X from 9 Project Affected Villages have been provided with scholarships. **Ongoing Project in Education:** Knowledge Centres & e-Learning centres have been established to provide quality education beyond classroom. Total 8 knowledge centres & e-Learning centres are operational at Chungthang, Theng, Pegong, Shipgyer, Ramom, Safoo, Singhik & Kazor. **Other Educational Activities in Project Affected Villages (PAVs)-** Singhik village – The construction of a 100 bedded hostels for girls and boys in progress. The hostel will be provided with dining hall, visitor's room, library, kitchen, separate toilets and dressing rooms, laundry space and a space	the project proponent. The efforts made by the project proponent in the fields of Skill Development, Livelihood, Education, Health & Social Infrastructures to the local communities are noteworthy. The help and the relief rendered by the project to the local people during natural disasters and otherwise were praiseworthy. The elaborate arrangements made by the project to provide drinking water, village pathways and road links are the laudable steps taken up for wellbeing of the locals. The LADP works go a long way in the wellbeing of the people and hence need to be continued.

			for a play ground. The hostel would have separate space for boys and girls. Kazor village – The extension of school ground at Government Primary School, Kazor has been completed. Theng village – The reconstruction of primary school is in progress after obtaining NOC from State Government. Chungthang village – The renovation of four storied Girl's Hostel was completed and construction of the school laboratory also completed. Shipgyer village – The construction of hostel for Monastic School has been completed. Safoo-Salim-Pakyel village – The work of extension of school ground is completed and handed over to School Management Committee. **Water & Sanitation Plan:** Drinking Water Supply has been provided in five villages – Pegong, Ramam, Safoo, Singhik & Kazor. In all 415 household were benefited under the scheme. All the water supply schemes in different villages are being managed by Water	

			Management Committees consisting of villagers. **Employment:** Based on the skills and qualification, preference in employment have been granted to project affected families. From the State of Sikkim 862 persons were employed including 129 nos. PAPs. **Other works**: Access road of around 4.5 km uptill Adit-IV portal was already constructed which is further linked to Ramam village by another km, for the utilisation of villagers, till Safoo Chungthang road as a goodwill gesture to villagers by the project. The road will be maintained by the villagers in the future. Cement Concrete footpath of 1.5 km for Shipgyer village has been constructed for the villagers. Gurulakhang prayer hall is under construction at Chungthang village. Meditation hall completed at Chungthang Gumpa. Community Centre constructed for Theng village. Manilakhang prayer hall under construction at Theng. Community Centre constructed and handed	

			over to Pegong Panchayat. Gumpa Kitchen constructed and handed over to community at Ramam village. Renovation and reorganisation of Gumpa at Ramam is under progress. Yapring ground at Safoo was completed. Gumpa kitchen construction is under progress at Safoo. Gumpa Kitchen at Singhik village was constructed and handed over to the community. Renovation of Singhik school completed and handed over. Construction of midday meal shed and toilet under progress in Singhik school. **Livelihood development plan/social development activities:** Bhavishya Bharat Foundation (BBF) has initiated livelihood development programmes by constituting SHGs & Farmers clubs in the respective affected villages. They are mainly enhancing knowledge by promoting sustainable agricultural practices, providing technical support in mixed cropping, spread of knowledge by linking with line departments & agencies, skill development trainings.	

~~114~~

			Mobile Healthcare Van & Medical facilities: The total health profiling of the villagers is being carried out and periodic medical camps at PAVs are also being conducted, with on the spot screening and pathological tests. Also medical setups present in the villages were renovated and additional infrastructures are being provided to the respective PHSCs and PHCs. At various sites, ambulances have been parked to facilitate the site workers as well as villagers. There are 7 nos. of ambulances catering to the needs. **Economic opportunities:** - **Allotment of Shops and Kiosks:** At different construction sites, shops of different usable articles have been established. The shops are run by local people which has given good opportunity for the enhancement of their economy. - **Award of petty contracts:** During the execution of the project, contractual works falling within the capability of local villagers were granted in consultation with village Panchayats. In this process 167 local contractors were engaged and works worth 68	

~~115~~

			Cr. had been executed by them.	
M)Safety Measure				
1.	Safety Measures proposed as per EMP	- To establish dam safety surveillance and monitoring programme, formulation of Emergency Action Plan - Public awareness for disaster mitigation	The Reservoir Operation and Dam Safety (RODS) plan has already been formulated and issued by M/s WAPCOS Ltd. for implementation. The emergency evacuation plan, is a part of RODS which exist in the above plan. M/s WAPCOS Ltd. is formulating a Disaster Management Plan which is likely to be issued for operation in due course of time. State guidelines on Public Safety are being adopted and complied.	Safety measures adopted for general safety of the workers are exhaustive and satisfactory The existing RODS plan is in place. The recommendations of M/s WAPCOS Ltd. provided in the plan should be adopted in consultation with District Disaster Management Authority in totality during operation of the project. Public awareness programs should be conducted at regular intervals to educate the people in the downstream and around the project areas.

~~16~~

Multidisciplinary Committee Members who visited the project site

Name	Signature
Dr. P. G. Sastry **Environmental Expert, Ex-chairman, Expert Appraisal Committee, MoEFCC**	
Shri Karma R. Bonpo (IAS) **District Collector, North Sikkim**	
Dr. Subash Nautiyal **Scientist G and National Project Director** **FRI, Dehradun**	25.09.16
Dr. S P Sinha **Wildlife Consultant** **Wildlife Institute of India, Dehradun**	
Dr. Gopal Pradhan **Principal Scientist** **State Pollution Control Board, Sikkim**	25/09/16.
Shri Dazom Lachenpa **DFO / Joint Director** **Forest, Environment & Wildlife Management Department** **Government of Sikkim**	25/9/2016
Shri Palchen Lepcha **Panchayat President, Singhik Village, North Sikkim**	25.9.2016.
Dr. V K Bahuguna **Sr. Vice President - Project** **Teesta Urja Limited**	25/9/16.

~~117~~

ANNEXURE-D

Compliance Status of Environmental Monitoring Programme during Project Operation Phase

S. No	Items to be monitored	Parameters	Frequency	Location	Comments
1.	Water	pH, Temperature, EC, Turbidity, Total Dissolved Solids, Calcium, Magnesium, Chlorides, Sulphates, Nitrates, DO, COD, BOD, Iron, Zinc, Manganese	Thrice a year	1 km upstream of dam site Reservoir water and 1, 2 and 5 km downstream of Tail Race discharge	It is observed that PAs have monitored pH, Chlorides, Sulphates, Nitrates, DO, COD, BOD on a quarterly basis (06.09.2022, 08.12.2022, 15.02.2023, 10.06.2023) by third party agency Centre for Envotech and Management Consultancy Pvt. Ltd. ***PAs have not monitored EC, Turbidity, Total Dissolved Solids, Calcium, Magnesium, Iron, Zinc, Manganese.***
2.	Effluent from STP	PH, BOD, COD, TSS, TDS	Once every month	Before and after treatment from STP	Two compact Sewage Treatment Plants have been established in Powerhouse and Dam site permanent colony. Both the plants have a design capacity of 15 KLD. PAs informed that STP at Dams site has been washed away during the flood. PAs have submitted the monitoring report of STP inlet and outlet from Dam Colony for 10.06.2023 and STP inlet and outlet report for (11 no. colony) for 10.06.2023.
3.	Erosion & Siltation	Soil erosion rates, stability of bank embankment, etc.	Twice a year (Summer & post-monsoons)	-	***No soil erosion rates, stability of bank embankments study etc. has been conducted by the PAs.*** PAs have stated that the Catchment area treatment plan was executed by the State Forest Department through CAMPA. No major erosion/ siltation occurred during the project operation phase.
4.	Ecology	Status of afforestation programmes	Once in 5-years	-	As per the six monthly compliance report, PAs deposited to the State the cost of the Compensatory Afforestation of Rs. 2.15 Cr for the treatment of an area of 137 Ha. It has been stated that as per the progress report received from the State Government, an area of 137 Ha in three Forest Ranges i.e. Chungthang, Mangan & Dzongu plantations were carried out.

B. Shakida Parvin

5.	Fisheries	Phytoplankton's, zooplanktons, benthic life, fish composition	Twice a year	1 km upstream of dam site Reservoir water 1, 2 and 5 km downstream of Tail Race discharge	***PAs have not conducted study on the composition of phytoplankton, zoonplanktons benthic life and fish composition for the following locations: 1 km upstream of dam site Reservoir water; 1, 2 and 5 km downstream of Tail Race discharge.*** PAs have stated that under the Fish Management Plan, a Fish rearing cum hatchery farm was established in Rabum village. The Fish farm was handed over to State Fisheries Department for operation along with maintenance fund.
6.	Incidence of water related diseases	Cause and control measures for diseases. Various diseases.	Once in a year	Project colony Statements Within 2-3 km of the project site.	***It is observed that no study has been conducted and report submitted for incidence of water related diseases in the project colony settlements within 2-3 km of the project site.***
7.	Meteorological aspects	Temperature, rainfall, humidity, cloud cover, wind speed and direction	Continuous	Project office	It has been informed that out of the two automatic weather stations installed in Power house & Dam site Office, the weather station at the Dam site along with its records have been washed away during the flood. PAs have submitted the data for the following: Outdoor temperature, Outdoor Humidity, Dew point, Heat Index, Wind Chill, Barometric Pressure, Rain, Wind Speed, Indoor Temperature and Indoor Humidity (17.1.2024 to 1/2/2024)
8.	Flow monitoring	Discharge in river Teesta	Continuous	Just downstream of dam site	As per the reports submitted it is observed that the Dam site river daily discharge has been measured for the years: 2021, 2022 and January to September 2023.

Dr. Shahida Parvin

(डॉ. शाहिदा परवीन काज़ी / Dr. Shahida Parvin Quazi)

वैज्ञानिक-ई / Scientist-E

~~19~~

ANNEXURE-E

Compliance of Disaster Management Plan:

1. As per the Disaster Management Plan submitted by PAs in case a dam breaks, the measures needed to implement to minimize loss of lives and property are:

   To establish an effective Dam Safety Surveillance and monitoring programme including rapid analysis and interpretation of instrumentation

   &

   To formulate and implement an Emergency Action Plan to minimize the possible loss of life and damage to property in the event of failure.

   The disaster management plan for the Teesta-III HEP has suggested safety surveillance and monitoring programme during five phases in the life cycle of a dam:

   a. Design and Investigation Phase
   b. Construction Phase
   c. First Reservoir Filling
   d. Early Operation Period
   e. Operation and Maintenance Phase.

   PAs have informed that during ***Design and Investigation Phase*** the investigations carried out are mentioned in Detailed Project Report (DPR). The related extract of DPR has been submitted by PAs (**Annexure-E1**). Further, surveillance during ***Construction Phase*** was conducted through installation of hydraulic settlement gauge and the survey targets in dam body. PAs informed that reports with respect to this have been washed away during the flood (on 3rd and 4th October, 2023). Hence, PAs have provided the drawings of instrumentation installed for surveillance of dam during construction phase (**Annexure-E2**). PAs have stated that for the **First Reservoir filling Phase,** the surveillance of dam was conducted as per the filling manual by the team of experts. PAs have submitted the reservoir filling manual (**Annexure-E3**). For the **Early Operation Period and Operation & Maintenance period,** surveillance of the CFRD was conducted through the instruments installed. PAs have provided the reading of the following:

   - Perimetric joint meters at CFRD (from 08.10.2022 to 02.09.2023)
   - Piezometer at CFRD cut off wall (5th April 2022 to 26th September 2023)
   - Power Intake MPBX observation (19th May 2022 to 26th September 2023)
   - Stand Pipe Peizometers at D/S of CFRD (2nd May 2022 to 26th May 2023)
   - Joint Meter Observation at CFRD (15th July 2022 to 26th September 2023)
   - Access Tunnel Load Cell and MPBX observations (13th September 2022 to 26th September 2023) All the readings are annexed as **Annexure-E4.**

2. Further, in 2016, a detailed emergency action plan and DMP (**Annexure-E5)** for Teesta-III was prepared by WAPCOS based on the guidelines provided in the Disaster Management Act. The plan includes hazard specific disaster (natural and man-made) which may cause substantial loss of properties, human life, etc. These risks include earthquake, Flood due to cloud burst, landslides, disaster due to fire, disaster due to gate Operation failure, Terrorist/ bomb threat/ attack etc. In the DMP 2016, it is stated that "The Periodical Inspection of dam and appurtenant structures is necessary especially before and after monsoon season to ascertain/ examine their condition and functioning". An effective inspection program involving Routine Inspections, Annual Inspections and 5 yearly Periodic Inspections are essential for identifying problems and providing safe performance of a dam.

   Pre and Post Monsoon Inspection: From the information submitted by PAs, it is observed that an expert committee comprising of Shri S C Gupta (Construction Expert), Shri B D Patni (Geo Technical Expert) and Shri R K Mohapatra (E & M Expert) conducted the post monsoon inspection of Teesta III from 18.11.2022 to 21.11.2022 (**Annexure-E6**). Further, a pre monsoon inspection was also conducted by

a committee comprising of Shri S C Gupta (construction Expert), Shri B D Patni (Geo-technical Expert) and Shri H K Sahu (H & M Expert) from 05.06.2023 to 08.06.2023 (**Annexure-E7**).

This Office has emailed Project Authorities to provide a compliance status with respect to the routine inspection program, annual inspection program and 5 year periodic inspection. The report from PAs is yet to be received.

3. **Mock Drills:** As per information submitted, it is observed that last mock drill was conducted on 25.04.2023 with the following topic: Cloud Burst in Upstream (Dam) mock drill rehearsal. The mock drill report is annexed as **Annexure-E8**.

4. **Emergency Action:** Project Authorities have not submitted a detailed Emergency Action Taken Report with respect to the incidence of flood on 3.10.2023. However vide email dated 29.01.2024, PAs have submitted the following which is quoted below:

"SUL took the following actions during the flood of 03.10.2023:

-Emergency Response System was activated by the Project and the warning by way of sirens was issued.

-Chungthang Town was informed about the possibility of flash flood.

-About 250 people from the project colonies at Dam site were evacuated and shifted to higher level.

-Power House was informed and plant shut down at around 12:50 AM of 04.10.2023.

-People worked inside the power house have been evacuated.

-Downstream projects were informed through email and telephone.

-After receipt of the message from ITBP at 11:17 PM by Sikkim Urja Limited, while confirmation from local authorities was being sought and awaited, the lowering of Dam level was started from11:30 PM onwards. The river discharge on the night of flood was around 250 cumecs, out of which around 200 cumecs was passing through the machines. Dam team started lowering the level by partial opening of spillway gates. Approx. 5 m of reservoir level lowered in one hour time. Despite getting no confirmation, SUL authorities passed on information received from ITBP to Chungthang village for necessary action. Further, Safety Officer of SUL activated the security agency to wake up people in the Project colony and the workers colony for evacuation. Both the colonies were evacuated, and people shifted to higher level. Emergency Response Team of the project was activated.

-As the discharge continued to be in the range of 250 cumecs i.e., about 100 cumecs above normal trend and communication with u/s observation posts indicated higher discharge, the Project Head of SUL took a call after 12:40 AM of 04.10.2023 to fully open the Dam Gates and shut down the Power Plant. Accordingly, full gate opening command for all gates was given at 12:41 AM. Powerhouse was also shut down between 12:45 AM to 12:50 AM. The flash flood hit the Teesta- III Dam at around 12:55 – 01:00 AM of 04.10.2023".

Dr. Shahida Parvin

(डॉ. शाहिदा परवीन काज़ी / Dr. Shahida Parvin Quazi)
वैज्ञानिक-ई / Scientist-E

3. GEOLOGY

3.1 General

The implementation of Teesta Stage III HE Project, which is a run of the river scheme, has been taken up as a part of the integrated power development plan of Teesta river basin, which envisages six stages. While Teesta Stage III has been allotted to Teesta Urja Limited, stages IV, V (under construction) located immediately down stream are with NHPC Ltd., and Stage VI is with Lanco Ltd. whereas stage I & II (upstream) are with M/s Snowy Mountains, and M/s Him Urja respectively.

3.2 Earlier Studies/ Investigations

Feasibility studies for different project layouts, at various alternate sites, based on Geological and Geotechnical considerations have been carried out in detail by Central Water Commission (CWC) and Geological Survey of India (GSI).The project site has been investigated in detail in various campaigns from 1973 to 1987. The following eminent geologists of GSI have been associated with detailed geological mapping and subsurface explorations of the Project area over a period of about 10 years:

Shri B N Sinha, Director (1973),Shri V P Singh (1974-1975 & 1976),Shri S N Chaturvedi (1976),Shri B Chatterjee (1979-80), Shri C N Phukan (1980),Shri B Chatterjee (1980-81), Shri B Chakaraborti and

Shri H Banerjee (1982), Shri S Kumar (1981-82), Shri P N Verma (1981-82) to (1984-85).

The geological investigations by CWC under guidance of the above experts comprises detailed geological mapping, core drilling at different structure locations and an exploratory drift at power house site (refer Part 2 of Vol V of the DPR prepared by C.W.C. 1987). A brief account of the geological explorations is contained in **Chapter 2 – Field Investigation** and the table is attached **(referPlate-3.1)**

Mr.N.K.S.Tomar (Project Geologist),Mr.Shyo Prasad and Mr.S. Kumar, Advisor (Geology) have carried out a review of the existing geological studies through desk studies and frequent site visits on behalf of Teesta Urja Limited **(TUL)**.For further details refer **Proposed Explorations/ Investigations by Teesta Urja Limited**. In earlier studies, 4 alternative dam sites were investigated, all located between 300m and 1.0 km downstream from the confluence of the rivers Lachen Chu and Lachung Chu at Chungthang. Of all the above, two sites i.e. Alternatives 1 and 4 were considered more favourable than Alternates 2 & 3. (**refer Plate – 1a**).

The first Geological reconnaissance of the dam site was carried out in December 73 by Shri B.N. Sinha , Director, Engineering Geology, Eastern Region followed by Shri V.P. Singh, Geologist, Geological Survey of India in the company of C.W.C. Engineers during the field season of 1974-75. Two possible locations of the dam site were inspected below the confluence of Lachen Chu and Lachung Chu at

Chungthang and it was decided to explore the down stream site by core drilling (GSI reports by Shri V.P. Singh, 1974-75 and 1975-76). Two more alternative locations of dam axis were also studied in detail by the aid of exploratory drilling. Geology of the dam site has been described in detail in the report of Shri V.P. Singh, Geologist (Field season 1975-76) and also by Shri P.N. Verma and Shri K. Guha (Field season 1984-85) According to these reports, the river bed is covered with large size boulder to gravels in small quantity of sand matrix. There are 18 m to 25 m high terraces on both the banks of Teesta river which normally are not submerged even during high floods, except once in 1963. The channel of Teesta river during normal fair weather period is about 20 to 25 m wide. It flows closer to the right bank. The left bank of river bed is marked by accumulation of big boulders which has diverted the flow towards right bank.

The geology at various alternative sites of dam is briefly described below:

i) Dam Site Alternative 1 (Dam Axis)

The alternative 1 site which has been finally selected as Dam Axis, is located about 100m down stream from the Chungthang Hydrological gauging station. Resistant rock outcrops are observed on both the banks.(**refer Plate -1**)

Hard quartzite and calc-gneiss with thin beds of biotite -schist, amphibolite, etc. are exposed on the right bank of Teesta river and

above the high level terraces. The slope of the abutment varies from 45° to 50°. A nala is flowing about 90 m downstream of the dam axis along a slide scar on the right bank slope. Hard calc-gneiss is also exposed between the dam axis and 30m upstream. Beyond this the entire area is occupied by high level terraces. The left bank, above the terraces comprises of hard, jointed & strong quartzites. The strike of bedding/foliation plane is NW-SE dipping 55° due NE . Three prominent joint sets occur along the foliation plane of the rocks, trending E.W. with 50° N dip and N-S with 70° E dip. Because of the presence of crushed, brecciated rocks on both banks along NW-SE, a fault has been interpreted along this direction passing oblique to the southward flow of river **(refer Plate -01)**.

The availability of bed rock in the river bed section along the dam alignment has been interpreted at depths ranging between 25m and 47m which was confirmed by three drill holes DH1, DH2 and DH3 (**refer Plate -01**). The overburden material consists of riverine terrace deposit in unconsolidated state anticipated to possess high permeability. The bed rock consists of micaceous quartzite with subordinate bands of calc-gneiss, with occasional thin bands of amphibolite and biotite gneiss, at places.

ii) Dam Site Alternative 2 & 3

. Dam axis alternatives 2 and 3 of dam axis are located near Patal Bridge and are geologically and geotechnically (by Shri P.N. Verma

1984-85) not suitable for dam foundation due to the presence of a palaeochannel on the right bank.

iii) Dam Site Alternative 4

Alternative 4 site, located about 300m down stream from alternative 1 provides another potential location of the dam. At this location exposures of bed rock are visible on the right bank in the form of steep escarpments, whereas the left bank is covered in overburden which abuts against bed rock at El. 1650m.

iv) Dam Site Alternate -5

The location was initially selected by TUL for CFRD, but after detailed geological mapping axis-1 was found to be more suitable. The location and tentative geological cross sections along the above 5 alternative dam axes are shown in **plata- 1a.**

In general, river terraces along the valley sides are interrupted by cones of colluvial debris formed by detritus derived from weathering of outcrops at higher elevations. Ridges of more resistant rock finger down to river level. The thickness of the valley infilling investigated by a number of drillings confirms overburden depths of 30-50m. A lateral buried channel up to 75m depth has also been identified at one location. Thus the depth to bedrock in the valley floor is a significant issue for the location and design of the dam. It is noteworthy that in the Teesta Stage V project downstream, currently under construction,

the excavation for the dam is about 50m below the riverbed involving extensive works for the cofferdams.

3.3 Project Layout

The present layout of the Project comprises a 60m high Concrete Face Rock Fill Dam across river Teesta 300m down stream of the confluence. A 13.32 km long, 8m dia, circular shaped head race tunnel will divert the discharge of Teesta river to an underground Power House of Dimension 220.5m x 21.50m x 46m located on the right bank of river Teesta near village Leaching. A 1.0 Km long, 8 m x 8 m dia tail race tunnel will channelize the flow from the powerhouse back to the Teesta River. The project envisages utilization of a flow of 175 cumecs at a head of 805 m to generate 1200 MW power (**referPlate-3.1**)

3.4 Regional Geological Setup

The rocks of the area belong to the Chungthang series and Darjeeling series of the Kanchenjunga Group comprising Central Crystalline Gneissic Complex. (refer GSI report by sriV.P.Singh-1974-75)

a) **Chungthang Series**: Are mainly constituted by Calc silicate rocks, Biotite Schist, Gneiss and Quartzite.

b) **Kanchenjunga Group**: -Comprises hard, compact and well jointed Augen Gneiss and streaky Gneiss.

3.5 Structural Setup

Due to complex folding, Gneissic and Schistose bands are intricately folded with the meta sedimentary units. The folds are generally asymmetric and isoclinal in nature with more or less North Easterly dips. Besides intense folding, the rocks are subjected to extensive shearing, fracturing and folding accompanied by lateral intrusions, both along and across the foliation.

3.6 Geology and Geomorphology of the Project Area

The Teesta river at the proposed Dam site flows in N 142° direction though a U shaped gorge at present bed level of about EL 1531m at Dam Axis. The river bed and river course are lined by riverine terrace deposits on either bank, overlain by colluvial debris of boulder to pebble grade. At places, fluovioglacial debris of varying depth is found to occur. Bedrock of hard Quartzite with inter-bedded Calc Gneisses with occasional thin bands of Biotite Schist and Amphibolites are observed projecting steeply out of the overburden strewn banks, in the form of escarpment faces. The 13.32 Km long HRT is aligned on the right bank of the Teesta River through various lithological formations comprising Darjeeling Gneisses, foliated Granite, Calc Gneiss, and Quartzite and Quartz Schists. The initial 8.5 Km of tunnel length is roughly aligned through the Chungthang series, the intermediate length of 8.5 to 12 Km through intrusive Granitic Gneiss and the terminal portion through Darjeeling Gneisses. The general trend of

theses rocks is due NW/SE with moderate NE dips. Steep, South Easterly dipping cross joints are observed intersecting the rock mass. A thrusted contact exists between the Darjeeling Gneisses and the Chungthang series, marked by a granitic intrusion. Localized faulting has been deciphered at locations on the basis of slicken sides and fault breccias.

The underground Power House will be hosted in banded Gneiss of the Darjeeling Group with subordinate Schist lenses.

3.7 Proposed and completed Explorations/ Investigations by Teesta Urja Limited

Apart from the earlier explorations carried out by both CWC and GSI for investigation of various alternate sites in the feasibility and Pre DPR Stages, the following additional investigations have been suggested/ carried out in the Post DPR/Pre construction stage:-

1) **Geological Mapping**: The area covering the Dam and Power House complex has been geologically mapped in 1:2000 scale, Geological data compiled has been utilized for discontinuity analysis, for determination of prominent discontinuity patterns based on density of poles. After obtaining results of insitu stress measurement the orientation of power house will be reviewed on the basis of prominent discontinuity pattern analysis and stress conditions. The HRT alignment has been geologically mapped on 1:10,000 scale, principle lithological units identified and

structural breaks traced. Similar method has been adopted for carrying out discontinuity analysis of individual lithological units expected to be encountered at tunnel grade. Discontinuity intersections have been studied for determination of major wedges for stability analysis, by the aid of Unwedge Software. Two Drill Holes –DH2 & DH-3 have been completed to a depth of 78.05m and 72.00 respectively.DH-1 and DH-2a also have been completed at the earlier proposed diaphragm wall .DH-2 has intercepted bedrock at 48.60m(El-1479.33m) **-refer annexure 1 - 8.**

2) **Geophysical Exploration**: Seismic profiles and Seismic refraction surveys are proposed to be taken up at both Dam and Power House locations.

3) **Exploratory Drilling**: The following drill holes have been proposed for acquiring subsurface data of Dam and Power House area.

a) Dam Complex

	Drill hole	Structure
1)	DH1, DH2 (a)	Diaphragm wall.
2)	DH-2	D/S of dam axis
3)	DH3	Main Spillway
4)	DH4	outlet of diversion tunnel

5)	DH6	Diversion Tunnel alignment
6)	DH-7	Spillway at dam axis
7)	DH-8	Spillway at outfall
8)	DH-9	Tunnel spillway at gooseneck

b) HRT – The HRT alignment has already been explored earlier, by the aid of five drill holes. However ,in the course of geological traversing, low cover zones will be investigated further, if the necessity so arises.

c) Power House Complex -

A drill hole (DH5) has been proposed at the centre line of surge shaft.

4) **Exploratory Drifting** ;-The following exploratory drifts are proposed.

Dam Area - Right bank dam axis/ Intake; approximate 200 m long Drift with U/S & D/S crosscuts.

Power House Area - Right bank Teesta River Power House exploratory drift with 2 cross cuts across the power house cavern.

5) Rock Mechanic Tests

a) In-situ tests in Dam and Power House drifts comprising plate load, insitu shear and hydro fracturing are proposed to be taken up for determination of engineering properties & insitu stress.

b) Laboratory tests of core samples for physio-mechanical properties of rock.

6) **Evaluation of Seismic Design Parameters**:

DEQ-IIT Roorkee has been approached for carrying out relevant study to determine the site specific seismic coefficients to be incorporated in the design of major structures.

3.8 Geological and Geotechnical assessment of Civil Structures

Based on the considerable investigations already carried out, both by CWC and GSI, for various alternative locations and geological field studies carried out till date, a broad assessment of Geotechnical conditions vis-à-vis major civil structures is attempted .The evaluation will be reviewed on the results of ongoing subsurface explorations as enumerated above : -

1. **Dam complex**:

The proposed 6o m high concrete faced rock fill dam is to be located very near to alternative site-I, proposed by CWC and GSI, near village Chungthang about 300 m below the confluence of river Teesta with Lachung chu, a left bank tributary of Teesta river. All four locations identified/explored by CWC and GSI are shown in **plate-1a.**

At the dam site, the river Teesta flows through a 170 -180m wide U-shaped valley with moderately steep flanks inclined at 40° -45° constituted by escarpment faces rising steeply out of the overburden covered river banks.

i) **Foundation conditions**

a) River bed:

In view of past geological history of the region, the banks are lined with slope wash debris overlying the riverine deposits. (**Refer Plate 1**) The slope wash is further overlain by colluvial debris brought down by weathering of exposed & steep rock escarpments. Three drill holes previously done along alternative site-I have revealed overburden depth varying from 55m to 60m comprising boulders, cobbles, gravels and pebbles in a medium to coarse sandy matrix. (**Refer Plate 2**) .As the dam will be founded on the overburden, investigations are in progress to determine permeability and grain size distribution of the overburden and to determine precise bedrock depth and characteristics.

In view of the high drill water loss in overburden in earlier drillings, high permeability values are envisaged, to counter which, provision of a cut off diaphragm wall is kept approx 76 m upstream of the Dam axis to bedrock level. (**refer Plate-1**). Two drill holes, one on either bank are proposed for probing this location . The first hole DH-2 has been drilled down to a depth of 78m and has negotiated an

overburden depth 48.60m. constituted by a heterogeneous assemblage of boulder to cobble grade fragments of Granite Gneiss, Quartzite etc. in a coarse granular to sandy matrix. Permeability values range from 5×10^{-3} to 7×10^{-1}.Hence in view of the higher permeability ,the overburden appears to be unconsolidated & has poor compaction.

Bed rock of Hard, Strong to Very Strong moderately jointed Quartzites of Chungthang Series has been encountered at 48.60m depth, corresponding to EL. 1447.23m. The Quartzites show occasional intrusions (Amphibole Gneiss) of 1-1.5 m thickness along foliation. The intrusions are dark grey in color. Weathering along joints is noticed to complete drilled depth as a consequence of which permeability values are occasionally high, of the order 40 to 81 lugeons but generally range from 4 to 35 lugeons. Core recovery ranges from 62to100% and RQD from 30 to100%.so far no fine horizon of liquefiable nature has been encountered. In the event such horizons are located the same will be tested for liquefaction potential.

In the course of earlier explorations, a fault had been encountered in the drill holes at alternative site I, the alignment of the fault has been marked on the map (**refer Plate -1**) and provision of treatment of the same by grouting has been kept.

b) Abutments:

The river banks are generally lined with colluvial deposits. Bedrock along either abutment comprises of strong to very strong, moderately jointed Quartzite and inter-bedded Gneisses of the Chungthang Series. In the course of geological mapping three to four major discontinuity sets have been identified intersecting the rock mass .These are :-

Left bank

Set No.	Av/Orientation	Spacing	Persistence	Aperture	Remarks
S 1	030°-035°/35°-40°	20-25 cm	5-8 m	0.5-2 mm	Undulating
S 2	180°/68°	1-2 m	20 m	20-30 cm open	Planar
S 3	290°/25°	1-1.5m	1.5-5 m	Tight	Smooth planar

Right bank

Set No.	Av/ Orientation	Spacing	Persistence	Aperture	Remarks
S1	040°-050°/50°-60°	20-25 cm	5-8 m	0.5-2 mm	Undulating
S2	180°/68°	1-2 m	20 m	20-30 cm	Planar

				open	
(a)	290°/25°	1-1.5 m	1.5-5 m	Tight	Smooth planar
(b)	290°/68°	2 m	5- 10 m	0.5- 2 mm	Slightly Undulating

As is apparent, the prominent foliation joints are valley dipping at moderate angles on the right flank and dip towards the hill side on the left flank. In view of the slightly open nature of the foliation, provision for grouting of the bedrock along the flanks is being kept to eliminate seepage. Furthermore, stripping of abutments will be limited to removal of initial weathered bedrock only, if so required, considering the type of structure proposed. As the stripping will be limited and minimized, no abutment instability in the form of wedge failure is apprehended on either bank.

ii) Spillway:

The 43 m wide, approx 120 m long spillway with crest level at EL 1545m located 10m below intake sill level, will be founded on insitu rock strata. As such no rock excavation is involved. One drill hole (DH3) is done and two more drill holes DH-7 & DH-8 proposed as one at outfall and one at concrete dam with barrage spillway, to identify the depth and characteristics of overburden and insitu bedrock.

One auxillary spillway with open crest ogee type control structure connected to diversion tunnel through a goose neck with two radial gates.The crest level is 1573.00m.

Diversion Tunnel:

One 660m long, 9 m dia, circular diversion tunnels has been proposed on the left bank. The tunnel has been aligned to maintain sufficient lateral and top cover and will be excavated in strong to very strong moderately jointed Quartzite and inter-bedded Gneiss. The tunnel has generally been aligned across the prevalent bed rock strike direction for maximum stability. On the basis of geotechnical classification of rock masses , the rock mass in this reach is expected to vary from fair (class III) to good (class II) with rock mass ratings ranging from 55 to 65 .The ratings have been adjusted for joint orientations in respect of tunneling conditions. Provision of adequate support in the form of shotcrete and rock bolts is being kept in the contract document to counter wedge instability in the course of tunneling operations. One drill hole DH-4 is proposed at the out fall of the structure to probe overburden thickness and another DH-6 along the alignment to determine extent of rock cover. The outlet portal is expected to be located in overburden and provision of support for stability of the outlet is being kept accordingly.

Power Intake:

The three number, 4.6 m dia, power intake structures will be accommodated on the right bank at EL 1554.80 m, 45m upstream of the Dam axis. The intake area is being explored by means of a drill hole(DH-3a) and an exploration drift on the right bank. The intake structures will be founded in strong to very strong Quartzite with inter bedded Gneisses of the Chunthang Series with prominent upstream dipping foliation joints. The rock mass is expected to be of fair to good quality i.e. Class III to Class II .During excavation, wedge instability of the rock mass is apprehended, for which adequate support arrangements in the form of initial shotcrete and rock anchors are being provided, so that portal faces can be sufficiently treated for stability.

iii) Desilting chambers:

The three, D-shaped, 16 m wide,18 m high & 250 m long desilting chambers, will be excavated on the right bank in strong to very strong moderately jointed to massive Quartzite with Gneissic laminations. The exploratory drift being driven on the right bank is expected to provide further information on bedrock characteristics expected at depth .This information will be supplemented by data from the drill hole at the intake. Due to folding within the rock mass inversion in foliation direction is generally noted. However, in general, the foliation is prevalent with moderate NE Dips. Hence for maximum stability, the

structure is oriented across the prevalent foliation strike. Rock mass ratings based on geotechnical classification of the rock mass derived from surface outcrops range from 50 to 70, thereby grading the rock mass as fair (Class III) to good (Class II). However, zones of poor (class IV) rock are expected in localized areas of shearing and folding. In view of the proximity of the three structures to each other, sufficient lateral cover of the order of 20m has been maintained to minimize stress of rock pillars. Furthermore, excavation pattern will be staggered and appropriate support provided in the form of shotcrete and rock bolts/anchors to check wedge instability as a consequence of stress built up. The structures will also be monitored for stability during excavation by the aid of a suitable instrumentation programme.

2. Head Race Tunnel

The 13.325 km long, 7.50m dia, circular Head race tunnel will be aligned on the right bank of the Teesta river and has been investigated by the aid of surface geological mapping supported by subsurface investigations in the form of 5 nos. drill holes. Superincumbent cover over the HRT varies i.e with highest cover of the order of 1000m & lowest cover of the order of 150m. The HRT has been aligned so as to maintain sufficient lateral and top cover in low cover zones and to facilitate the ease of construction adits. Litho stratigraphic units along the tunnel alignment have been identified and are briefly described below:

a) Quartzite with lenses of Biotite Gneiss and Chloritic Biotite Schist:

This unit comprises hard and strong Quartzite with intermediate lenses of Gneiss, occasionally Schist bands up to 35cm in width are observed. The trend of the foliation in this rock type is due NW with moderate dips towards NE. Discontinuity analysis depicts presence of four joint sets. This rock unit is expected to continue till RD 9.0KM . The vertical and lateral cover in this reach is of the order of 150m. This rock unit has been observed to range from class II (good) to class III (fair). However some class IV (poor) zones are expected in zones of shearing associated with Schist bands. In this reach the foliation is oblique to the tunnel alignment.

b) Granitic Gneiss:

The remaining 4 km tunnel length will be negotiated through Gneisses of the Darjeeling Group .This litho unit is constituted by hard, moderately strong to strong Mylonite Gneiss with occasional Schist bands. On the basis of geotechnical classification of surface outcrops, the rock mass has been evaluated to range from fair (class III) to poor (class IV). The Gneisses are dissected by three prominent joint sets. Principal foliation set dips at moderate to steep angles towards North East direction.

Geo technical assessment of tunneling conditions

1. Generally, the tunnel is expected to negotiate bed rock condition varying from good (class II) to fair (class III) ,occasionally poor zones (class IV) are expected to be encountered .The zones associated with Schist bands could be of very poor (class V) nature, particularly in zones of water charged strata where high cover prevails.

2. The contact between the Chungthang Series and Darjeeling Gneisses is expected to be sheared and marked by intrusions. As such, rock conditions in this reach are expected to range from poor to very poor and may require resort to multidrift excavation with controlled blasting.

3. The low cover zones could be associated with water charged strata and need careful excavation.

4. In zones of high cover, high vertical stresses could prevail as a consequence of which rock bursting phenomena could be encountered during excavation.

Provision of adequate drainage in the form of pressure relief zones is being kept in zones of water charged strata .Furthermore resort to probe drilling will be kept in the contract document for forecasting of tunneling conditions. In order to facilitate HRT construction, five adits are proposed.These are briefly described below:

ADIT-I

Adit I will be located in a rocky escarpment, on the right bank of the Teesta River in well jointed strong Quartzite with inter bedded Schists. The adit will be aligned oblique to the prominent foliation strike, the adit face will need to be stabilized with the aid of appropriate supports hence, and provision of steel rib supports for the initial length is accordingly being kept.

ADIT- II

Adit II, will be located in the bedrock of hard and strong Quartzite. However in the initial reach some slumping is apprehended, furthermore in view of open nature of discontinuities, the bedrock is expected to be moderately to slightly weathered in the initial reach. Due to low cover zones, in some intermediate reaches, adequate support measures are called for, hence low cover zones would require careful excavation with concurrent support. The adit is in general oriented oblique to the prevalent foliation strike of bedrock.

ADIT- III

Adit III will be located on the right bank of Penkung nallah in Quartzites and Schist .In view of prevalent Schist exposures the portal will need to be stabilized with the aid of adequate steel supports.

ADIT- IV

Adit IV is proposed to be located on the left bank of the Ramam chu, the adit is aligned oblique to the prominent foliation strike in bed rock of hard, strong, moderately jointed Quartzites. In view of open jointed and slightly weathered nature, wedge instability at adit portal face and initial length is apprehended for which appropriate support with shotcrete, wiremesh supplemented by rock bolts/ anchors will be provided.

ADIT-V

The adit to HRT and surge shaft bottom is located on the right bank of Rahi Chu. and aligned oblique to the prominent strike of foliation. The bed rock comprises hard, moderately jointed Darjeeling Gneiss of Kanchenjunga series assessed to be of Class II and Class III nature, as per geotechnical classification of surface outcrops. In initial length, due to weathering and stress relief features, appropriate support with shotcrete wiremesh supplemented by rock bolts is to be provided.

3. Surge Shaft

The 20m dia open to sky, 121m deep surge shaft having the top elevation 1630m and bottom elevation 1509m will be accommodated in strong, moderately jointed bended Gneisses and Augen Gneiss with subordinate lenses of Schist. The Surge Shaft had been explored

earlier, during prefeasibility stage by the aid of an approx 108 deep drill hole (DH13). The rock mass has been evaluated to range from good (Class II) to fair (Class III) with some poor (class IV) zones. Four number of discontinuity sets have been identified in surface mapping. Data from the drill hole indicates fair to good recovery with high permeability value as a consequence of deep surface weathering and open joints. The general trend of foliation is upstream. The discontinuity sets have been classified below:

Set No.	AV Orientation	Spacing (cm)	persistence	Aperture (mm)	Condition
S1	050° / 45°	50-150	5-8 m	2 to 5	Slightly Rough
S2	090° / 80°	80-100	12-14 m	5 to 8	Planar, Smooth
S3	180 °/ 78°	80-100	3-7m	tight	Slightly undulating

Detailed geological mapping in the area has revealed the presence of slump joints intersecting the rock mass, weathering along these planes has resulted in slumping to a considerable depth. Hence, for stability of the structure and cut slopes, necessary support provision have been envisaged. In view of expected deep weathering of bedrock one drill hole (DH5), is proposed at the centre of surge shaft up to Tunnel invert to ascertain the depth of glide cracks and rock mass

characteristics. Provision of consolidation grouting is being kept to treat the open joints supplemented by appropriate support comprising shotcrete with wiremesh and rock bolts/rock anchors, with resort to steel supports in poor rock horizons. Similar bed rock conditions are envisaged for the valve house too.

4. **Pressure Shafts**

The three number 3.8m dia, 1200m long pressure shafts will be hosted in Banded Gneisses of Darjeeling series. The rock mass as per surface mapping is expected to comprise strong to very strong, moderately jointed, Banded Gneiss with Augen Gneiss. The rock mass rating is assessed to range from 56-70 (class II to Class III). No significant problem is anticipated in the course of excavation due to limited dimension of the shafts, however, provision of grouting and drainage by the aid of pressure relief holes is being kept apart from standard support provision.

5. Power House Complex

Two locations have been explored earlier for hosting the underground power house complex (for details refer Volume 5 – part 2 of Geology DPR of CWC). Prior investigations include a 55m long drift excavated at elevation 791m on the left bank of Talung chu which is 1200m from the original location and 1700m from possible alternative location. 3-D geological logging of the excavated drift to a length of 55m was carried out by G.S.I. and the same is appended as **Plate-3.2**. Rock

types met within the exploratory drift include hard biotite quartz gneiss, biotite muscovite quartz schist with thin veins and lenses of quartz along foliation, occasional meta amphibolite lenses and 1-1.5 meter thick biotite schist bands .The prominent foliation dips at 55° due NE.

The underground Power House with dimensions of 220.50m x 21.50m x 46m having installed capacity of 1200 MW is located near village Leaching, inside the hill on the right bank of river Teesta, in strong to very strong Darjeeling Gneiss with subordinate Schist bands / lenses, the superincumbent cover above the structure is expected to be of the order of 450m.

In course of current geological mapping, three major discontinuity sets have been identified intersecting the rock mass. These are given below.

Set No.	AV Orientation	Spacing (m)	Persistence(m)	Aperture (mm)	Condition
S1	059° / 51°	0.35-1 m	5-8 m	2 to 5	Slightly Rough
S2	185° / 63°	2-3.5 m	12-14 m	5 to 2	Planar, Smooth
S3	263°/77°	2.5m	5- 10 m	tight	Rough, Undulating

Surface investigations have revealed the presence of an approximate 90m wide Schist band comprising poor rock mass, intersecting this area. As the original location was explored with a drift, the same is being retained presently. However, during pre-construction investigations, a drift would be explored at possible alternative new location to avoid the schist band. Data from the drift will be supplemented by rock mechanics tests to determine engineering properties and prevailing insitu stress conditions.

i) MAIN ACCESS TUNNEL (MAT)

The 577.3m long main access tunnel is located on the right bank of river Teesta down stream of Ringdong suspension bridge, in bed rock of hard, strong, moderately jointed Gneiss of Darjeeling series.(**refer plate -3**) The tunnel is aligned oblique to the prevalent Foliation strike and will be driven in class II to Class III rock mass. However, some Class IV zones are expected to be encountered during tunneling, for which adequate support requirement comprising shotcrete with wiremesh and rock bolts/anchors are foreseen. The MAT portal is expected to be located at the base of a vertical cliff in hard and strong moderately jointed Gneiss, by virtue of its location, possibility of fracturing in bed rock as a consequence of high vertical stresses is anticipated. Hence provision of adequate support viz, shotcrete with rockbolts/rock anchors is being kept to maintain Portal stability

II) TAIL RACE TUNNEL (TRT)

The approximately 1Km long 8x8m dia,D-shaped Tail race tunnel will channelize the flow from the powerhouse back to the Teesta river and will be excavated in Banded Gneisses of Darjeeling series. As the entire length of TRT is aligned oblique to the prominent foliation strike of the rock mass, susceptibility of Schist horizons to instability is apprehended & appropriate support provided accordingly. The outfall structure of TRT will also be accommodated in hard, strong, moderately jointed banded Gneiss with subordinate Mica Schist lenses. The rock mass is expected to range from class II to class III i.e. good to fair quality with some Class IV (poor) horizons.

3.9 Reservoir

The Reservoir at FRL of 1585 is expected to extend 1.15 km upstream along Lachung chu and 1 km upstream along Lachen chu from the confluence. The Reservoir area is lined on either banks by stable slopes comprising intact & competent rock exposures constituted by Quartzites interbedded with Gneisses of the Chungthang series, at places overlain by riverine terrace /shoal deposits. No geodynamic features such as land slides etc, are found to occur within the Reservoir Rim. Hence, the Reservoir is watertight and its slopes are stable.

3.10 Seismicity

As per IS: 1893:2002, the entire Sikkim falls in Zone-IV. The map showing seismic zones of India is shown in **Annexure – 3.2**. The Himalayan Seismic Belt from Kashmir in the west to Arunachal Pradesh in the east can be divided into different seismo-tectonic blocks. The Darjeeling-Sikkim tectonic block is one block where there have been a number of moderate to large magnitude earthquakes (M>5.0). The MCT and the MBT are two major structural discontinuities, which could be considered as potential sources of earthquake activity. Some earthquakes have been located close to the MCT in northern Sikkim. Earthquake activity analyzed over the period 1964-2003 suggests that the regional seismicity of the Sikkim Himalayas is relatively high to the north of the Main Boundary Thrust (MBT) and progressively decreases southwards from the lesser Himalayas to the fore deep region, under sediment cover. One of the notable earthquake events their according in the project area was the 1934 Bihar earthquake (M=8.4). A more recent event of M=6.7 in 1988 near to the 1934 epicentre was felt in Darjeeling. The isoseismal VII passes through Gangtok in an approximately NE-SW direction. Recently, workers (Reena Da and Kyal 2003) have suggested that the tectonics in the Sikkim-Darjeeling area are controlled by the deep rooted MBT producing continuous earthquakes from the surfaces to the lower crust (0-45km). To the

east of Sikkim a 200 km lineament is suggested as the source of mid-crust level events (10-25 km in depth).

Necessary studies are being carried out by DEQ, IIT Roorkee to determine & evaluate suitable seismic coefficient. The same will be incorporated in the design of major project structures.

SGS

TEESTA URJA LIMITED.

Annexure-1

GEOLOGICAL LOG OF DRILL HOLE

PROJECT	Teesta Stage-III, H.E.P.-North Sikkim	DEPTH OF HOLE	78.05 m
LOCATION	Diaphragm Wall (Right Bank)	TYPE OF CORE BARREL	Double/ Triple Tube
FEATURE	Dam Site	DRILLING AGENCY	M/S Shivalk Geotech Services, Mohali
GROUND ELEVATION	1527.83 m	TYPE OF BIT	Diamond Core Bit
COLLAR ELEVATION	1527.93 m	CO-ORDINATES	N 14807.99, E 23548.99

BORE HOLE NO	DH-82
SHEET NO	1 of 8
TYPE/MAKE OF MACHINE	Longyear-38/ Hydraulic Feed
BEARING OF HOLE	Vertical
PERIOD OF EXECUTION	16-12-2005 to 17-01-2006

Date	Depth of Drill Hole (m) Depth	Elevation (RL)	Lithology: Description of Strata	Log	Structural Conditions: Description of Joints	Log	Fracture Conditions	Weathering Grade	Fracture Index (FI)	Percentage of Core Recovery: 0 - 20	20 - 40	40 - 60	60 - 80	80 - 100	R.Q.D: 0 - 25	25 - 50	50 - 75	75 - 100	Size of Core Pieces: <10mm	10 to 25mm	25 to 35mm	75 to 150mm	>150mm	Size of Hole	Size of Bit	Size of Casing (mm)	Depth of Water Level	Colour of Return Water	Drill Water Loss	Permeability: Test Section	Lugeon Value	Penetration Rate (cm/min.)	Special Observations/ Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
16-12-05	0.00	1527.83	River born material comprising gravels, cobbles of Gneisses, Quartz-Feldspar with Coarse sand, rounded/ sub-rounded Quartzite, coarse, medium fine gravels size <11cm long	Overburden Strata	Overburden Strata	Overburden Strata	Overburden Strata	Overburden Strata	Overburden Strata					100									1						Dry Drilling			Boulder from 1.90 to 4.30m (2.40m)
	0.50		GWL																													
	1																															
	1.20	1526.63																														
17-12-05	2		River born material/ overburden comprising boulders and one cobble of Gneisses, size 8-54cm. Big boulder (2.40m).								29											3	1									1.39	
18-12-05	3													100									2								1.74	
	3.85	1523.98												100									2								0.53	
	4		River born material of boulders of gneiss one cobble of Biotite Gneiss (?), size 16-40cm											100									2								0.55	
	4.50	1523.33												92									2								0.76	
	5				Overburden Strata						36												1								1.25	
19-12-05	6											48											2								1.22	
	7		River born material comprising mostly rounded/ subrounded, generally coarse and sometimes fine gravels and cobbles two boulders of Quartzite, Gneiss, Garnetiferous Quartz Biotite-Gneiss(?). Quartz, size 15-20cm								30									2											2.08	
											36									1	1										1.92	
20-12-05	8												75									1	1								0.73	
													71								2	1									0.78	
21-12-05	9												70							2											2.50	
	10												76									2	1								0.64	

SGS

TEESTA URJA LIMITED. Annexure-2

GEOLOGICAL LOG OF DRILL HOLE

PROJECT	Teesta Stage-III, H.E.P.-North Sikkim	DEPTH OF HOLE	78.05 m.	BORE HOLE NO.	DH-02
LOCATION	Diaphragm Wall (Right Bank)	TYPE OF CORE BARREL	Double/ Triple Tube	SHEET NO.	2 of 8
FEATURE	Dam Site	DRILLING AGENCY	M/S Shivalik Geotech Services, Mohali	TYPE/MAKE OF MACHINE	Longyear-38/ Hydraulic Feed
GROUND ELEVATION	1527.83 m.	TYPE OF BIT	Diamond Core Bit	BEARING OF HOLE	Vertical
COLLAR ELEVATION	1527.93 m.	CO-ORDINATES	N 14807.99, E 23548.99	PERIOD OF EXECUTION	16-12-2005 to 17-01-2006

Date	Depth of Drill Hole (m) Depth	Elevation (RL)	Lithology: Description of Strata	Log	Structural Conditions: Description of Joints	Log	Fracture Conditions	Weathering Grade	Fracture Index (FI)	Percentage of Core Recovery 0-20	20-40	40-60	60-80	80-100	R.Q.D 0-25	25-50	50-75	75-100	Size of Core Pieces <10mm	10 to 25mm	25 to 75mm	75 to 150mm	>150mm	Size of Hole	Size of Bit	Size of Casing (mm)	Depth of Water Level	Colour of Return Water	Drill Water Loss	Permeability Test Section	Permeability Lugeon Value	Penetration Rate (min/m.)	Special Observation/ Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
	10												76									3	1									0.64	Quartz to boulder 10.40 to 10.87m (0.47m)
	10.20	1517.67	River born material of Quartzite, boulders, size 45cm.									58											1					Light Grey	Partial			0.77	
	11.00	1516.83	Overburden of Garnetiferous Quartz-Biotite Gneiss, silty gravelss, coarse gravels and cobbles, size range-2-14cm.											90								2									0.55	
22-12-05	12.00	1515.83	River born material of generally (submounded/ subangular, coarse gravels and cobbles of Gneisses, size 2.0-8.0cm.									65										3									0.77	
	13.00	1514.83	River born material comprising boulders, cobbles and some coarse gravels subrounded/ subangular of Gneisses, size 2-42cm long.									80										2									0.77	
	14											48										1	1								1.00	Biotite Gneiss boulder 12.10 to 12.52m (0.42m).
												51				Overburden Strata							1								0.87	
					Overburden Strata							52										1		2								0.79	
23-12-05	15.00	1512.83	River born material of submounded/ subangular coarse gravels, cobbles, boulders of Quartz-Feldspar Gneiss, Pegmatite, size 2.5-21cm long.								34												2								0.98	
	16											47										2		1							0.76	Quartzitic Gneiss boulder 16.39 to 17.34m (0.55m).
	17.00	1510.83	Overburden of boulders, coarse gravels of Gneiss, size 2.5-34cm.									47										2		1							0.71	
24-12-05	18.00	1509.83	Overburden of coarse gravels, cobbles of Gneisses (Quartz-Feldspathic, fine grained), size 2-8cm.									51										2	1								0.95	
	19.00	1508.83	River born material of cobbles with few coarse, medium gravels of Quartzite, Gneiss, size 1.5-15cm long.									40											1	1							0.89	
	20.00	1507.83																															

TEESTA URJA LIMITED. Annexure-3

GEOLOGICAL LOG OF DRILL HOLE

PROJECT	Teesta Stage-III, H.E.P.-North Sikkim	DEPTH OF HOLE	78.05 m.
LOCATION	Diaphragm Wall (Right Bank)	TYPE OF CORE BARREL	Double/ Triple Tube
FEATURE	Dam Site.	DRILLING AGENCY	M/S Shivalk Geotech Services, Mohali
GROUND ELEVATION	1527.83 m.	TYPE OF BIT	Diamond Core Bit.
COLLAR ELEVATION	1527.93 m.	CO-ORDINATES	N 14807.99, E 23548.99

BORE HOLE NO.	DH-02
SHEET NO.	3 of 8
TYPE/MAKE OF MACHINE	Longyear-38/ Hydraulic Feed
BEARING OF HOLE	Vertical
PERIOD OF EXECUTION	16-12-2005 to 17-01-2006.

Date	Depth of Drill Hole (m) Depth	Elevation (RL)	Lithology: Description of Strata	Log	Structural Conditions: Description of Joints	Log	Fracture Conditions	Weathering Grade	Fracture Index (FI)	Percentage of Core Recovery 0 - 20	20 - 40	40 - 60	60 - 80	80 - 100	R.Q.D 0 - 25	25 - 50	50 - 75	75 - 100	Size of Core Pieces <10mm	10 to 25mm	25 to 75mm	75 to 150mm	>150mm	Size of Hole	Size of Bit	Size of Casing (mm)	Depth of Water Level	Colour of Return Water	Drill Water Loss	Permeability Test Section (m)	Permeability Lugeon Value	Penetration Rate (cm/min.)	Special Observation/ Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
	20		River born material of boulders, cobbles with few coarse gravels of Gneisses, size 22cm.		Overburden Strata	Overburden Strata	Overburden Strata	Overburden Strata	Overburden Strata			43										3		NX	NXC	HX (115)		Light Grey	Partial			0.79	
25-12-05	21.00	1506.83	Overburden of boulders, cobbles, few subrounded/ subangular, medium coarse gravels of Garnetiferous Gneiss, other Gneisses, size- 2.5-80cm.										80								2	1								21.0m	372.2	0.79	Biotite Gneiss boulder 21.20 to 21.80m (0.60m)
	22											55									1	2									0.67	
	23.00	1504.83	Generally boulders, few cobbles, one gravel of Gneiss, size 5-24cm.											94	Overburden Strata						1		4				Dark Grey				0.98	
26-12-05	24.00	1503.83	Cobbles, boulders and few coarse, medium gravels of Generally Quartz, few Gneiss, size 10-24.0cm.											100								2	1								0.62	Boulder (Gneiss) 23.15 to 24.00m (0.85m)
	25													92								4	2								0.75	
	26												80								1		1				Light Milky				0.69	Boulder (Quartzite) 24.16 to 25.64m (1.48m).
	26.30	1501.53	River born material of gravels, cobbles of Gneiss, size 4-11cm											86							4	2					Brownish Grey				1.60	
27-12-05	27.00	1500.83	River born material of mostly sub-rounded/ sub-angular medium, coarse gravels, cobbles of Quartzite Gneiss (Quartz-Biotite Garnetiferous), size 1-9cm.								70											1							27.0m	84.3	0.95	
	28																														1.82	
	29.00	1498.83	Medium, coarse gravels, cobbles of Gneisses, size 18-90cm long.								30										1						Light Grey				2.38	Boulder (Quartzite) 29.92 to 30.14m (0.22m)
28-12-05	30.00	1497.83										41									1										1.72	

TEESTA URJA LIMITED. Annexure-4

GEOLOGICAL LOG OF DRILL HOLE

PROJECT	Teesta Stage-III, H.E.P.-North Sikkim.	DEPTH OF HOLE	78.05 m.	BORE HOLE NO	DH-02
LOCATION	Diaphragm Wall (Right Bank)	TYPE OF CORE BARREL	Double/ Triple Tube	SHEET NO.	4 of 8
FEATURE	Dam Site.	DRILLING AGENCY	M/S Shivalk Geotech Services, Mohali	TYPE/MAKE OF MACHINE	Longyear-38/ Hydraulic Feed
GROUND ELEVATION	1527.83 m.	TYPE OF BIT	Diamond Core Bit.	BEARING OF HOLE	Vertical
COLLAR ELEVATION	1527.93 m.	CO-ORDINATES	N 14807.99, E 23548.99	PERIOD OF EXECUTION	16-12-2005 to 17-01-2006

Date	Depth of Drill Hole (m) Depth	Elevation (RL)	Lithology: Description of Strata	Log	Structural Conditions: Description of Joints	Log	Fracture Conditions	Weathering Grade	Fracture Index (FI)	Percentage of Core Recovery 0-20	20-40	40-60	60-80	80-100	R.Q.D 0-25	25-50	50-75	75-100	Size of Core Pieces <10mm	10 to 25mm	25 to 75mm	75 to 150mm	>150mm	Size of Hole	Size of Bit	Size of Casing (mm)	Depth of Water Level	Colour of Return Water	Drill Water Loss	Permeability Test Section	Lugeon Value	Penetration Rate (min/m.)	Special Observation/ Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
28-12-05	30		Angular/ subangular, medium, coarse gravels, cobbles, boulders of Quartzite, size 1.5-29cm.		Overburden Strata	Overburden Strata	Overburden Strata	Overburden Strata	Overburden Strata			52										1	1	NX	NWD Core Bit	NX (60)		Light Grey	Partial			2.00	
	31.00	1496.83	River born material of medium coarse gravels, few cobbles of Quartzite, Gneiss, rounded/ subrounded, size 1-7cm								27										2										2.22	
	32.00	1495.83	Medium, coarse gravels of Quartzite, Biotite Gneiss, size 1-4cm, rounded/ sub-rounded.								36									2								Brownish Yellow				3.33	
29-12-05	33.00	1494.83	Boulders with medium, coarse gravels of Garnetiferous Quartz-biotite Gneiss Quartzite, size 1-35cm									47				Overburden Strata						1	1							33.0m	6201.0	3.57	Boulder (Quartzite) 33.35-33.65m (0.30m)
	34.00	1493.83	Boulders, angular coarse gravels, mostly Quartzite, some Gneiss size 4 to 80m.										75									2	1					Light Milky				0.61	Boulder (Quartzite 34.00-34.60m
30-12-05	35.00	1492.83	River born material of medium, coarse gravels, two cobbles of Quartzite- Garnetiferous Quartz-Biotite Gneiss, size 1-42cm.										80									2	2					Light Grey				0.77	Boulder (Garnetiferous Quartz-Biotite gneisses) 35.08-35.50m (0.42m)
	36	1491.83	Medium coarse gravels, cobbles of Quartzite, Gneiss, size 2-13cm										80								2							Light Milky Greyish Brown		36.0m	1088.5	0.71	
	37.00	1490.83											72								2	1									0.67	
	38		Boulders, cobbles with medium, coarse gravels, sub-rounded/ sub-angular of Quartzite Gneiss and Quartzite, size 110-80.0cm.									57									2		2									0.83	
31-12-05	39													93								1	2				Light Milky				0.57	Boulder (quartzite Gneiss) 38.14-39.00m (0.85m)
	40.00	1487.83									37										2	1						Partial	39.0m	527.6	1.43	

TEESTA URJA LIMITED . Annexure-5

GEOLOGICAL LOG OF DRILL HOLE

PROJECT	Teesta Stage-III, H.E.P.-North Sikkim	DEPTH OF HOLE	78.05 m.	BORE HOLE NO.	DH-02
LOCATION	Diaphragm Wall (Right Bank)	TYPE OF CORE BARREL	Double/ Triple Tube	SHEET NO.	5 of 8
FEATURE	Dam Site	DRILLING AGENCY	M/S Shivalk Geotech Services, Mohali	TYPE/MAKE OF MACHINE	Longyear-38/ Hydraulic Feed
GROUND ELEVATION	1527.83 m.	TYPE OF BIT	Diamond Core Bit.	BEARING OF HOLE	Vertical
COLLAR ELEVATION	1527.93 m.	CO-ORDINATES	N 14807.99, E 23548.99	PERIOD OF EXECUTION	16-12-2005 to 17-01-2006

Date	Depth of Drill Hole (m) Depth	Elevation (RL)	Lithology: Description of Strata	Log	Structural Conditions: Description of Joints	Log	Fracture Condition	Weathering Grade	Fracture Index (FI)	Percentage of Core Recovery: 0 - 20	20 - 40	40 - 60	60 - 80	80 - 100	R.Q.D: 0 - 25	25 - 50	50 - 75	75 - 100	Size of Core Pieces: <10mm	10 to 25mm	25 to 75mm	75 to 150mm	>150mm	Size of Hole	Size of Bit	Size of Casing (mm)	Depth of Water Level	Colour of Return Water	Drill Water Loss	Permeability: Test Section	Lugeon Value	Penetration Rate (cm/min.)	Special Observation/ Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
	40																																
01-01-06	41		River born material of cobbles and medium coarse gravels of medium grained Biotite Gneiss, garnetiferous Quartz-Biotite Gneiss, Quartzite. Size 0.5-22cm									44										2	1								1.25	Boulder (Garnetiferous Quartz- Biotite Gneiss) 42.20-42.50m (0.3mx)
												43										2									1.57	
02-01-06	42.00	1485.83										47										1	2					Light Grey		42.0m	648.9	1.21	
														82								2	2									1.52	Boulder (Garnetiferous quartz- Biotite Gneiss) 42.77-43.05m (1.18m)
	43		River born material boulders, cobbles with medium, coarse gravels of Garnetiferous-Quartz biotite Gneiss, size 1.50-1.18m										73										4									1.22	
	44				Overburden Strata												Overburden Strata																
	44.30	1483.53											63									1	2									1.35	
03-01-06	45		River born material of boulders, cobbles and few sub-angular, medium, coarse gravels of Quartzitic Gneisses, Quartzite size 15-21.0cm										72									1	2	NX									1.25	
												42									4								45.0m	944.0	1.56	
	46																								NWG Core Bit								
												50									1	1						Light Grey				1.33	Note:- Artesian Condition encountered at 49.60m depth Outflow @2.20-2.68 l/min
04-01-06	47.00	1480.83	River born material comprising of sub-angular, medium, coarse gravels, cobbles of silica, Quartzite, Quartzitic Gneiss, biotite Gneiss, size 0.5-8.0cm								34										1	1									2.50	
	48																															
05-01-06	48.60	1479.23									38								1										48.0m	310.4	3.75	
	49		Pale white Quartzite, very strong.		Other joint 48.98m-49°, slightly open joint surface reddish brown coloured,C-VIII	J1	FI-7	W1	3.68				62		11						3	2								6.4			Rock Started from 48.60m
06-01-06	49.60	1478.23	Pale white Quartzite strong to extremely strong		OJ 49.98m-39°, few spots of pale yellow on joint surface B-IV rough, undulatory open	J1	FI-5 FI-7	W0	3.32					100				81				1	2							3.0m	7.9	0.63	
	50																														7.6	0.88	

SGS

TEESTA URJA LIMITED

Annexure-6.

GEOLOGICAL LOG OF DRILL HOLE

PROJECT	Teesta Stage-III, H.E.P.-North Sikkim.	DEPTH OF HOLE	78.05 m.
LOCATION	Diaphragm Wall (Right Bank)	TYPE OF CORE BARREL	Double/ Triple Tube
FEATURE	Dam Site.	DRILLING AGENCY	M/S Shivalk Geotech Services, Mohali
GROUND ELEVATION	1527.83 m.	TYPE OF BIT	Diamond Core Bit
COLLAR ELEVATION	1527.93 m.	CO-ORDINATES	N 14807.99, E 23548.99

BORE HOLE NO	DH-02
SHEET NO	6 of 8
TYPE/MAKE OF MACHINE	Longyear-38/ Hydraulic Feed
BEARING OF HOLE	Vertical
PERIOD OF EXECUTION	16-12-2005 to 17-01-2006

Date	Depth of Drill Hole (m) Depth	Elevation (RL)	Lithology: Description of Strata	Log	Structural Conditions: Description of Joints	Log	Fracture Conditions	Weathering Grade	Fracture Index (FI)	Percentage of Core Recovery: 0 - 20	20 - 40	40 - 60	60 - 80	80 - 100	R.Q.D: 0 - 25	25 - 50	50 - 75	75 - 100	Size of Core Pieces: <10mm	10 to 25mm	25 to 75mm	75 to 150mm	>150mm	Size of Hole	Size of Bit	Size of Casing (mm)	Depth of Water Level	Colour of Return Water	Drill Water Loss	Permeability: Test Section	Lugeon Value	Penetration Rate (cm/min)	Special Observation/ Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
	50						FD-5 FD-7	WI	0.37					100				81				1	2								0.88	(*) may be Amphibolites/ Biotite Gneiss (medium grained) blackish grey 53.70-54.10m 54.80-60.30m.
07-01-06	50.30	1477.53	Pale white Quartzite, extremely strong.																													
	50.95	1476.88				J1	FD-5 FD-7	WI	7.69					100			72				1	1	2							6.5		
	51		--do--		No Joint		FD-5	WI	11.00					98				98					1							5.2	0.72	
	51.70	1476.13																												24.6		
	52		--do--		OJ 52.03m- 35°, C-VIII, slightly open, pale yellow, patches on the joint surface.	J1 U U	FD-4	WI	4.00					94				83				1	2					Light Milky		51.4	0.84	
	52.70	1475.13	--do--																											81.8	0.83	
	53				No Joint		FD-5	WI	8.00					100				94				1	2							49.2	0.71	
	53.20	1474.63	Pale white Quartzite upto 53.70m. Amphibolites to blackish grey with white very spots (53.70-54.10m) very strong.	Intrusive	Angle intrusion (60°, 70°) OJ 54.00m- 20°, yellowish brown to joint surface, Q-V from 53.95-54.05m	J1	FD-3	WI	3.33					98				84					1							23.5	0.82	
	54																															
08-01-06	54.10	1473.73	Blackish grey with white Pockets-Amphibolites (54.10-54.85m) very strong, Pale white Quartzite (54.85-54.95m)		OJ 54.20m- 10°, B-V. 54.80m- 70°, yellowish brown surface, B-V.	J1	FD-5 FD-7	WI-MWI	5.88					100		36						1	1			Greyish white		4.5	0.87	
	54.95																													3.0		
	55																													4.8	0.78	
	55.65	1472.18	Pale white Quartzite, very strong.		Joint 55.13m- 10°, B-V, slightly open	J1	FD-3	WI	11.43					100				100					2							3.2	0.63	
	56													100		34						1								4.1	0.66	
			Pale white Quartzite, strong.		OJ 56.80m- 50°, C-VIII, clean, 57.10m- 40°, clean, B-V, other joints are not in measurable condition.	J1	FD-1 Occ FD-5 FD-6	WI-MWI	12.89					97		43						2								0.63	
09-01-06	57													100	0			1									Light milky				0.55	
	57.40	1470.43	Pale white Quartzite, very strong.											97		33						1									0.63	
	58.05	1469.78				J2 J1	FD-5 FD-7	WI-MWI	6.15					97			52					1	1						22.2		
	58.90	1468.93	Pale white Quartzite (58.05-58.40m) strong. Amphibolites (*), very strong.			J2 J2 J1	FD-5	WI-MWI	7.05					94		43							2							15.8	0.86	
	59		Blackish grey with two white spots-Amphibolites, very strong.			J1 J1 J1	FD-1 FD-7	WI-MWI	8.88					95			66					1	1						13.9	0.83	
	59.75	1468.08	Quartz-Biotite Gneiss (*) upto 60.30m blackish grey, very strong.						7.75					90			38						2						14.8	0.81	
	60																													20.6	0.78	

NX

NWG Core Bit

No Casing Used

Partial

1 Nos

3 Nos

3 Nos

185

428

SGS

TEESTA URJA LIMITED. Annexure-8

GEOLOGICAL LOG OF DRILL HOLE

PROJECT	Teesta Stage-III, H.E.P.-North Sikkim.	DEPTH OF HOLE	78.05 m.
LOCATION	Diaphragm Wall (Right Bank)	TYPE OF CORE BARREL	Double/ Triple Tube
FEATURE	Dam Site.	DRILLING AGENCY	M/S Shivalk Geotech Services, Mohali
GROUND ELEVATION	1527.83 m	TYPE OF BIT	Diamond Core Bit.
COLLAR ELEVATION	1527.93 m	CO-ORDINATES	N 14807.99, E 23548.99

BORE HOLE NO.	DH-02
SHEET NO.	8 of 8
TYPE/MAKE OF MACHINE	Longyear-38/ Hydraulic Feed
BEARING OF HOLE	Vertical
PERIOD OF EXECUTION	16-12-2005 to 17-01-2006

Date	Depth of Drill Hole (m) Depth	Elevation (RL)	Lithology: Description of Strata	Log	Structural Conditions: Description of Joints	Log	Fracture Condition	Weathering Grade	Fracture Index (FI)	Percentage of Core Recovery: 0 - 20	20 - 40	40 - 60	60 - 80	80 - 100	R.Q.D: 0 - 25	25 - 50	50 - 75	75 - 100	Size of Core Pieces: <10mm	10 to 25mm	25 to 75mm	75 to 150mm	>150mm	Size of Hole	Size of Bit	Size of Casing (mm)	Depth of Water Level	Colour of Return Water	Drill Water Loss	Permeability: Test Section	Lugeon Value	Penetration Rate (cm/min)	Special Observation/ Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
13-01-06	70		Pale white Quartzite, strong to very strong.	C	BF 70.45m- 25°- C-VSI, S-O., The joint is dry but shows evidence of water flow such as staining (yellowish brown.)	J1	FD-1 Occ FD-5	WII	4.76					100				100				1	1	NX	NXM Core Bit	No Casing		Light Milky	Low	10m	86.4	0.89	Cavity 70.03-70.13m
	71																													72.9		
	72.00	1455.83	Pale white Quartzite, very strong.		BJ 71.61/ 71.65m- 0°- Yellowish brown staining, it is the evidence of water flow on this drill hole.	J3 J3	FD-7	WI-WII	6.15					89			75					2									0.80	Note:- Artesian condition out flow varies from 2.835-10.2 l/min.
	73.00	1454.83			No loss		FD-1	WI	2.00					100				100				1	1							0.87	
16-01-06	74.00	1453.83	Pale white Quartzite, strong to very strong.		CJ 71.30m- 0/P- Yellowish brown staining B-IV CJ 71.79m- 30°, Brown staining, very thin staining of brown powder. S-IV	J1 J1	FD-1 Occ FD-5	WI-WII	8.00					100			66					1								51.0	0.89	
	75			C	Non encounter conditions		FD-7	WI-WII	13.50					84	0														50.6	1.10	
	75.60	1452.23	Pale white Quartzite, strong		FJ 74.87m- 30°- Open, thinc, pale yellow, staining, S-V. CJ 75.31m- 10°, pale yellow staining, B-V, open.	J2 J1 J1	FD-6	WI-WII	7.50					98			55					2								46.0	1.23	Cavity 74.60-74.70m (yellowish brown).
	76		Pale white Quartzite medium strong to strong.		CJ 76.05m- 20°- yellowish brown staining FJ 76.05m- 10°, yellowish brown staining, B-IV, open	J2	FD-6	WII Occ WI	18.40					98	23							1								52.1	0.90	
	77.00	1450.83			CJ 76.75m- 20°, yellowish brown staining, B-V. CJ 77.25m- 20°, Yellowish brown staining.	J1	FD-6	WII Occ WI	17.00					95		26						1	1							47.1	0.90	Cavity 76.70-76.75m.
17-01-06	78.05	1449.78	Blackish with white tiny patches. Biotite Gneiss.	Intrusion		J1 J1 J1	FD-7 Occ FD-5	WI	10.75					99		26						1	1				Light Grey			67.2	0.90	
	79																													68.2	0.90	
	80				Drill hole completed upto 78.05m depth.																											0.94	

SGS

TEESTA URJA LIMITED. Annexure-7

GEOLOGICAL LOG OF DRILL HOLE

PROJECT	Teesta Stage-III, H.E.P.-North Sikkim	DEPTH OF HOLE	78.05 m.
LOCATION	Diaphragm Wall (Right Bank)	TYPE OF CORE BARREL	Double/ Triple Tube
FEATURE	Dam Site	DRILLING AGENCY	M/S Shivalik Geotech Services, Mohali
GROUND ELEVATION	1527.83 m.	TYPE OF BIT	Diamond Core Bit.
COLLAR ELEVATION	1527.93 m.	CO-ORDINATES	N 14807.99, E 23548.99

BORE HOLE NO.	DH-02
SHEET NO.	7 of 8
TYPE/MAKE OF MACHINE	Longyear-38/ Hydraulic Feed
BEARING OF HOLE	Vertical
PERIOD OF EXECUTION	10-12-2005 to 17-01-2006

Date	Depth of Drill Hole (m) Depth	Elevation (RL)	Lithology: Description of Strata	Log	Structural Conditions: Description of Joints	Log	Fracture Condition	Weathering Grade	Fracture Index (FI)	Percentage of Core Recovery: 0 – 20	20 – 40	40 – 60	60 – 80	80 – 100	R.Q.D: 0 – 25	25 – 50	50 – 75	75 – 100	Size of Core Pieces: <10mm	10 to 25mm	25 to 75mm	75 to 150mm	>150mm	Size of Hole	Size of Bit	Size of Casing (mm)	Depth of Water Level	Colour of Return Water	Drill Water Loss	Permeability: Test Section	Permeability: Lugeon Value	Penetration Rate (cm/min.)	Special Observation/ Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
	60		Pale white Quartzite from 60.35m, strong.		OJ 59.03m- 20°, Brown staining, S.O., C-VII OJ 60.35m- 05°, S.O., B-V, yellowish brown staining	J1 J1	FD-5, Occ. FD-1	WI	7.78					96			58					2								0.78	Note:- Artesian condition outflow varies from 2.85-6.75 litre/min.
10-01-06	60.65	1467.18																										Light Grey					
	61				OJ 60.72m- 20°, B-V, yellowish brown staining OJ 60.83m- 12°, brown staining, B-V	J1	FD-6	WI-WII	18.95					95		42						2	1							27.1	0.83		
	62				OJ 62.85m- 20°, yellowish brown staining C-VII. OJ 62.52m- 40°-yellowish brown staining, B-V	J1 J1	FD-5, Occ. FD-1	WI-WII	12.00					98		45									2						26.5 23.6	0.80		
	63				OJ 62.78m- 60°- slight open, yellowish brown staining, B-V	J1	FD-5, Occ. FD-9	WI-WII	11.85					96			57					2	2							25.1 24.3	0.79		
11-01-06	64		Pale white Quartzite strong to very strong		OJ 63.85m- 20°, yellowish brown staining, C-VII.	J1	FD-6	WI	13.56					100		43							2	1					24.9	0.72		
					OJ 64.35m- 60°, clean, C-VII, tight	J1	FD-7	WII	17.14					100	0				1										34.4	0.43		
	65				OJ 64.85m- 30°, yellowish brown staining open, C-VII. OJ 64.96m- 30°-Pale yellow staining, C-VII, open	J1 J1	FD-5, Occ. FD-7	WII-WI	13.89					92		38									2						28.5 32.4	0.70 0.71		Cavity 65.17- 65.22m
12-01-06	66				OJ 65.16m- 20°-yellowish brown staining, open, C-VII/ No Joint	J1	FD-5	WII	13.66					95			88					1	2							50.7	0.71		Cavity 66.13- 66.60m
13-01-06	66.60	1461.22			No Joint		FD-3	WI	0.00					84			84						1									
	67		Pale white Quartzite strong.		OJ 66.86 & 66.74m 10°, shiny, B-IV OJ 67.08m- 10°- Mod. Open yellowish brown staining, B-IV OJ 67.24m- 45°-yellowish brown staining	J1 J1 J1	FD-6	WI-WII	15.55					99		33						1	1							43.7	0.82		
14-01-06	68				OJ 67.85m- 10°- tight, clean A-I	J1	FD-3	WII	12.22					100			78					1	2							37.8	0.63		
	68.80	1459.03			OJ 68.33m- 10°-to- C-VII, clean, 2 sets no-ne smooth undulating	J2	FD-7	WI	13.00					90			90						1							-	0.55		
	69		Pale white Quartzite strong to very strong.		No Joint		FD-3, Occ. FD-5	WI, WII	0.29					93	0				1										-	0.50		
	70.00				OJ 70.17m- 10°- Yellowish brown staining, A-I	J1	FD-5, Occ. FD-1	WII	6.67					94	16							1								-	0.75		
														99			66					1	1								0.78	

NX

NWG Core Bit

NWG Core

HMLC Core Bit

NXM Core

No Casing Used

Light Milky

Partial

Low

3.0m

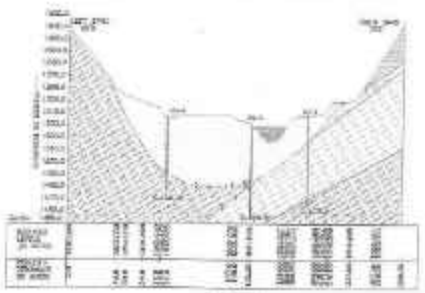
3.0m

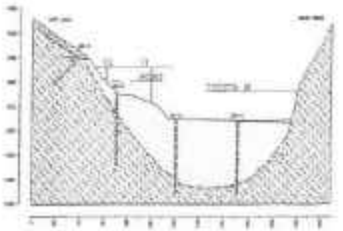
3.0m

3.0m

TEESTA URJA LIMITED
TEESTA STAGE-III H. E. PROJECT
ENDURTE ENGINEERS PRIVATE LIMITED
GEOLOGICAL PLAN SHOWING LAYOUT
OF DAM AND APPURTENANT STRUCTURES
PLATE NO.-1
N

PLATE NO.-1a



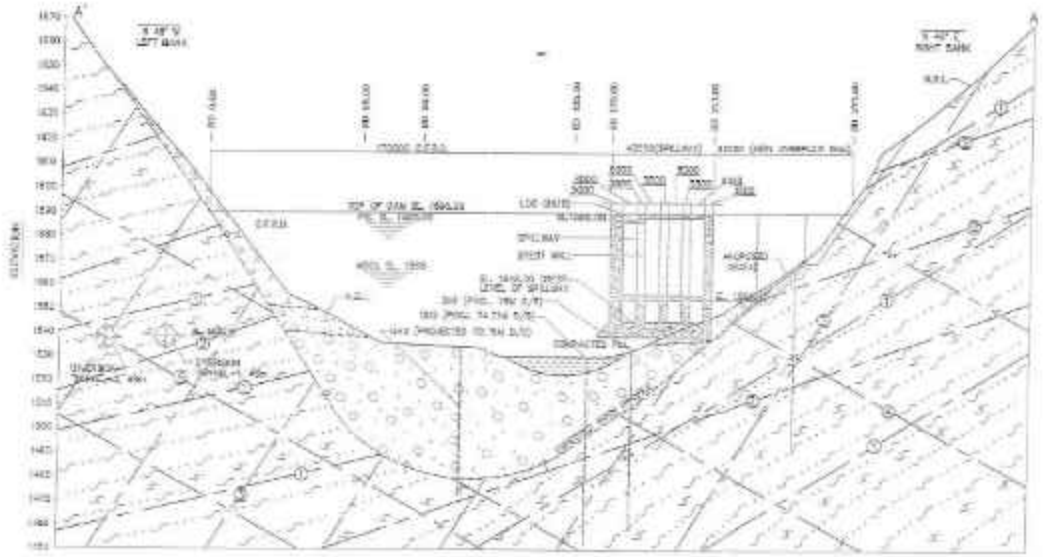


NOTE:
THE DRAWING IS BASED ON THE GEOLOGICAL INFORMATION AVAILABLE IN THE EARLIER DPR OF DHC WATER TEST

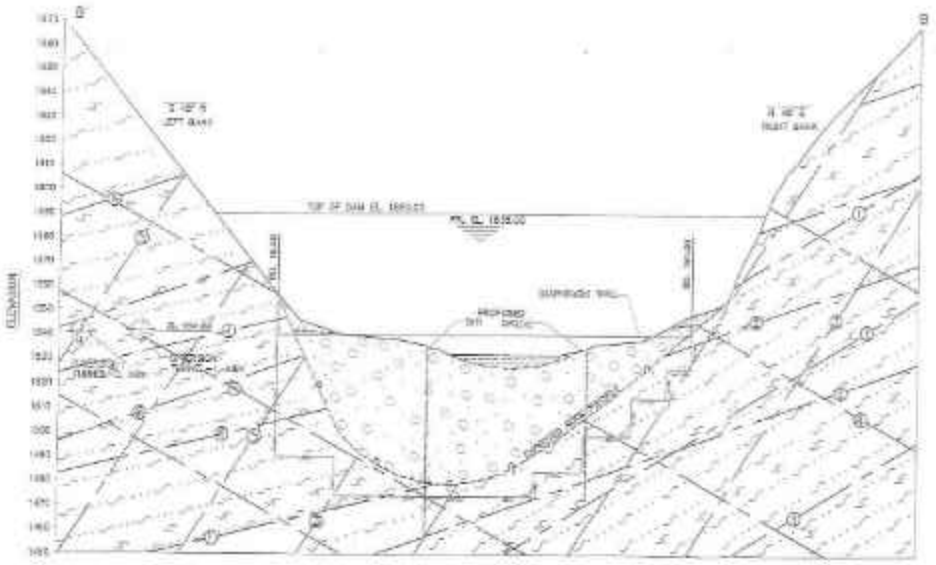
Client	TEESTA URJA LIMITED
Project	TEESTA STAGE-III H. E. PROJECT
Consultant	ERUDITE ENGINEERS PRIVATE LIMITED
Drawing	PLAN AND GEOLOGICAL SECTIONS OF ALTERNATIVE DAM AXES
Drawn :	Approved :
Date : Feb 2008	T3-P-04-R1

~~19~~

PLATE NO.–3



SECTION A-A' (DAM AXIS)



SECTION B-B' (DIAPHRAGM WALL)

INDEX

CLASSIFICATION OF MAJOR DISCONTINUITY

DISC. NO.	DIP/DIP DIRECTION	SPACING	PERSISTENCE	APERTURE	CONDITION
J1	030–035/30–40	20–30 CM	3–4 M	0.5–1 MM	UNDULATING PLANAR
J2	180/80	1–2 M	10 M	10–20 CM OPEN	PLANAR
J3	090/30	1–1.5 M	1.5–2 M	HEAVY	SMOOTH PLANAR

DISC. NO.	DIP/DIP DIRECTION	SPACING	PERSISTENCE	APERTURE	CONDITION
J1	040–050/50–60	20–25 CM	5–6 M	0.5–1 MM	UNDULATING PLANAR
J2	180/70	1–1.5 M	10 M	15–20 CM OPEN	PLANAR
J3(a)	120/70	1–1.5 M	1.5–2 M	THIN	SMOOTH PLANAR
J3	090/30	2 M	0–10 M	0.5–1 MM	SLIGHTLY UNDULATING

NOTE :– THE SEEPAGE CONTINUITY IN KHEA CHANNEL & REACH 2 TOOTH CUT HAS BEEN TO CHANGE, BASED ON PREVIOUS DATA FROM OLD DRILL HOLES DONE AT DAM AXIS-1, PLANNED FEASIBILITY STAGE INVESTIGATIONS.

SCALE :–

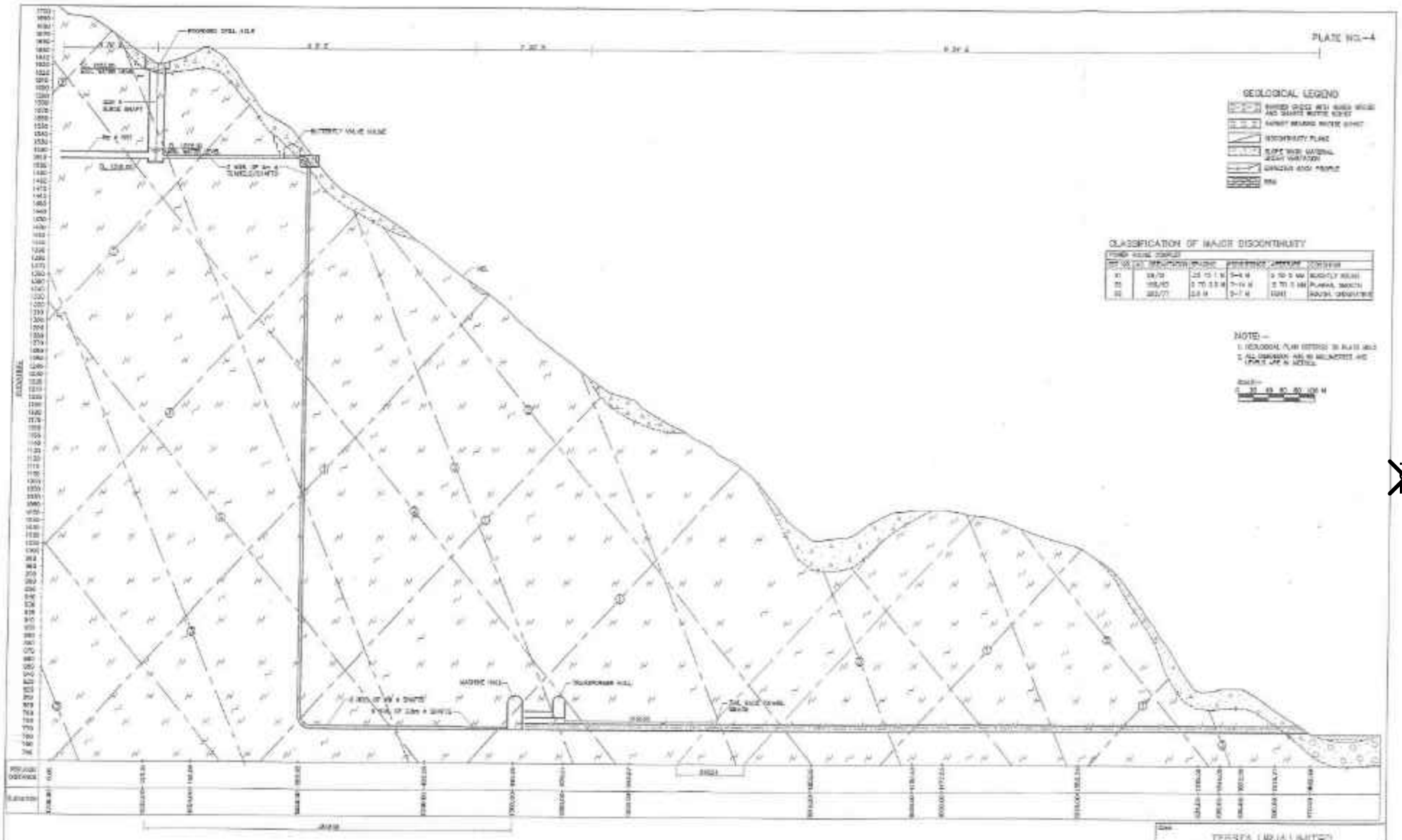
Client	TEESTA URJA LIMITED
Project	TEESTA STAGE-III H. E. PROJECT
Consultant	ERUDITE ENGINEERS PRIVATE LIMITED
Drawing	GEOLOGICAL SECTION A-A' ALONG PROPOSED DAM AXIS & B-B' ALONG DIAPHRAGM WALL
Drawing No.	T3-P-GEO-02-R1
Rev.	Rev. - 1

~~180~~

433

GEOLOGICAL PLAN OF
POWER HOUSE AREA
TEESTA URJA LIMITED
TEESTA STAGE-III H. E. PROJECT
ERUDITE ENGINEERS PRIVATE LIMITED
INDEX
N
PLATE NO.-5

PLATE NO.-4



GEOLOGICAL SECTION C-C'

Client	TEESTA URJA LIMITED
Project	TEESTA STAGE-III H. E. PROJECT
Consultant	ERUDITE ENGINEERS PRIVATE LIMITED
Title	GEOLOGICAL SECTION ALONG SURGE SHAFT POWER HOUSE AND TRT
Drawing No.	TS-F-GEO-04-R1
Rev.	Rev-1

~~103~~

SURFACE GEOLOGICAL MAP OF THE PROJECT AREA
OF
TEESTA HYDEL PROJECT STAGE III

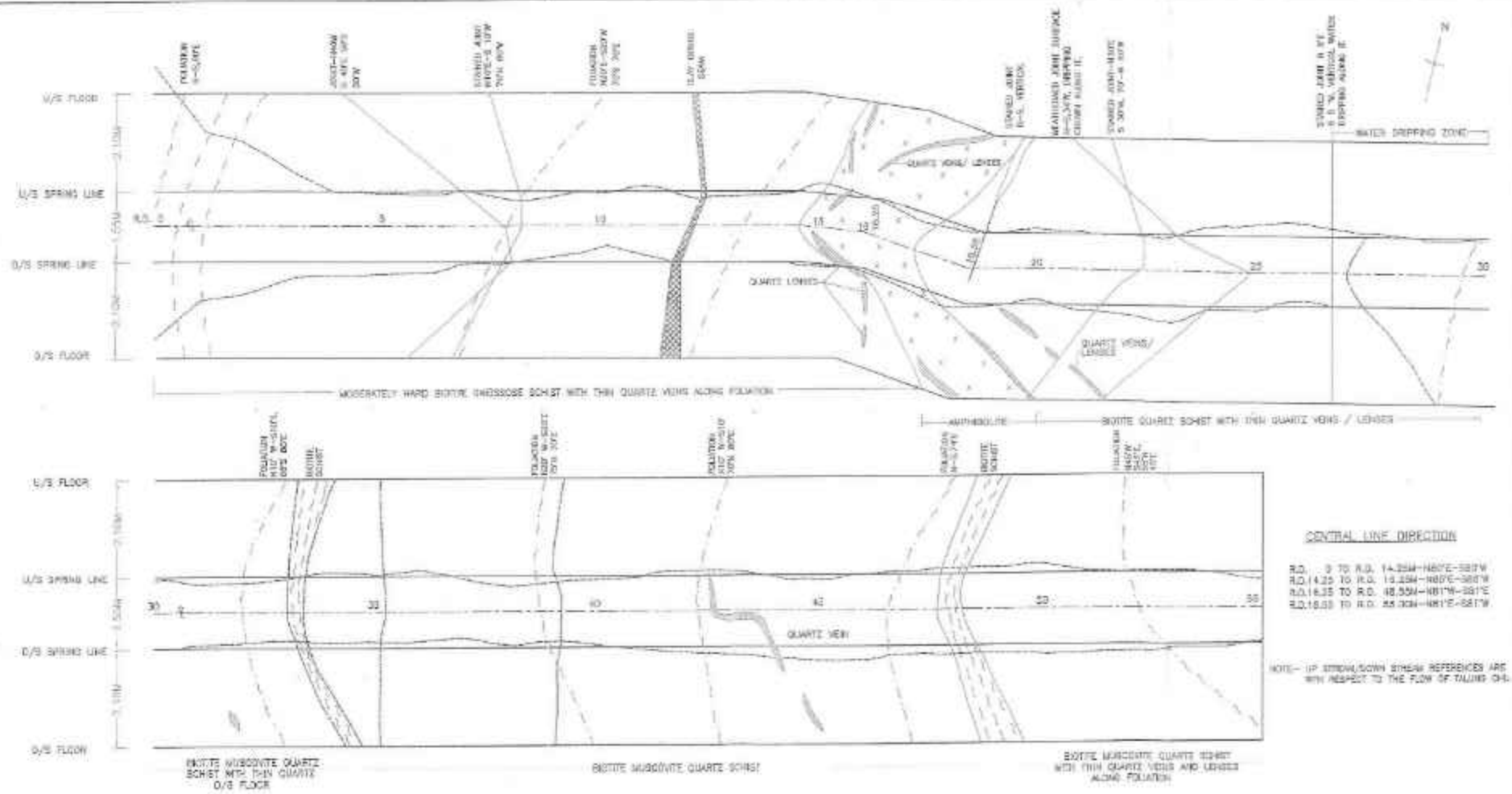
GEOL PLATE-3.4

TEESTA HYDRO-ELECTRIC PROJECT STAGE-III NORTH SIKKIM

GEOL PLATE-3.2

THREE DIMENSION GEOLOGICAL LOG OF EXPLORATORY DRIFT TO POWER HOUSE BETWEEN R.D.-0M AND 56M

0 1 2 3 METRE

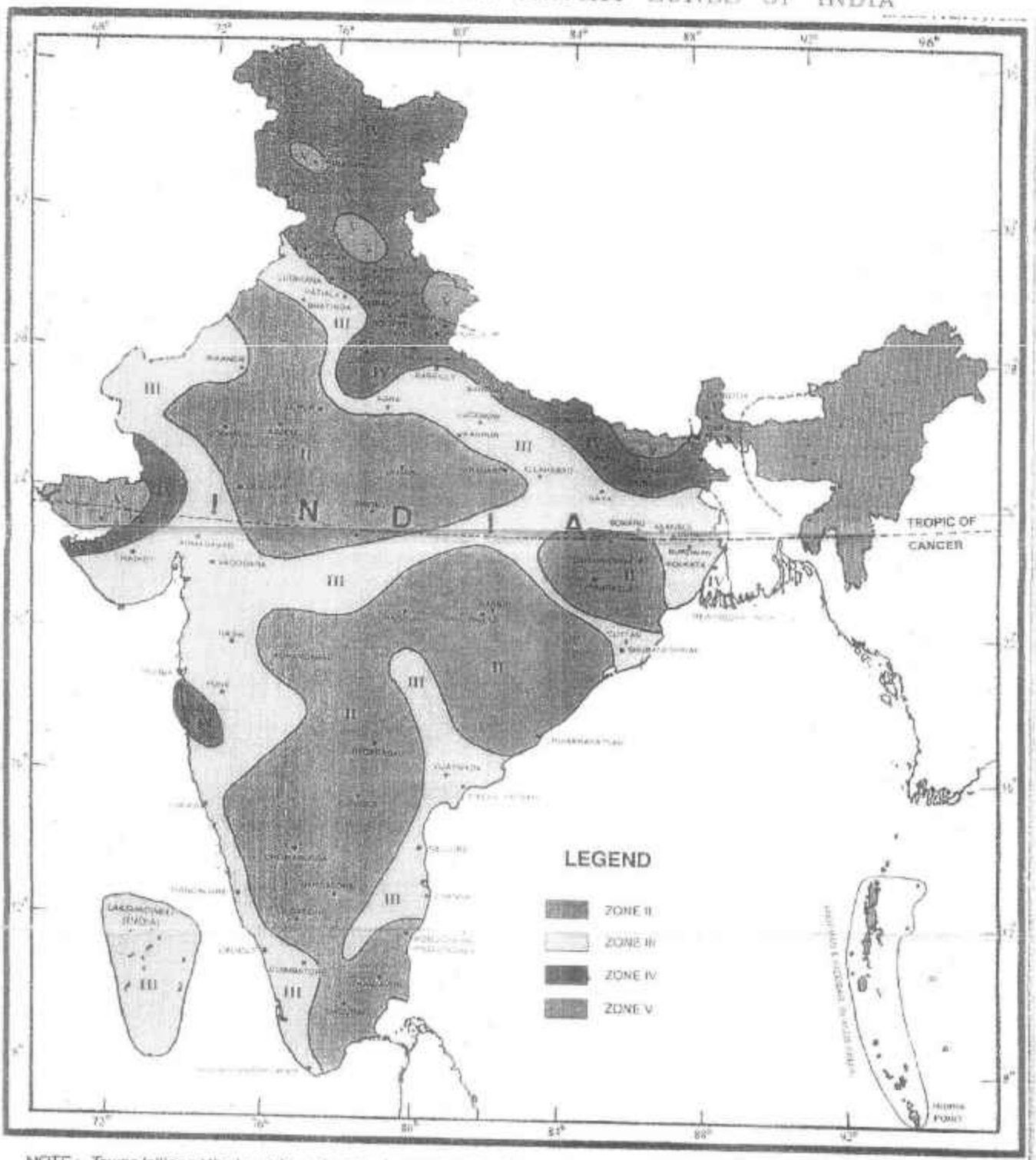


CENTRAL LINE DIRECTION

R.D. 0 TO R.D. 14.25M–N60°E–S30°W
R.D.14.25 TO R.D. 18.35M–N60°E–S30°W
R.D.18.35 TO R.D. 48.55M–N81°W–S81°E
R.D.48.55 TO R.D. 55.30M–N81°E–S81°W

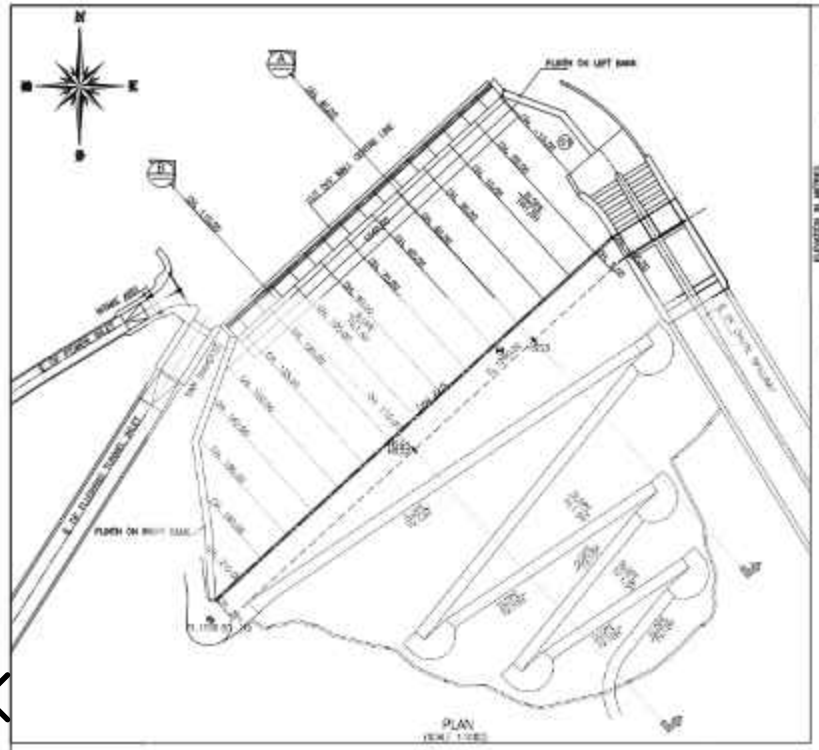
NOTE– UP STREAM/DOWN STREAM REFERENCES ARE WITH RESPECT TO THE FLOW OF TAILING CHL

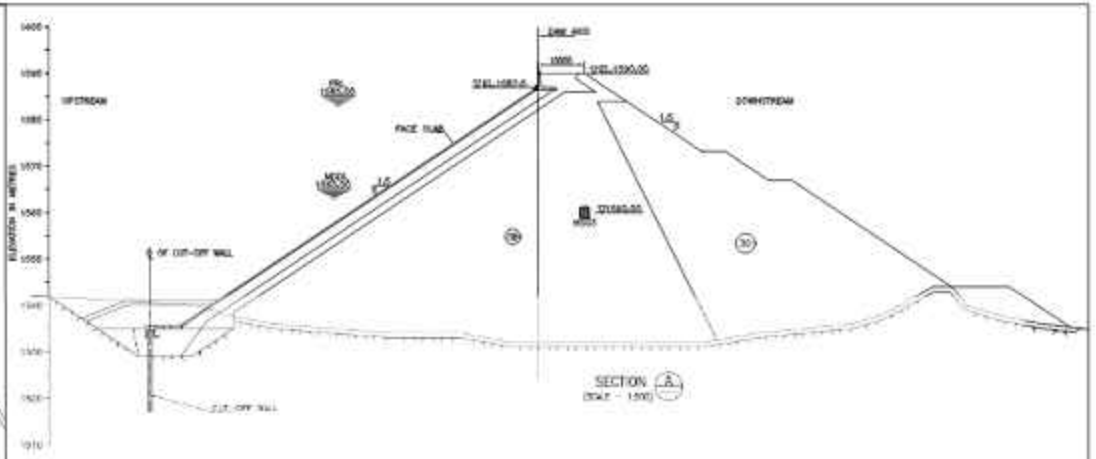
MAP OF INDIA SHOWING SEISMIC ZONES OF INDIA



NOTE : Towns falling at the boundary of zones demarcation line between two zones shall be considered in High Zone.

ANNEXURE-E2





NOTES :-

1. ALL DIMENSIONS ARE IN MILLIMETERS & ELEVATIONS IN METERS UNLESS OTHERWISE SPECIFIED.
2. THIS DRAWING IS MEANT FOR INSTRUMENTATION DETAILS OF HYDRAULIC SETTLEMENT GAUGE.
3. INSTALLATION DETAILS OF HYDRAULIC SETTLEMENT GAUGES FROM THE MANUFACTURER/SUPPLIER SHALL BE SUBMITTED TO ENGINEER-IN-CHARGE FOR APPROVAL.
4. MINOR MODIFICATION IN THE LOCATION OF INSTRUMENTS SHOWN MAY BE MADE TO SUIT SITE CONDITIONS.
5. MONITORING FREQUENCY SHALL BE STIPULATED BY THE ENGINEER-IN-CHARGE.
6. FINAL LAYING OF THE TERMINAL STRUCTURES IN LINE WITH TELEMETRY SPECIFICATIONS SHALL BE PROVIDED BY MANUFACTURER/ CONTRACTOR AND SHALL BE SUBJECTED TO ENGINEER-IN-CHARGE'S APPROVAL.
7. FOR LOCATION OF INSTRUMENTS REQUIRED TO MONITOR FACE CONSTRUCTION BEHAVIOUR OF THE DAM SUCH AS JOINT MOVEMENTS, PIEZOMETERS AND SURFACE SETTLEMENT PINS(REFER DRAWING SHALL BE REFERRED).
8. REFER LATEST REVISION FOR REFERENCE DRAWINGS.

REFERENCE DRAWING :-

1. 73-300-41-00-002 DAM COMPLEX, CONCRETE FACE ROCK FILL DAM, GENERAL ARRANGEMENT PLAN
2. 73-300-41-00-008 DAM COMPLEX, CONCRETE FACE ROCK FILL DAM, GENERAL ARRANGEMENT, CHAINAGE SECTIONS (SHEET 1 OF 2, SHEET 2 OF 2)
3. 73-300-41-00-009 DAM COMPLEX, CONCRETE FACE ROCK FILL DAM, GENERAL ARRANGEMENT, L-SECTION

FOR CONSTRUCTION

SCALE: 1:500

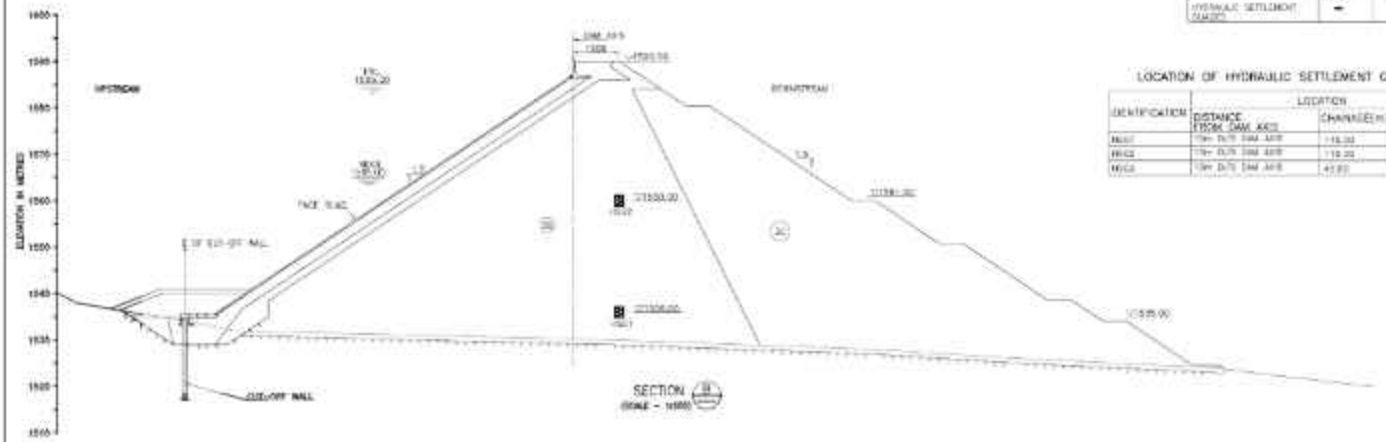
SCALE: 1:1000

LEGEND :-

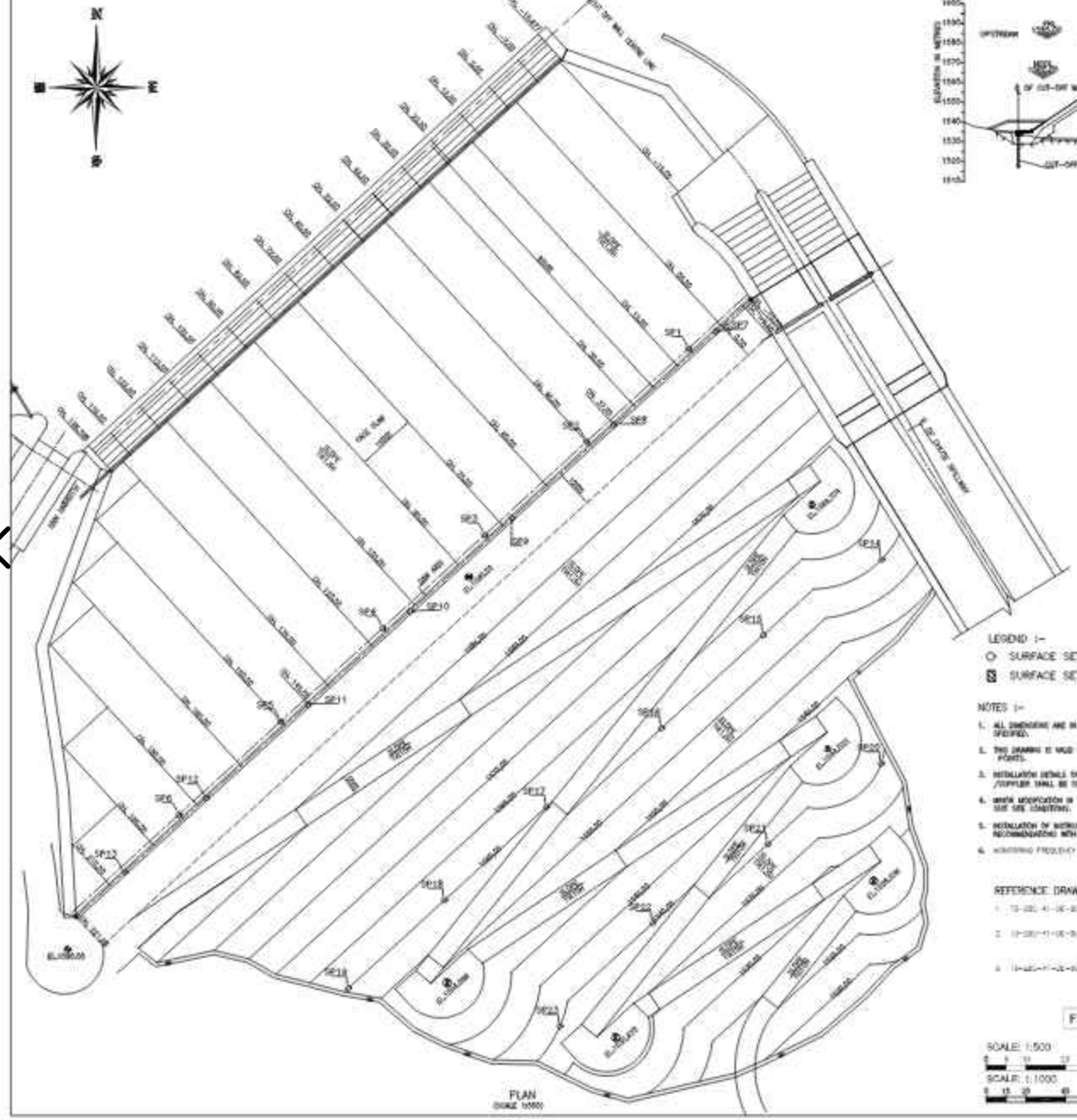
INSTRUMENT	SYMBOL	
	PLAN	SECTION
HYDRAULIC SETTLEMENT GAUGES	▬	■

LOCATION OF HYDRAULIC SETTLEMENT GUAGES

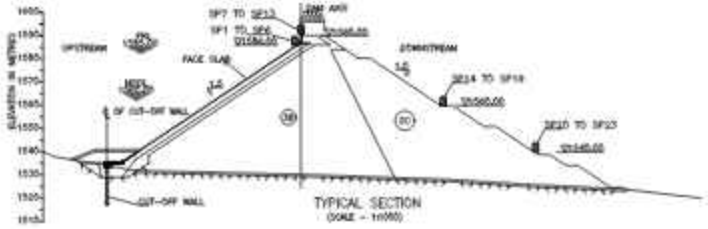
IDENTIFICATION	LOCATION		
	DISTANCE FROM DAM AXIS	CHAINAGE(m)	ELEVATION(m)
HSG1	15m D/S DAM AXIS	115.00	1538.00
HSG2	15m D/S DAM AXIS	115.00	1550.00
HSG3	15m D/S DAM AXIS	43.00	1550.00



CLIENT	TEESTA URJA LIMITED
PROJECT	TEESTA STAGE-III H. E. PROJECT
CONSULTANT	ENERGY INFRATECH PRIVATE LTD.
DRAWING	DAM COMPLEX CONCRETE FACE ROCK FILL DAM INSTRUMENTATION HYDRAULIC SETTLEMENT GAUGE
DRAWN : AKG	REVIEWED : A. K. SARKAR
DESIGN : A. P. TULSHYAN, M. K. GUPTA	APPROVED : R. SETHI
DRAWING NO : 73-300-41-00-012	REV NO : 1
DATE : MARCH 2010	ORIGINAL PRINT SIZE : A0



PLAN
(SCALE 1:500)



TYPICAL SECTION
(SCALE - 1:1000)

LOCATION OF SURFACE SETTLEMENT POINTS

IDENTIFICATION	CHAINAGE (m)	ELEVATION (m)	LOCATION DESCRIPTION
SP1	15.00	1586.00	(1.0m U/S OF DAM AXIS) ON FACE SLAB
SP2	40.00	1586.00	(1.0m U/S OF DAM AXIS) ON FACE SLAB
SP3	80.00	1586.00	(1.0m U/S OF DAM AXIS) ON FACE SLAB
SP4	115.00	1586.00	(1.0m U/S OF DAM AXIS) ON FACE SLAB
SP5	155.00	1586.00	(1.0m U/S OF DAM AXIS) ON FACE SLAB
SP6	195.00	1586.00	(1.0m U/S OF DAM AXIS) ON FACE SLAB
SP7	3.00	1591.00	(DAM AXIS) TOP OF PARAPET WALL
SP8	37.00	1591.00	(DAM AXIS) TOP OF PARAPET WALL
SP9	72.00	1591.00	(DAM AXIS) TOP OF PARAPET WALL
SP10	107.00	1591.00	(DAM AXIS) TOP OF PARAPET WALL
SP11	142.00	1591.00	(DAM AXIS) TOP OF PARAPET WALL
SP12	177.00	1591.00	(DAM AXIS) TOP OF PARAPET WALL
SP13	205.00	1591.00	(DAM AXIS) TOP OF PARAPET WALL
SP14	10.00	1560.00	(71.02m U/S OF DAM AXIS)
SP15	45.00	1560.00	(64.88m U/S OF DAM AXIS)
SP16	80.00	1560.00	(64.88m U/S OF DAM AXIS)
SP17	115.00	1560.00	(59.94m U/S OF DAM AXIS)
SP18	155.00	1560.00	(59.94m U/S OF DAM AXIS)
SP19	195.00	1560.00	(59.94m U/S OF DAM AXIS)
SP20	45.00	1540.00	(109.09m U/S OF DAM AXIS)
SP21	80.00	1540.00	(104.71m U/S OF DAM AXIS)
SP22	115.00	1540.00	(99.83m U/S OF DAM AXIS)
SP23	155.00	1540.00	(103.22m U/S OF DAM AXIS)

LEGEND :-

- ○ SURFACE SETTLEMENT POINT IN PLAN
- ⊠ SURFACE SETTLEMENT POINT IN SECTION

NOTES :-

1. ALL DIMENSIONS ARE IN MILLIMETERS & ELEVATIONS IN METERS UNLESS OTHERWISE SPECIFIED.
2. THIS DRAWING IS VALID FOR INSTRUMENTATION DETAILS OF SURFACE SETTLEMENT POINTS.
3. INSTALLATION DETAILS OF SURFACE SETTLEMENT POINTS FROM THE MANUFACTURER /SUPPLIER SHALL BE SUBMITTED TO ENGINEER-IN-CHARGE FOR APPROVAL.
4. WHERE MODIFICATION IN THE LOCATION OF INSTRUMENTS SHOWN MAY BE MADE TO SUIT SITE CONDITIONS.
5. INSTALLATION OF INSTRUMENTS SHALL BE CARRIED OUT AS PER MANUFACTURER'S RECOMMENDATIONS WITH PRIOR APPROVAL OF ENGINEER-IN-CHARGE.
6. MONITORING FREQUENCY SHALL BE ESTABLISHED BY THE ENGINEER-IN-CHARGE.

REFERENCE DRAWING :-

1. T3-DEC-41-00-007 — DAM COMPLEX, CONCRETE FACE ROCK FILL DAM, GENERAL ARRANGEMENT, PLAN
2. T3-DEC-41-00-008 — DAM COMPLEX, CONCRETE FACE ROCK FILL DAM, GENERAL ARRANGEMENT, CROSS SECTIONS (SHEET 1 OF 2, SHEET 2 OF 2)
3. T3-DEC-41-00-009 — DAM COMPLEX, CONCRETE FACE ROCK FILL DAM, GENERAL ARRANGEMENT, DETAILS

FOR CONSTRUCTION

SCALE: 1:500

SCALE: 1:1000

REV.	DRN.	DES.	REVW.	APPD.	DATE	DESCRIPTION

CLIENT :
TEESTA URJA LIMITED

PROJECT :
TEESTA STAGE-III H. E. PROJECT

DESIGNERS :
ENERGY INFRATECH PRIVATE LTD.

TITLE :
DAM COMPLEX
CONCRETE FACE ROCK FILL DAM
INSTRUMENTATION
SURFACE SETTLEMENT POINTS

DRAWN : ANIL — REVIEWED : K. K. SARKAR

DESIGNED : A. P. TILE (SUPERVISION), M. K. GUPTA — APPROVED :

DRAWING NO. : T3-DEC-41-00-013 — REV. NO. : R0

DATE : MARCH 2010 — ORIGINAL PRINT SIZE : A0

TEESTA URJA LIMITED

(A Government of Sikkim Enterprise)

TEESTA-III H.E. PROJECT (6 x 200 MW)

(SIKKIM)

PROCEDURE FOR INITIAL WATER FILLING OF RESERVOIR & WATER CONDUCTOR SYSTEM AND EVACUATION PLAN

(Document No: T3-WAP-MAN-001)

AUGUST–2016

वाप्कोस लिमिटेड
WAPCOS LIMITED

WAPCOS LIMITED,
76-C, Institutional Area, Gurgaon-122015 (Haryana)
Tel: (+91-124) 2399421 (16 lines)
Fax :(+91-124) 2397392
E-mail: mail@wapcos.gov.in

TABLE OF CONTENTS

1. INTRODUCTION 1
2. CRITERION FOR INITIAL FILLING OF RESERVOIR 2
2.1 Initial Filling Criteria for Earthen Dams by CWC 2
2.2 Initial Filling Criteria for Earthen Dams as per BIS: 3
3. CRITERIA FOR INITIAL FILLING OF WATER CONDUCTOR SYSTEMS (WCS): 3
3.1 Criterion for Initial filling of Pressure Tunnel (WCS) as per BIS 4
3.2 Criterion for Initial Filling of Pressure Tunnel (WCS) as per ASCE: 4
4. INSPECTION OF STRUCTURES BEFORE INITIAL FILLING 5
4.1 Reservoir 5
4.2 Concrete Faced Rock-fill Dam (CFRD) 5
4.3 Right Bank Flushing Tunnel (RBFT) 6
4.4 Diversion/ Spillway Tunnel-1 and Spillway Tunnel- 2 6
4.5 Chute Spillway 6
4.6 Power Intake 6
4.7 De-silting Chambers 6
4.8 Head Race Tunnel and Surge Shaft 7
4.9 Butterfly Valve 7
4.10 Pressure Shafts 7
4.11 Power House Cavern 8
4.12 Tail Race Tunnel and Outlet 8
5. STAGE-DISCHARGE CURVES (RATING CURVES) OF VARIOUS STRUCTURES 8
I. Discharge Rating curve of right bank Flushing Tunnel 9
II. Discharge Rating curve of Power Tunnel Intake 9
III. Discharge Rating curve of Left Bank Spillway Tunnel (LBST) NO.-1 9
IV. Discharge Rating curve of Left Bank Spillway Tunnel (LBST) NO.-2 10
V. Discharge Rating curve of Left Bank Chute Spillway 10
6. PLAN FOR INITIAL FILLING RESERVOIR AND WATER CONDUCTOR SYSTEM 11
6.1 Day-1: Filling of De-silting Chambers upto d/s HRT invert EL. 1546.90 m 12
6.2 Day-2: Filling of HRT from EL. 1506.25 to EL. 1514.25 m 12
6.3 DAY-3 FILLING 13
6.3.1 Filling of HRT from EL. 1514.25 to EL. 1522.25 m 13
6.3.2 Filling of Pressure Shaft from EL. 766.0 to EL. 816.0 m 13
6.4 DAY-4 FILLING 14
6.4.1 Filling of HRT from EL. 1522.25 to EL. 1530.25 m 14
6.4.2 Filling of Pressure Shaft from EL. 816.0 m to EL. 865.0 m 14
6.5 DAY-5 FILLING 15
6.5.1 Filling of HRT from EL. 1530.25 m to EL. 1538.25 m 15
6.5.2 Flushing of Pressure Shaft 15
6.6 DAY-6 FILLING 15
6.6.1 Filling of HRT from EL. 1538.25 m to EL. 1546.25 m 16

6.6.2 Re-filling of Pressure shaft from EL. 766.0 m to EL. 816.0 m 16
6.7 DAY-7 FILLING 16
6.7.1 Filling of HRT from EL. 1546.25.25 m to EL. 1556.50 m 16
6.7.2 Re-filling of Pressure Shaft from EL. 816.0 m to EL. 865.0 m 16
6.8 DAY-8 to DAY-13 FILLING 16
6.9 DAY-14 FILLING & DAY-15 17
6.10 DAY-16 to DAY-45: FILLING OF RESERVOIR UPTO FRL 18
7. SURVEILLANCES PLAN DURING INTIAL FILLING OF RESERVOIR AND WCS 21
8. EVACUATION OF RESERVOIR 21
9. RESERVOIR REGULATION DURING INITIAL FILLING 24
10. MONITORING: 25
ANNEXURES (1 TO 10) 34
APPENDIX (A, B, C, D, E, F & G) 45
DRAWING OF VARIOUS STRUCTURES 64

1. INTRODUCTION

Teesta-III Hydro Electric Project is a run-of-the-river scheme with diurnal storage to generate 1200 MW power by utilizing the 175 cumecs discharge of River Teesta and head between EL.1585.0 m and EL.768.0 m. The Project is being developed by Teesta Urja Limited (TUL), a Special Purpose Vehicle, which is a Government of Sikkim Enterprise. The diversion dam has been constructed across Teesta River at location about 400m downstream of the confluence of Lachen Chu and Lachung Chu. The diverted water would be carried to the powerhouse through 7.5m diameter and 13.8 km long head race tunnel followed by two pressure shafts. The dam site is located near Chungthang Town and Powerhouse site is located near to Mangan, the District Town in the State of Sikkim. The powerhouse is of underground type and is equipped with 6 units of 200MW each vertical Pelton type turbines. The turbines would run under a rated head of 780.33m. The water released from the turbines would be carried through a tail race tunnel to join back the Teesta River at a point slightly upstream of the confluence with Talungchu.

The Project has the following main components:

- Concrete Faced Rock-fill Dam (CFRD)
- Spillways to surpass 7000 cumecs comprises two bays of Chute Spillways, 2 Nos. of Spillway Tunnels on left bank and 1 No. of Flushing cum Spillway Tunnel on right bank
- One No. of Power Intake and 2 Nos. of De-silting Chamber
- Horse-shoe shaped 7.5 m dia. HRT on right bank of Teesta River
- Surge Shaft with restricted orifice
- Two Pressure Shafts
- Underground Powerhouse housing 6 Units each 200 MW generating equipment's using 175 cumecs of discharge and 780.33 m head
- 8.0 x 8.2 m, D-Shaped Tail Race Tunnel

On successful completion, the Project would provide **1200 MW peaking power and 5228 MU of design energy.** The detailed salient features of the Project are given in **Appendix-A.**

The main dam comprises of a compacted rock fill section with a concrete face slab on the upstream slope and a concrete toe slab. Plastic diaphragm wall is provided from the upstream toe of dam going into bedrock, to act as a foundation seepage barrier. The top of dam has been kept at 1590.0m, which gives a free board of 5m above the FRL. The total length of dam at its top including spillway is about 260 m. The 32 m long spillway is located in such a way that the flow joins the main river channel on the downstream. Dam (CFRD) is provided between the spillway and the right abutment. The Dam (CFRD) of 60.0 m high is resting over RBM in its entire length with upstream cut-off wall of 65m maximum depth.

The works of the Teesta-III HEP are nearing completion and as on the month ending February 2016, 95.32% of works have been completed. The remaining works is expected to be complete by the end of current monsoon season.

The scope of this document covers the methodology of initial water filling of Reservoir and Water Conductor System of Teesta-III Hydroelectric Project. The Surveillance plan during the Water Filling in Reservoir & Water Conductor System is also included in the document.

2. CRITERION FOR INITIAL FILLING OF RESERVOIR

The "initial reservoir filling" is defined as a deliberate impoundment to meet Project purposes. The initial reservoir filling is the first test of the dam to perform the function for which it was designed. In order to monitor this performance, the rate of filling should be controlled to the extent feasible to allow as much time as needed for a predetermined surveillance program including the observation and analysis of instrumentation data.

The criticality of initial filling of reservoir emerges from the fact that heavy floods may cause an uncontrolled rising of the reservoir during periods when it is unwarranted either for proper monitoring of the dam on the first filling and also for the safety of the structures, if unanticipated seepage occurs. A solution to this problem is generally considered by dividing the filling into stages i.e. up to certain elevation where practically no major downstream hazard exists and that above the elevation where loads, pressures, and volume of reservoir storage become significant.

2.1 Initial Filling Criteria for Earthen Dams by CWC

Central Water Commission has laid down the following general guidelines for initial filling of reservoir for earth and rock-fill dams.

- In order to monitor reservoir performance, the rate of filling should be controlled to the extent feasible to allow in accomplishing a pre-determined monitoring programme. Sufficient discharge capacity to maintain the reservoir filling rates specified by the initial filling criteria to hold reservoir levels reasonable within limits is provided. Inflow into the reservoir should be assumed as the average of the mean monthly inflow in the selected filling period and reasonable, frequency flood.
- Reservoir filling criteria are established on a dam-by-dam basis. In general the objective as already stated above is to provide a planned programme with adequate time for monitoring and evaluating performance of the dam and its foundation as the reservoir is being filled for the first time.

The first stage consists of filling the reservoir up to MDDL. This filling can be done without restraint.

The second stage consists of filling the reservoir from MDDL to the crest of spillway. In case of earth and rock fill dam, this stage filling shall be done in two parts.

The reservoir above MDDL should be gradually built at a rate not exceeding 3 metres per fortnight, and filling should be temporarily stopped at 50% elevation from MDDL to crest of spillway in order to assess the behaviour of the structure on the basis of observed values and to take a decision about further storage.

After a decision is taken to continue the filling, further building up of the storage should be done in gradual sub-stages of 2 to 3 metres depending upon the height of the dam. Observations of

pore pressure cells, uplift pressures, seepage quantum, and other instrumentation data should be carried out at each stage after allowing a suitable stabilizing period before going on to the next sub-state of filling.

The third stage consists of filling above the crest of the spillway up to the full reservoir level (FRL).

The rate of reservoir filling above crest of spillway should be restricted to0.3 metres (1 ft.) in 48 hours. The reservoir should be temporarily held at half the height between FRL and crest of spillway for sufficient time for monitoring and evaluating performance of dam, also taking into account instrument response time, and to take a decision about further storage.

2.2 Initial Filling Criteria for Earthen Dams as per BIS:

As per BIS code **IS 15472:2004** the following is the criteria for initial filling program in respect of embankment dams, which can be suitably modified as necessary, is as under:

a) The first stage consists of filling the reservoir up to MDDL. This filling can be done without restraint as the hazard potential to the public and economic development downstream of the dam is low.

b) The second stage consists of filling the reservoir from MDDL to the crest of spillway. For earth and rock-fill dams this stage filling should be done in two parts.

   The reservoir above MDDL should be gradually built at a rate not exceeding 3 m per fortnight and filling should be temporarily stopped at half the height between MDDL and crest of spillway, for a reasonable time in order to assess the behaviour of the structure on the basis of observed values and to take a decision about further storage and remedial measures in case of distress.

   After a decision is taken to continue the filling, further building up of the storage should be done in gradual sub-stages of 2 to 3 m per fortnight depending upon the height of the dam and increase in storage capacity. The reservoir should then be temporarily held at the crest level of the spillway for a reasonable time for monitoring and evaluating the performance of the dam and to take a decision about further storage.

c) The third stage consists of filling above the crest of the spillway up to the full reservoir level (FRL).

The rate of reservoir filling above crest of spillway should be restricted to sub-stages of 0.3 m in 48 h. The reservoir should be temporarily held at half the height between FRL and crest of spillway for sufficient time for monitoring and evaluating performance of dam and to take a decision about further storage/remedial measures, if any.

The instrumentation program and frequency of taking observations during initial filling of the reservoir including the periods for which the reservoir is held constant at specified levels should also be finalised simultaneously for structural monitoring of the structure at that time. The structural behaviour reports should be prepared for each stage

3. CRITERIA FOR INITIAL FILLING OF WATER CONDUCTOR SYSTEMS (WCS):

The water conductor system shall be filled as per criteria mentioned in BIS code **IS 12633:1989** and American society of Civil Engineers **(ASCE) "Steel Penstocks" Second Edition**.

3.1 Criterion for Initial filling of Pressure Tunnel (WCS) as per BIS

As per BIS code **IS 12633:1989** the following is the criteria for initial filling of Pressure Tunnel (WCS):

Filling is normally done from the downstream end of the water conductor system, that is, the machine inlet valve. However, in case of long head race tunnel, where a surge shaft is provided, the system shall be filled initially up to the surge shaft, if provided with gates, otherwise up to the emergency valves downstream of valve. The portion of water conductor system between the emergency valves downstream of shaft and the main inlet valve provided just upstream of the machine, may be filled up only after detection and rectification of leakage upstream of the butterfly valve.

- The water conductor system shall be filled at very slow rate so that the internal pressure increases gradually and the surrounding conditions get sufficient time for stabilization.
- In case of gated arrangement, the leakage on gates shall be checked and ascertained for the efficacy of the seals. This shall apply to penstock and draft tube gates also.
- The water conductor system shall be filled at a slow rate so that there is no scope for the air to get entrapped, compressed and then released.

3.2 Criterion for Initial Filling of Pressure Tunnel (WCS) as per ASCE:

As per American society of Civil Engineers **(ASCE) "Steel Penstocks" Second Edition** the following is the criteria for initial filling of Pressure Tunnel (WCS):

A slow filling rate must be initiated to ensure full control of the system. A suggested maximum range for this initial filling rate for inclined penstocks and shafts is 20 to 50 vertical feet/ hour (equivalent to vertical 6.0m to 15.2m/ hour), which usually allows adequate control for filling operations. For horizontal tunnels liners, or tunnels, a conservative fill rate less than 30 vertical feet/ hour (vertical 9.1m / hour) should be used.

Depending upon the length of the system, number of probable seepage observation points and filling requirements, the total time taken to complete the initial filling shall be estimated. This can be calculated and arrived at once the volume of water required to fill the system is known. The following steps shall be followed for initial filling:

1. Gates of intake shall be lowered and pond level maintained at desired level with the help of spillway gates and/or other discharge outlets.
2. Surge shaft gates/butterfly valve and machine inlet valve gate shall be kept closed.
3. If filling is to be done by crack opening, intake gate shall be raised up to the height calculated by estimating the discharge requirements for filling up the system in the programmed schedule of time frame of filling. The velocity should be restricted to about 6 m/s. The crack-opening would generally be of the order of 20 to 40 mm.
4. Surge shaft gates/butterfly valves, machine inlet valves, penstock couplings, etc, shall be checked and tested.
5. The tunnel shall be filled in appropriate pre-determined steps of water head so that excessive tension in the lining is avoided. The steps may be worked out on the basis

of known properties of the surrounding rock mass.

6. A waiting period of at least 48 h shall be allowed between first and second steps of filling and of at least 24 h between each subsequent steps of filling.
7. Water levels in the surge tank shall be recorded concurrently during the filling operation.
8. At the end of each step of filling, the intake gates shall be closed and water levels in the surge tank shall be observed every hour. The loss of water from tunnel through drainage galleries around surge tank and leakage through machine inlet valve shall also be noted.
9. Close monitoring of instruments installed in head race tunnel, surge tank and penstock shall be done before, during and after filling of the system.
10. The water conductor system shall be filled maintaining the reservoir water level as low as possible. The water level shall be raised slowly in the reservoir as far as practicable till it reaches the maximum reservoir level.
11. If the drop in water level is more at any step, the reasons for leakage shall be investigated and remedial measures should be taken. Next filling steps shall only be taken after ensuring that drop in water level in the preceding step is within the pre-determined limits.
12. All gates, stop-logs, observation points, valves and expansion joints on penstocks shall be monitored for leakage during and after filling.

4. INSPECTION OF STRUCTURES BEFORE INITIAL FILLING

The inspection of entire reservoir, Head works including main dam, spillways, diversion tunnels, Flushing Cum Spillway Tunnel, De-silting Chambers, Head Race Tunnel, Surge Shaft, Pressure Shaft, Power house and Tail Race Tunnel and Pot Head Yard shall be carried out by a team of senior executives of the project prior to initial reservoir filling. It shall be ensured that all these structures are in good/ satisfactory condition and considered to be ready for operation. However a brief of the inspection to be carried out in respect of each of the project components are mentioned below:

4.1 Reservoir

The initial filling of the reservoir is the first test of the dam to perform the intended functions. The reservoir area in river bed level up to the full reservoir level shall be cleared of all habitation. The local administration shall be intimated so that the general population shall be informed to stay clear of the reservoir area. The inspection of the reservoir area is carried out to ensure that:

- All temporary installations/ tool and plants/ construction machineries etc. within the reservoir area have been removed.
- Reservoir RIM Treatment works should be completed

4.2 Concrete Faced Rock-fill Dam (CFRD)

The inspection of the dam shall be carried out to ensure that all the temporary installations erected during construction from the dam body shall be removed. It must be ensured that the

plinth and cut off wall of the Concrete Face Rock-fill dam is protected properly from the big size debris/ boulders expected during initial reservoir filling to avoid any damage in the dam structure. It must be ensured that all instruments have been installed and functioning properly and their initial readings may be taken from the dam top. Adequate illumination arrangement shall be provided of the dam top.

4.3 Right Bank Flushing Tunnel (RBFT)

River diversion through RBFT has been successfully completed on 29th February 2016.

4.4 Diversion/ Spillway Tunnel-1 and Spillway Tunnel- 2

The diversion/ spillway tunnel-1 and spillway tunnel2 shall be inspected to ensure that the entire tunnels are free from debris and tunnel surface is clean. All the temporary installations erected during construction shall be removed. Inlet structure of the tunnel shall be cleared of all debris. It shall be ensured before reservoir filling that the Service and Emergency Gates provided in tunnel are properly functioning and it shall also be ensured that there is no leakage from the seals of the gates. The seepage, if any, shall be recorded.

4.5 Chute Spillway

The inspection of the Chute Spillway shall be carried out to ensure that:

- The approach channel, Spillway chute, buckets and apron is cleared of all debris.
- Visual inspection is carried out to ensure that final finish has been achieved in respect of Control structure, Chute, bucket and apron of the Spillway structure.
- The Service and Emergency Gates provided in are properly functioning.
- It shall also be ensured that there is no leakage from the seals of the gates.
- All the instruments provided to monitor the performance of the Spillway are operational.
- Various accesses are clear and operational.
- The downstream area has been cleared of all materials.
- Arrangements related to release of Environmental Flow shall be completed.

4.6 Power Intake

The Power Intake shall be inspected to ensure that the entire tunnel is free from debris and tunnel surface is clean. All the temporary installations erected during construction shall be removed. The intake structure of the tunnel shall be cleared of all debris. It shall be ensured before reservoir filling that the Service, Emergency Gates and other water flow control devices are provided in tunnel are properly functioning and it shall also be ensured that there is no leakage from the seals of the gates. Trash-rack and air vent shall be cleaned. A telephone/wireless set shall be provided at gate with trained crews posted for operation of gate.

4.7 De-silting Chambers

The inspection of the De-silting chambers shall be carried out to ensure that:

- All the construction materials, machinery and the debris have been removed.
- Pressure relief holes are not blocked.
- Contact grouting/void filling is completed
- Consolidation grouting in the specified area is completed

- Re-calibrate the various instruments and record the readings prior to filling the basins.
- The holes provided in the gutters are clear.
- The de-silting chambers gates are functional.
- Silt flushing tunnel gates are operational.

4.8 Head Race Tunnel and Surge Shaft

The following checks shall be performed in the head race tunnel & surge shaft before initial filling:

- All the construction material/equipment shall be removed and the tunnel cleared of all extraneous material such as left over concrete lumps, projections, protruding dowels/ steel bars etc. The tunnel surface shall be smooth.
- It shall be ensured that all cold joints are properly treated and the holes for grouting be sealed perfectly and the surface ground smooth.
- It shall be ensured that contact grouting has been done accordance with the design requirements .It shall also be ensured that consolidation grouting has been done in accordance with the design requirements.
- All the points such as man-holes, construction adits etc, shall be properly sealed/ plugged in accordance with design requirements.
- It shall be ensured that all the instruments required for observations before filling, during filling and after filling are installed and are functioning properly.
- Drainage holes and dewatering pipe, wherever provided, shall be checked and it shall be ensured that these are functioning properly.
- It shall be ensured that there is no obstruction in the air vent pipes, outlet and inlet pipes provided.
- It shall be ensured that the adit gates/man holes for Adit-0, Adit-2, Adit-3 Adit-4 and Adit-5 are working and sealing have been bolted/locked properly.

4.9 Butterfly Valve

The following checks shall be carried out on Butterfly Valves before start of initial filling:

- All hydraulic and electrical systems should be checked.
- The air inlet valve and vacuum breaking valves should be cleared for overflow of any water.
- The drain from the valve house should be cleared for overflow of any water.
- The communication between valve house and power house shall be tested.
- The control system from the control room to the valve house shall be checked and tested for proper operation.

4.10 Pressure Shafts

The pressure shafts, PS-1 and PS–2 are proposed to be filled simultaneously and the following checks shall be carried out in both pressure shafts:

- Entire length of pressure shafts shall be thoroughly cleaned. The pressure shafts shall be painted and completed in all respects and inspected for before filling the water.

- All the machine inlet valves shall be checked for proper operation.
- All the bolts of man-holes shall be checked and tightened.
- Any instruments provided in pressure shafts shall be calibrated and monitored.
- It shall be ensured that grouting holes are properly plugged and repainted.
- It shall be ensured that the air vents are clear of any obstruction and air valves are working properly.
- It shall be ensured that filling and dewatering systems are working properly.

4.11 Power House Cavern

The inspection of the Power House Cavern shall be carried out to ensure that:

- All instruments provided are functional and calibrated and take initial readings.
- Observe and record seepage/dampness in the crown and side walls.
- All the powerhouse drainage systems are operational.
- All shaft seals are assembled and the draft tube gates of all units are lowered and checked for no leakage.
- All Penstock drains valve are closed.
- Pressurised covers of dewatering sump are secured in position and tested for no leakage.
- The interconnection valve between drainage and dewatering sump is closed.
- MIV of the other unit, which is common to the pressure shaft to be closed and checked for no leakage including completion of all the assemblies.
- MIV valves are closed in respect of all units.
- All activities in Power House shall be done in close coordination with E-M wings and guidelines supplied by the E-M agency shall be followed.

4.12 Tail Race Tunnel and Outlet

The inspection of the tail race tunnel and outlet shall be carried out to ensure that:

- Tailrace tunnel is free from all debris and waste material.
- Contact grouting operation is complete. Also observe and record seepage if any
- All the debris / waste materials from the TRT is removed.
- Marking of Gauges on the outlet is complete.

5. STAGE-DISCHARGE CURVES (RATING CURVES) OF VARIOUS STRUCTURES

The Stage-Discharge Curves (Rating Curves) of the following structures/ gates have been prepared considering the invert levels at Intake of different structures and various water levels in reservoir up to the MWL (EL. 1588.00m). These will be required to assess the time required for filling/ evacuation of Reservoir and Water Conductor System:

I. Discharge rating curve of Right Bank Flushing Tunnel
II. Discharge rating curve of Power tunnel Intake
III. Discharge rating curve of Left Bank Spillway Tunnel No.-1
IV. Discharge rating curve of Left Bank Spillway Tunnel No.-2
V. Discharge rating curve of Left Bank Chute Spillway

I. Discharge Rating curve of right bank Flushing Tunnel

The Stage-Discharge Curves (Rating Curves) of the Right Bank Flushing Tunnel has been prepared considering the following input:

- Right Bank Flushing Tunnel intake Invert — El.1540.00m
- Height of Flushing Tunnel opening — 9.30m
- Width of Flushing Tunnel opening — 9.00m
- FRL — El.1585.00m
- MWL — El.1588.00m

The coefficient of discharge has been considered based on the **"Hydraulic Model Studies for the Flushing Tunnel of Teesta-III HEP, Sikkim conducted by IRI, Roorkee (Uttrakhand)"**while computing the Discharge rating curve. It has been decided that during control filling of reservoir all extra in flows shall be discharged through flushing tunnel till the reservoir level reaches El. 1565.Therefore the discharge capacity of flushing tunnel with partial/full gate opening for different reservoir level have been computed and the Discharge rating curve of Right Bank Flushing Tunnel from the invert of the tunnel to MWL (El. 1540.0m to El. 1588.0m) is appended as **Annexure- 1 and Annexure- 2**. The Discharge Rating Curves (Rating Curves) of the Right Bank Flushing Tunnel for partial gate opening keeping the different reservoir levels **El. 1550.0m; El. 1565.0m; El. 1585.0m and El. 1588.0m** have been also prepared and the same are placed at **Annexure-3, Annexure-4, Annexure-5, Annexure-6, Annexure-7, Annexure-8, Annexure-9 and Annexure-10 respectively.**

II. Discharge Rating curve of Power Tunnel Intake

The Stage-Discharge Curve (Rating Curves) of the Power Tunnel Intake has been prepared considering the following input:

- Right Bank Power Tunnel intake Invert — El.1549.00m
- Height of Flushing Tunnel opening — 7.50m
- Width of Flushing Tunnel opening — 7.50m
- FRL — El.1585.00m
- MWL — El.1588.00m

The coefficient of discharge has been considered based on the **"Hydraulic Model Studies for Hydraulic Performance of Power Intake Teesta-III HEP, Sikkim conducted by IRI, Roorkee (Uttrakhand)"** while computing the Discharge rating curve.

The Discharge Rating Curves (Rating Curves) of the Power Tunnel Intake for partial gate opening keeping the different reservoir levels **El. 1550.0m; El. 1565.0m** have been also prepared and the same are placed at **Appendix- D (Sheet 1 to 4).**

III. Discharge Rating curve of Left Bank Spillway Tunnel (LBST) NO.-1

The Stage-Discharge Curve (Rating Curves) of the Left Bank Spillway Tunnel No.-1 has been prepared considering the following input:

- Left Bank Spillway Tunnel No.-1 intake Invert El.1555.00m
- Height ofLBSTNo.-1 opening at intake 7.00m
- Width ofLBSTNo.-1 opening at intake 12.00m
- FRL El.1585.00m
- MWL El.1588.00m

The coefficient of discharge has been considered based on the **"Hydraulic Model Studies for Hydraulic Performance of Left side diversion tunnel No.-1 of Teesta-III HEP, Sikkim conducted by IRI, Roorkee (Uttrakhand)"** while computing the Discharge rating curve. The computation of the Discharge rating curve of Left Bank Spillway Tunnel No.-1 from the invert of the tunnel to MWL (El. 1555.0m to El. 1588.0m) is enclosed as **Appendix- E (Sheet 1 & 2).**

IV. Discharge Rating curve of Left Bank Spillway Tunnel (LBST) NO.-2

The Stage-Discharge Curve (Rating Curves) of the Left Bank Spillway Tunnel No.-2 has been prepared considering the following input:

- Left Bank Spillway Tunnel No.-1 intake Invert El.1572.00m
- Height ofLBSTNo.-1 opening at intake 13.00m
- Width ofLBSTNo.-1 opening at intake 11.00m
- FRL El.1585.00m
- MWL El.1588.00m

The coefficient of discharge has been considered based on the **"Hydraulic Model Studies for Hydraulic Performance of Left side diversion tunnel No.-2 of Teesta-III HEP, Sikkim conducted by IRI, Roorkee (Uttrakhand)"** while computing the Discharge rating curve. The computation of the Discharge rating curve of Left Bank Spillway Tunnel No.-2 from the invert of the tunnel to MWL (El. 1572.0m to El. 1588.0m) is enclosed as **Appendix- F (Sheet 1 & 2).**

V. Discharge Rating curve of Left Bank Chute Spillway

The Stage-Discharge Curve (Rating Curves) of the Left Bank Chute Spillway has been prepared considering the following input:

- Left Bank Chute Spillway crest level El.1565.50m
- Height of spillway opening 14.43m
- Width of Gates 11.00m
- Nos. of gate 2Nos
- Type of spillway Orifice type
- FRL El.1585.00m
- MWL El.1588.00m

The coefficient of discharge has been considered based on the **"Hydraulic Model Studies for Hydraulic Performance of Chute Spillway of Teesta-III HEP, Sikkim conducted by IRI, Roorkee (Uttrakhand)"** while computing the Discharge rating curve. The computation of the

Discharge rating curve of Left Bank Chute Spillway from the invert of the tunnel to MWL (El.1565.50m to El. 1588.0m) is enclosed as **Appendix- G (Sheet 1 & 2).**

The Discharge Rating Curves (Rating Curves) of the Left Bank Chute Spillway for partial gate opening keeping the reservoir level **El. 1585.0m** has been also prepared and the same are placed at **Appendix- G (Sheet 3 & 4).**

6. PLAN FOR INITIAL FILLING RESERVOIR AND WATER CONDUCTOR SYSTEM

The Initial reservoir filling is the first test of the dam to perform the function for which it was designed. In order to monitor the performance, the rate of filling is controlled to the extent feasible to allow as much time as needed for a predetermined surveillance program including the observation and analysis of instrumentation data.

The initial water conductor system filling (WCS) is the process of filling the system at a slow rate so that the internal pressure increases gradually and the surrounding material get sufficient time for stabilization.

The reservoir area from the river bed level up to the full reservoir level shall be cleared of all habitation and the rim of the reservoir shall secured by providing fencing. The local administration shall be intimated so that the general population shall be informed to stay clear of the reservoir area.

Before the initiation of filling of the reservoir or water conductor system, all the protocols/ checklists mentioned in **Para-4 above** of this report shall be complied fully.

Teesta-III Hydro Electric Project is a run-of-the-river scheme with diurnal storage to generate 1200 MW power by utilizing the discharge of River Teesta. It is not a storage scheme. The total reservoir capacity of the project is very small and is only 5.07 MCM. If at any time during the initial filling of the reservoir any serious seepage through the dam or foundation occurs or due to abnormal functioning of any of the components of the project is noticed, the outlet flow would be increased to lower the pool at a controlled rate.

The inflow of Teesta River at Diversion Dam Site as per 10-daily discharge is given in **Appendix-B**. The reservoir Area-Capacity curve of Teesta-III Project is enclosed as **Appendix-C (Sheet 1 & 2).**

It has been planned to start the initial filling of reservoir upto MDDL and water conductor system after completion of balance works.

The initial filling of the reservoir upto 1.5 m above MDDL and water conductor system has been proposed to be filled in 15 days. The filling should be carried out during day time only.

Initial filling of reservoir from EL. 1566.50 m to EL. 1585.0 m (i.e. FRL of the Project) is scheduled to be filled in 30 days after monsoon period (end of October). Hence the filling reservoir and water conductor system shall be carried out in two phases, i.e schedule for phase-1 is 15 days and phase-2 is 30 days.

6.1 Day-1: Filling of De-silting Chambers upto d/s HRT invert EL. 1546.90 m

Filling of De-silting Chambers upto EL. 1546.90 m shall be carried out on Day-1 by operating RBFT gate partially. The volume of water to be filled is 74120 m^3. It is proposed to fill the dead pool of both De-silting Chambers in 8 hours' time. The required flow rate of 2.57 m^3/s shall be maintained for the period of 8 hours. The reservoir level shall be raised gradually to allow the flow through power intake. Reservoir level shall be maintained at EL. 1549.33 m for the day-1. The discharge rating curve for power intake opening in un-gated condition is given below.

Discharge Rating Curve Details of Power Intake in Un-gated Condition

Sl. No.	Water Level (m)	Discharge (Cumecs)	Sl. No.	Water Level (m)	Discharge (Cumecs)
1	1549.0	0.15	7	1549.6	2.75
2	1549.1	0.42	8	1549.7	3.36
3	1549.2	0.77	9	1549.8	4.01
4	1549.3	1.19	10	1549.9	4.70
5	1549.4	1.66	11	1550.0	5.42
6	1549.5	2.18	-	-	-

The following steps shall be followed for initiation of day-1 filling;

- Water Level sensors shall be installed at Power Intake or Flushing Inlet
- Levels shall be marked on CFRD slab, RBFT Pier and Chute Spillway Training Wall
- Power intake gate shall be kept in open condition
- Bonnet Gates of Silt flushing tunnels for both De-silting Chambers shall be closed
- Power Intake Tunnel Adit Gate installed in upstream of De-silting chambers shall be closed and locked.
- Inspection Galley to DC-1 and DC-2 Gates shall be closed and locked.
- RBFT Gate: Initially in full open condition, partially closed for rising reservoir level upto EL. 1549.33 m and to maintain this level for entire filling time on day-1.
- The water level in the De-Silting Chambers shall be monitored on hourly basis and filling shall be stopped as soon as the water level attained EL. 1546.9 m.
- Once the filling is completed for Day-1, RBFT gate shall be opened completely.
- During the remaining period, water level and structure shall be monitored for water loss and distress in associated structures.

6.2 Day-2: Filling of HRT from EL. 1506.25 to EL. 1514.25 m

In day-2, filling of HRT shall be initiated by both closing Butterfly Valves of Pressure shafts. Filling for 8m head shall be carried out for the day-2 i.e from EL. 1506.25 to EL. 1514.25 m. Volume of water to be filled for day-2 is 70751 m^3. Rate of filling required is 2.46 m^3/s considering filling time of 8 hours. The reservoir shall be raised gradually by closing the RBFT gate partially and the level of EL. 1549.32 m shall be maintained till the water level in HRT attains EL. 1514.25 m.

The following points shall be considered for day-2 filling;

- Ensure that Pressure Gauge installed in Adit-5 and level sensor may be installed at Surge shaft for continuous monitoring and record of water levels during initial filling.
- Distress in structure and water loss in de-silting chambers complex found if any shall be identified and rectified.
- Both the butterfly valves shall be closed and sealed.
- By-pass valves and drain valves in the butterfly valves shall be tightly shut
- Adit-5 Gate shall be closed and locked
- Water level in the reservoir shall be raised gradually and maintained at EL.1549.32 till the HRT fills upto EL. 1514.25 m.
- Water level in HRT can be eye witnessed by monitoring water level in surge shaft. On completion of day-2 filling, the water level would have touched the orifice slab.

6.3 DAY-3 FILLING

Filling of HRT and Pressure shaft shall be carried out simultaneously in day-3. Since simultaneous filling is planned, monitoring team of adequate size shall be deputed in 24x7 basis. Communication between control room and monitoring team at various locations shall be established and checked for proper working. The following is portions of the water conductor system are filled in day-3.

6.3.1 Filling of HRT from EL. 1514.25 to EL. 1522.25 m

Before start of filling for day-3, water loss and distress found if any during stoppage period shall be checked thoroughly. The volume of water required between EL. 1514.25 to EL. 1522.25 m is 136266 m^3. Rate of filling considering 8 hours filling time is 4.73 m^3/s. The water level in the reservoir shall be raised gradually and maintained at EL. 1549.50 m by controlling RBFT gate.

The water level in the HRT on completion of day-3 filling can be eye witnessed from man hole in Adit-4. The pressure gauge reading in the Adit-5 and water level in surge shaft shall be monitored continuously for proper control. Filling shall be stopped as soon as water level in the HRT reached EL. 1522.25 m and RBFT gate shall be opened fully.

6.3.2 Filling of Pressure Shaft from EL. 766.0 to EL. 816.0 m

Initially filling of left pressure shaft is planned as the works of right pressure shaft would take time for completion. In this manual, procedure for filling of left pressure shaft is described. For filling of right pressure shaft, similar procedure shall be followed. Filling of pressure shaft shall be initiated after carrying out the following checks;

- All unit MIV's should be in kept in closed condition
- All Manholes in the pressure shaft are in closed and bolts are tightened
- However, the manhole at top bend shall be kept open for air entry/escape and will be closed after the water level reached top bend.
- Drainage system in the Power house shall be checked for proper operation

- Drain valves in the downstream and upstream of MIV's shall be tightly shut

The filling of entire pressure shaft shall be carried out through by-pass valve in the butterfly valve. Butterfly fly valve will remain in closed condition till the time entire pressure shaft is filled and pressure balance is achieved.

The volume of water to be filled in the pressure shaft upto EL. 816.0 m including unit penstocks for day-3 is 5471 m^3. The rate of filling required considering 8 hours filling time is 0.19 m^3/s. The discharge capacity of by-pass valve under 1 m head is estimated to 0.35 m^3/s. Since the head acting at by-pass valve on day-3 would vary from 3 m to 11 m, the discharging capacity of by-pass would be more than the required filling rate. Hence filling shall be stopped intermittently on hourly basis based on the pressure gauge reading of MIV. Pressure gauges readings at MIV's will be used to regulate the inflow into the pressure shaft from bypass valve of butterfly valve. In no case the filing rate should exceed 15 m / hour.

By-pass valve shall be shut for day-3 once the pressure gauge shows reading corresponding to water level in the pressure shaft at EL.816.0 m.

In the remaining period, inspection and observations shall be carried out for water loss and distress in structures.

6.4 DAY-4 FILLING

Ensure that there is no water loss during the stoppage period by analysing the pressure gauge readings of Adit-5 for HRT and pressure gauge readings of MIV's for Pressure shaft. If any major water loss or seepage is deducted, the same shall be rectified before start of initial filling for day-4.

6.4.1 Filling of HRT from EL. 1522.25 to EL. 1530.25 m

RBFT gate shall be closed and the reservoir level is allowed to rise above power intake invert to start the filling of HRT. The volume of water to be filled in the HRT between EL. 1522.25 and EL. 1530.25 m is 129105 m^3. The filling time shall be of 8 hours. The flow rate required for day-4 filling of HRT is 4.48 m^3/s. The reservoir level of EL. 1549.48 m shall be maintained for 8 hours of filling time. Filling shall be stopped by opening RBFT gate completely as soon as the water level in the HRT reached EL. 1530.25 m. Monitoring pressure gage reading at Adit-5 and water level in Surge Shaft would guide in stopping the filling once the required level reached for the day.

6.4.2 Filling of Pressure Shaft from EL. 816.0 m to EL. 865.0 m

Filling of left pressure shaft from EL.816.0 m to EL. 865.0 m shall be initiated by opening bypass valve at butterfly valve. The rate of filling required to fill 2752 m^3 volume of water in 8 hours is 0.10 m^3/s. As described in day-3 filling, the discharging capacity of bypass pipe would be much more than the required flow rate. In that case, filling of pressure shaft shall be stopped intermittently by monitoring pressure gauge readings.

6.5 DAY-5 FILLING

In day-5, the following activities are scheduled;

i) Filling of HRT from EL. 1530.25 to EL. 1538.25 m
ii) Flushing of inclined and horizontal portion of Pressure Shaft

There should not any rise and fall in the pressure gauge readings during the stoppage period between day-4 and day-5 filling.

6.5.1 Filling of HRT from EL. 1530.25 m to EL. 1538.25 m

Ensure that manholes of Adit-4 and Adit-3 are in closed condition. Filling of HRT for day-5 shall be initiated by closing RBFT radial gate and allowing the reservoir level to rise above EL. 1549.0 m. RBFT gate shall be opened partially to maintain the reservoir level at EL. 1549.48 m. This is to maintain the flow rate of 4.40 m^3/s for 8 hours' time to fill a volume of 126841 m^3.

Filling shall be stopped as soon as water level reached EL. 1538.25 m for the day. RBFT gate shall be opened completely to lower the water level below invert of power intake so that depiction of silt is prevented during stoppage period. Pressure gauge readings shall be taken in hourly basis and water level in the surge shaft shall also be noted in hourly basis.

6.5.2 Flushing of Pressure Shaft

Flushing of pressure shaft shall be carried out for day-5. All drain valves in the penstocks shall be opened simultaneously. The entire volume of water in the inclined pressure shaft shall be allowed to drain.

- All drain valves in the downstream of MIV is shut tightly
- During flushing operation manhole at top bend shall be kept in open condition for air entry and monitored continuously for any up-normal behaviour
- Entire drainage system is checked for proper operation
- Flushing shall be carried out in a controlled manner
- Inspection of unit penstocks, horizontal and inclined portion pressure shaft shall be carried out from manhole. Foreign material found if any shall be removed
- Upon completion of all the above activities, manholes shall be closed and all the penstock drain valves are tightly shut.

Refilling of pressure shaft shall be initiated on day-6.

6.6 DAY-6 FILLING

The filling of the HRT and pressure shaft shall be resumed for the day-6 if the pressure readings of adit-5 / water level readings of surge shaft and pressure readings of MIVs remain the same as that at the close of previous day else the filling shall be suspended and investigated for loss of pressure and remedial measures shall be taken up. The following portions of water conductor system is scheduled to be filled for day-6

i) Filling of HRT from EL. 1538.25 m to EL. 1546.25 m

ii) Re-filing of Pressure shaft from EL.766.0 m to EL. 816.0 m

6.6.1 Filling of HRT from EL. 1538.25 m to EL. 1546.25 m

Ensure that there is no distress and water loss in the HRT and surge shaft during the stoppage period. Adit-2 gate is closed and locked in position.

The volume of water to be filled in the HRT between EL. 1538.25 m to EL. 1546.25 m is 126700 m^3. The rate of filling required to fill the volume in 8 hours is 4.40 m^3/s. Reservoir level shall be raised to EL. 1549.48 m and maintained during the filling time. Reservoir shall be lowered by opening RBFT gate as soon as the water level in the HRT reached EL. 1546.25 m. Water level in the surge shaft also reach at EL. 1546.25 at the end of day-6 filling.

6.6.2 Re-filling of Pressure shaft from EL. 766.0 m to EL. 816.0 m

Re-filling of bottom horizontal and inclined portion of pressure shaft is scheduled for day-6. Ensure that manholes in the unit penstocks are closed and bolts are tightened. All the penstocks drain valves are shut tightly. The procedure for day-6 filling of pressure shaft is similar to day-3 filling of pressure shaft.

6.7 DAY-7 FILLING

Pressure gauge readings and any other instrumentation data if available shall be analysed for water loss and distress of the structure. Ensure that Adit to HRT d/s gate is closed and locked. Manholes provided in the bottom bend of pressure shaft shall be closed as per standard procedure. In day-7, filling of inclined potion of left pressure shaft from EL.816.0 m to EL. 865.0 m shall be carried out. Simultaneously, filling of HRT is to be carried out from EL. 1546.25 m to EL.1556.50 m (overt of intake tunnel).

6.7.1 Filling of HRT from EL. 1546.25.25 m to EL. 1556.50 m

Since the water level in the HRT is to be raised above power intake invert (EL. 1549.0 m), the reservoir shall be raised gradually from EL. 1549.0 m to EL. 1556.50 m over the period of 8 hours. The volume of water to be filled in the HRT is 98321 m^3. Rate of filling for reservoir and HRT for day-7 would be about 1 m/hour.

6.7.2 Re-filling of Pressure Shaft from EL. 816.0 m to EL. 865.0 m

Procedure for filling of pressure shaft from EL.816.0 m to EL.865.0 m given in day-4 shall be followed for re-filling as well.

6.8 DAY-8 to DAY-13 FILLING

The following two activities would be carried out on routine basis daily from Day-8 to Day-14;

- Filling of Vertical Pressure Shaft from EL.865.0 m to EL. 1465.0 m @ 100 m/day
- Reservoir filling from EL.1556.50 m to EL. 1566.50 m

Filling of pressure shaft shall be carried out by opening bypass pass valve in the butterfly valve at the rate of 100 m/day or 12.5 m /hour (not exceeding 15 m/hour). Volume of pressure

shaft to be filled in a day is 1257 m^3. Rate of flow required to fill 100 m head of pressure shaft in a period of 8 hour is 0.04 m^3/s. Since the discharging capacity of bypass valve is much more than the required flow rate, filling of pressure shaft shall be stopped intermittently and hourly filling rate of 12.5 m/hour is to be maintained. In no case, hourly filling rate should exceed 15 m/hour.

Filling schedule for the period day-8 to day-13 is given below;

Day	Filling of Vertical Shaft Elevation	Volume (m^3)	Filling Time (hours)	MIV's Pressure gauge reading (kg/cm^2)
Day-8	EL.865.0 to EL.965.0 m	1257	8	9.5
Day-9	EL.965.0 to EL.1065.0 m	1257	8	19.5
Day-10	EL.1065.0 to EL.1165.0 m	1257	8	29.5
Day-11	EL.1165.0 to EL.1265.0 m	1257	8	39.5
Day-12	EL.1265.0 to EL. 1365.0 m	1257	8	49.5
Day-13	EL.1365.0 to EL. 1465.0 m	1257	8	59.5

Day	Filling of Reservoir Elevation
Day-8	EL.1556.50 to EL.1558.50 m
Day-9	EL.1558.50 to EL.1560.50 m
Day-10	EL.1560.50 to EL.1562.50 m
Day-11	Stoppage (No filling)
Day-12	EL.1562.50 to EL.1564.50 m
Day-13	EL.1564.50 to EL.1566.50 m

Reservoir filling from EL.1556.50 m to EL.1566.50 m shall be carried at the rate of 2 m/day from day-8 to day-13. Filling of reservoir shall be stopped for the day-11 to observe that dam behaviour. On this day, reservoir shall be maintained at EL. 1562.50 m by operating RBFT gate based on the inflow of the river. Raising the reservoir by 2 m in a day can be carried out in 2 hours and in the remaining period reservoir level shall be maintained for the day.

Data from the all the instruments installed in the dam shall be recorded in hourly basis. Seepage through the dam occurring if any shall be monitored closely. The behaviour of dam and reservoir rim shall be monitored vigorously and data collected shall be analysed before raising the level above EL. 1566.50 m.

Chute spillway gate shall be kept in complete open condition. RBFT gate shall be operated to maintain the reservoir level at EL.1566.50 m. (i.e 1.5 m above MDDL and 1 m above invert of Chute Spillway Gates).

6.9 DAY-14 FILLING & DAY-15

In day-14, filling pressure shaft from EL.1465.0 m to EL. 1515.0 m is scheduled. This includes filling of top horizontal pressure shaft upto butterfly valve. Before filling ensure that manholes in the top bend shall be closed and bolts shall be fastened.

Filling of pressure shaft would be completed on day-14. The volume of water to be filled in the pressure shaft is 2515 m^3. Rate of filling computed to 0.09 m^3/s for the period of 8 hours. Filling shall be carried cautiously to avoid entrapped air in the top horizontal portion of pressure shaft. Pressure gauge readings in the MIV shall be recorded on hourly basis.

Day-15, pressure balance between HRT and pressure shaft shall be carried out. The pressure in HRT would be corresponds to water level of EL.1566.50 m whereas in the top horizontal pressure shaft is just filled and the pressure is corresponding to water level of EL. 1515.0 m. Balancing the pressure in the upstream and downstream of butterfly valve shall be carried out at the rate of 15m/hour.

In day-15, Reservoir, HRT and Pressure Shaft are connected and water availability is made to for testing and commissioning of E-M Equipment's.

6.10 DAY-16 to DAY-45: FILLING OF RESERVOIR UPTO FRL

Filling of reservoir from EL. 1566.50 m to EL. 1585.0 m shall be carried out in two stages. Reservoir above MDDL shall be carried out when the flow of the river is below 100 m^3/s. During the filling period, RBFT gate may be closed based and one of the Chute Spillway Radial Gate shall be operated partially to carry out initial filling of the reservoir.

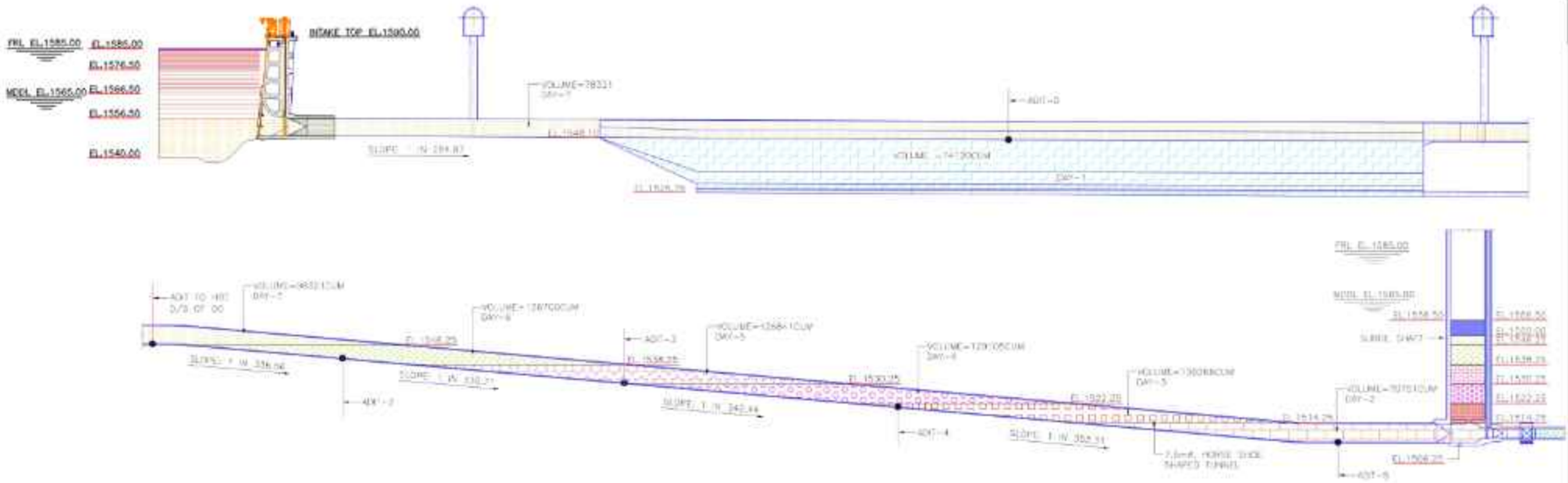
Ensure that ST-1 and ST-2 gates are closed and their functioning is ensured before start of filling above EL. 1566.50 m.

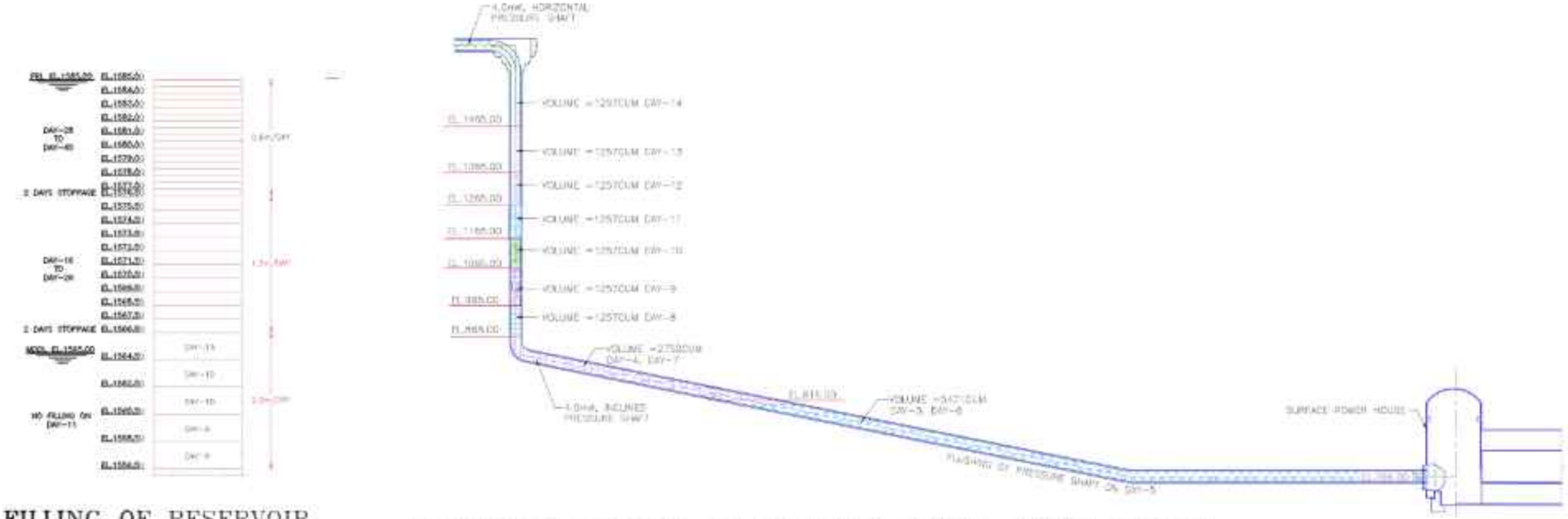
- Filling Reservoir from EL. 1556.50 upto EL. 1576.50 m @ 1 m per day
- Filling Reservoir above EL.1576.50 @ 0.5 m/day

Differential rate of filling has been provided to give sufficient time for the dam and reservoir rim to behave and stabilise.

Day	Reservoir Level (m)	Remarks	Day	Reservoir Level (m)	Remarks
Day-13	1566.50		Day-29	1577.00	Filling rate 0.5 m/day
Day-14	No Filling	2-days	Day-30	1577.50	
Day-15	No Filling		Day-31	1578.00	
Day-16	1567.50	Filling rate 1 m/day	Day-32	1578.50	
Day-17	1568.50		Day-33	1579.00	
Day-18	1569.50		Day-34	1579.50	
Day-19	1570.50		Day-35	1580.00	
Day-20	1571.50		Day-36	1580.50	
Day-21	1572.50		Day-37	1581.00	
Day-22	1573.50		Day-38	1581.50	
Day-23	1574.50		Day-39	1582.00	
Day-24	1575.50		Day-40	1582.50	
Day-25	1576.50		Day-41	1583.00	
Day-26	No Filling	3-days	Day-42	1583.50	
Day-27	No Filling		Day-43	1584.00	
Day-28	No Filling		Day-44	1584.50	
Continued			Day-45	1585.00	

A schematic diagram showing the details and schedule for the initial filing of reservoir and water conductor system is given below;

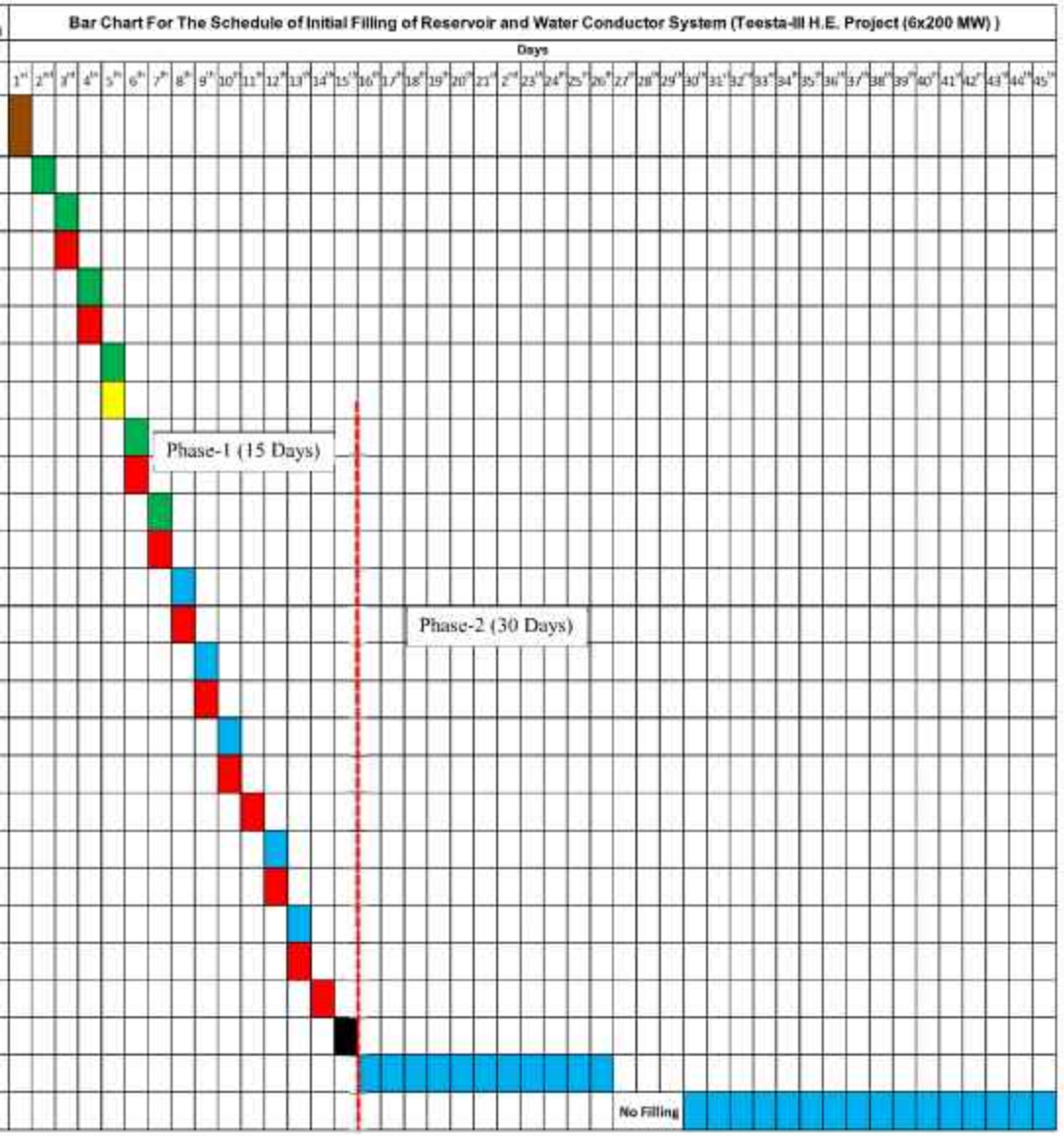




FILLING OF RESERVOIR

SCHEMATIC DIAGRAM OF W.C.S FOR INITIAL WATER FILLING

Sl. No.	Components	Elevation (m)		Filling Volume	Filling Rate	Time required
		From	Up to	m^3	m/hour or m/day	(Hours)
1	Filling of De-Silting Chambers upto HRT invert EL.1546.9 m by keeping Reservoir at EL.1550.0 m	-	1546.90	74120	-	8.00
2	Filling of HRT	1506.25	1514.25	70751	8.0 m/day	8.00
3	Filling of HRT	1514.25	1522.25	136266	8.0 m/day	8.00
4	Filling of Pressure Shaft	766.00	816.00	5471	6.25 m/hr	8.00
5	Filling of HRT	1522.25	1530.25	129105	8.0 m/day	8.33
6	Filling of Pressure Shaft	816.00	865.00	2752	6.13 m/hr	8.00
7	Filling of HRT	1530.25	1538.25	128841	8.0 m/day	8.00
8	Flushing of Pressure Shaft (Emptying)	869.00	766.00	8223	12.50 m/hr	8.00
9	Filling of HRT	1538.25	1546.25	126700	8.0 m/day	8.00
10	Re-Filling of Pressure Shaft	766.00	816.00	5471	6.25 m/hr	8.00
11	Filling of HRT & Raising of Reservoir	1546.25	1556.50	98921	10.3 m/day	8.00
12	Re-Filling of Pressure Shaft	816.00	865.00	2752	6.13 m/hr	8.00
13	Reservoir Filling	1556.50	1558.50	-	2.0 m/day	2.00
14	Filling of Pressure Shaft	865.00	965.00	1257	12.50 m/hr	8.00
15	Reservoir Filling	1558.50	1560.50	-	2.0 m/day	2.00
16	Filling of Pressure Shaft	965.00	1065.00	1257	12.50 m/hr	8.00
17	Reservoir Filling	1560.50	1562.50	-	2.0 m/day	2.00
18	Filling of Pressure Shaft	1065.00	1165.00	1257	12.50 m/hr	8.00
19	Filling of Pressure Shaft	1165.00	1265.00	1257	12.50 m/hr	8.00
20	Reservoir Filling	1562.50	1564.50	-	2.0 m/day	2.00
21	Filling of Pressure Shaft	1265.00	1365.00	1257	12.50 m/hr	8.00
22	Reservoir Filling	1564.50	1566.50	-	2.0 m/day	2.00
23	Filling of Pressure Shaft	1365.00	1465.00	1257	12.50 m/hr	8.00
24	Filling of Pressure Shaft	1465.00	1515.00	2515	6.25 m/hr	8.00
25	HRT & Pressure Shaft - Presure Balance	1515.00	1566.50	-	6.44 m/hr	8.00
26	Reservoir Filling @ 1 m/day	1566.50	1576.50	-	1m/day	8.00
27	Reservoir Filling @ 0.5 m/day	1576.50	1585.00	-	0.5m/day	8.00



7. SURVEILLANCES PLAN DURING INTIAL FILLING OF RESERVOIR AND WCS

Surveillance during the filling of reservoir and water conductor system is vital as it allows the systematic monitoring of performance of all civil and hydro-mechanical structures of the project and planning & implementation of emergency measures that may be required due to abnormal functioning of any of the components. The surveillance monitoring is particularly mentioned of the following structures:

- **Reservoir**

  The reservoir water levels, the weather conditions and discharge in the river are continuously recorded and reservoir is checked for any slide in the reservoir area during filling operation. Quantities of wooden logs entering the reservoir are recorded. The photographic records of the reservoir area are taken.

- **Spillway**

  The seepage through the foundation is continuously monitored. The behaviour of the area downstream of apron is recorded.

- **The Dam**

  All the instruments of the dam are continuously monitored. The readings of piezometers upstream and downstream of cut off wall have taken and seepage downstream of the dam is observed /recorded.

- **De-silting system**

  In the de-silting system, the Silt Flushing Tunnels are operated slowly and the conditions of silt are recorded.

- **HRT**

  Seepage from all the adits are monitored.

- **Powerhouse**

  Seepage in the powerhouse upstream wall is recorded. The readings of the all instruments in the powerhouse, drainage gallery and instrumentation drifts are regularly taken.

8. EVACUATION OF RESERVOIR

If at any time during the initial filling of the reservoir any serious seepage through the dam or foundation occurs or any distress in any structures of the project in noticed, the outlet flow would be increased to lower the pool as much as possible and all necessary warning would be issued. It is possible that extended and extensive rainfall could occur that would cause inflow to exceed the discharge capacity of the outlet. The pool level would then rise faster than the pre-planned rate. However, as soon as possible the pool filling would be returned to the scheduled rate of rise.

The discharging capacity of the right bank Flushing tunnel, when the water level in reservoir is at different levels varies from El. 1540.00m to El. 1588.00m,is tabulated below to compute the average discharging capacity:

Computations of average discharge from Right side flushing Tunnel (From EL. 1540 m to EL. 1588 m):

S.No.	Invert Level (m)	Reservoir Level (m)	Water Head (m)	C_d (Actual)	Actual Discharge (Cumec)	Remarks
1	1540.0	1540.0	0.0	0.51	0.00	
2	1540.0	1541.0	1.0	0.51	13.55	
3	1540.0	1542.0	2.0	0.51	38.34	
4	1540.0	1543.0	3.0	0.51	70.43	
5	1540.0	1544.0	4.0	0.51	108.43	
6	1540.0	1545.0	5.0	0.51	151.54	
7	1540.0	1546.0	6.0	0.51	199.20	
8	1540.0	1547.0	7.0	0.51	251.03	
9	1540.0	1548.0	8.0	0.51	306.69	
10	1540.0	1549.0	9.0	0.51	365.96	
11	1540.0	1550.0	10.0	0.51	428.62	
12	1540.0	1551.0	11.0	0.51	494.49	
13	1540.0	1552.0	12.0	0.51	563.43	
14	1540.0	1553.0	13.0	0.51	635.31	
15	1540.0	1554.0	9.4	0.59	668.86	
16	1540.0	1555.0	10.4	0.61	730.55	
17	1540.0	1556.0	11.4	0.61	765.66	
18	1540.0	1557.0	12.4	0.61	798.67	
19	1540.0	1558.0	13.4	0.61	830.38	
20	1540.0	1559.0	14.4	0.61	862.32	
21	1540.0	1560.0	15.4	0.61	891.86	
22	1540.0	1561.0	16.4	0.61	920.45	
23	1540.0	1562.0	17.4	0.61	948.18	
24	1540.0	1563.0	18.4	0.61	975.13	
25	1540.0	1564.0	19.4	0.61	1001.35	
26	1540.0	1565.0	20.4	0.61	1026.89	
27	1540.0	1566.0	21.4	0.61	1051.82	
28	1540.0	1567.0	22.4	0.61	1076.17	
29	1540.0	1568.0	23.4	0.61	1099.99	
30	1540.0	1569.0	24.4	0.61	1123.29	
31	1540.0	1570.0	25.4	0.61	1146.13	
32	1540.0	1571.0	26.4	0.62	1170.42	
33	1540.0	1572.0	27.4	0.62	1194.36	
34	1540.0	1573.0	28.4	0.62	1219.94	
35	1540.0	1574.0	29.4	0.62	1245.29	
36	1540.0	1575.0	30.4	0.62	1274.50	
37	1540.0	1576.0	31.4	0.63	1299.48	
38	1540.0	1577.0	32.4	0.63	1328.47	
39	1540.0	1578.0	33.4	0.63	1353.13	
40	1540.0	1579.0	34.4	0.63	1375.44	
41	1540.0	1580.0	35.4	0.64	1399.73	
42	1540.0	1581.0	36.4	0.64	1430.56	
43	1540.0	1582.0	37.4	0.65	1461.44	
44	1540.0	1583.0	38.4	0.65	1492.35	
45	1540.0	1584.0	39.4	0.66	1525.64	
46	1540.0	1585.0	40.4	0.66	1549.61	
47	1540.0	1586.0	41.4	0.66	1579.82	
48	1540.0	1587.0	42.4	0.68	1640.63	
49	1540.0	1588.0	43.4	0.71	1723.35	
Total					**44808.89**	

The average discharge/ outflow from the flushing tunnel shall be 44808.89/ 49 = 914.47m^3/sec. The total volume of water to be evacuated from reservoir from EL. 1540m to EL. 1588m is 5.840100Mm^3. Therefore, the time required for evacuation of reservoir through the flushing tunnel shall be 5.840100Mm^3 / 914.47 = 1.77 Hours only in case of emergency. However **the reservoir shall not be depleted/ evacuated at such a fast rate. Normally it shall be evacuated 1.0 to 2.0m height per day depending upon the situation.**

Computations of average discharge from Right side flushing Tunnel (From EL. 1540 m to EL. 1585 m)

Sl.No.	Invert Level (m)	Reservoir Level (m)	Water Head (m)	C_d (Actual)	Actual Discharge (Cumec)	Remarks
1	1540.0	1540.0	0.0	0.51	0.00	
2	1540.0	1541.0	1.0	0.51	13.55	
3	1540.0	1542.0	2.0	0.51	38.34	
4	1540.0	1543.0	3.0	0.51	70.43	
5	1540.0	1544.0	4.0	0.51	108.43	
6	1540.0	1545.0	5.0	0.51	151.54	
7	1540.0	1546.0	6.0	0.51	199.20	
8	1540.0	1547.0	7.0	0.51	251.03	
9	1540.0	1548.0	8.0	0.51	306.69	
10	1540.0	1549.0	9.0	0.51	365.96	
11	1540.0	1550.0	10.0	0.51	428.62	
12	1540.0	1551.0	11.0	0.51	494.49	
13	1540.0	1552.0	12.0	0.51	563.43	
14	1540.0	1553.0	13.0	0.51	635.31	
15	1540.0	1554.0	9.4	0.59	668.86	
16	1540.0	1555.0	10.4	0.61	730.55	
17	1540.0	1556.0	11.4	0.61	765.66	
18	1540.0	1557.0	12.4	0.61	798.67	
19	1540.0	1558.0	13.4	0.61	830.38	
20	1540.0	1559.0	14.4	0.61	862.32	
21	1540.0	1560.0	15.4	0.61	891.86	
22	1540.0	1561.0	16.4	0.61	920.45	
23	1540.0	1562.0	17.4	0.61	948.18	
24	1540.0	1563.0	18.4	0.61	975.13	
25	1540.0	1564.0	19.4	0.61	1001.35	
26	1540.0	1565.0	20.4	0.61	1026.89	
27	1540.0	1566.0	21.4	0.61	1051.82	
28	1540.0	1567.0	22.4	0.61	1076.17	
29	1540.0	1568.0	23.4	0.61	1099.99	
30	1540.0	1569.0	24.4	0.61	1123.29	
31	1540.0	1570.0	25.4	0.61	1146.13	
32	1540.0	1571.0	26.4	0.62	1170.42	
33	1540.0	1572.0	27.4	0.62	1194.36	
34	1540.0	1573.0	28.4	0.62	1219.94	
35	1540.0	1574.0	29.4	0.62	1245.29	
36	1540.0	1575.0	30.4	0.62	1274.50	
37	1540.0	1576.0	31.4	0.63	1299.48	
38	1540.0	1577.0	32.4	0.63	1328.47	
39	1540.0	1578.0	33.4	0.63	1353.13	
40	1540.0	1579.0	34.4	0.63	1375.44	
41	1540.0	1580.0	35.4	0.64	1399.73	
42	1540.0	1581.0	36.4	0.64	1430.56	
43	1540.0	1582.0	37.4	0.65	1461.44	
44	1540.0	1583.0	38.4	0.65	1492.35	
45	1540.0	1584.0	39.4	0.66	1525.64	
46	1540.0	1585.0	40.4	0.66	1549.61	
		Total			**39865.09**	

The average discharge/ outflow from the flushing tunnel shall be 39865.09/ 46 = 866.63m^3/sec. The total volume of water to be evacuated from reservoir from EL. 1540m to EL. 1585m is 5.078550Mm^3. Therefore, the time required for evacuation of reservoir shall be 5.078550Mm^3 / 866.63 = 1.63 Hours only in case of emergency. However the reservoir shall not be depleted/ evacuated at such a fast rate. Normally it shall be evacuated 1.0 to 2.0m height per day depending upon the situation.

Computations of average discharge from Right side flushing Tunnel (From EL. 1540 m to EL. 1565 m):

Sl. No.	Invert Level (m)	Reservoir Level (m)	Water Head (m)	C_d (Actual)	Actual Discharge (Cumec)	Remarks
1	1540.0	1540.0	0.0	0.51	0.00	
2	1540.0	1541.0	1.0	0.51	13.55	
3	1540.0	1542.0	2.0	0.51	38.34	
4	1540.0	1543.0	3.0	0.51	70.43	
5	1540.0	1544.0	4.0	0.51	108.43	
6	1540.0	1545.0	5.0	0.51	151.54	
7	1540.0	1546.0	6.0	0.51	199.20	
8	1540.0	1547.0	7.0	0.51	251.03	
9	1540.0	1548.0	8.0	0.51	306.69	
10	1540.0	1549.0	9.0	0.51	365.96	
11	1540.0	1550.0	10.0	0.51	428.62	
12	1540.0	1551.0	11.0	0.51	494.49	
13	1540.0	1552.0	12.0	0.51	563.43	
14	1540.0	1553.0	13.0	0.51	635.31	
15	1540.0	1554.0	9.4	0.59	668.86	
16	1540.0	1555.0	10.4	0.61	730.55	
17	1540.0	1556.0	11.4	0.61	765.66	
18	1540.0	1557.0	12.4	0.61	798.67	
19	1540.0	1558.0	13.4	0.61	830.38	
20	1540.0	1559.0	14.4	0.61	862.32	
21	1540.0	1560.0	15.4	0.61	891.86	
22	1540.0	1561.0	16.4	0.61	920.45	
23	1540.0	1562.0	17.4	0.61	948.18	
24	1540.0	1563.0	18.4	0.61	975.13	
25	1540.0	1564.0	19.4	0.61	1001.35	
26	1540.0	1565.0	20.4	0.61	1026.89	
Total					**14047.34**	

The average discharge/ outflow from the flushing tunnel shall be 14047.34/ 26 = 540.28m^3/sec. The total volume of water to be evacuated from reservoir from EL. 1540m to EL. 1565m is 1.751950Mm^3.Therefore, the time required for evacuation of reservoir shall be 5.078550Mm^3 / 866.63 = 1.63 Hours only in case of emergency. However the reservoir shall not be depleted/ evacuated at such a fast rate. Normally it shall be evacuated 1.0 to 2.0m height per day depending upon the situation.

A table showing the Details of evacuation of reservoir from various reservoir levels are shown below:

DETAILS OF EVACUATION OF RESERVOIR FROM VARIOUS LEVELS

S.N.	Water evacuation level (In meters)		Water filling height (In meters)	Volume (Mm^3)	Average Discharge (m^3/sec)	Time Required (In hours)	Remarks
	From	Up to					
1	1540.00	1588.00	48.00	5.840100	914.47	1.77	
2	1540.00	1585.00	45.00	5.078550	866.63	1.63	
3	1540.00	1565.00	25.00	1.751950	540.28	0.90	

9. RESERVOIR REGULATION DURING INITIAL FILLING

There are four outlets for regulation of the reservoir water downstream during the Monsoon as below:

1. Left Bank Flushing cum spillway tunnel of 11.0m diameter having invert level El.-1540.0m. The discharging capacity of this tunnel is **1750.00m^3/sec.**

2. Left Bank spillway tunnel-1 of 10.0m diameter having invert level El.- 1555.0m. The discharging capacity of this tunnel is **1028.00m^3/sec.**
3. Chute Spillway (Left bank) having crest level El.- 1565.50m.The discharging capacity of this spillway is **3500.00m^3/sec.**
4. Left Bank spillway tunnel-2 of 10.0m diameter having invert level El.- 1572.0m.The discharging capacity of this tunnel is **1400m^3/sec.**

In addition of above outlets there is a Power Intake tunnel with sill level El. 1549.0m having discharging capacity **202.0m^3/sec.**

The Reservoir Area-Capacity curve has been prepared to know the area and capacity of reservoir at different levels and the same is enclosed as **Appendix- C (Sheet 1 & 2).**

The following Stage-Discharge Curves (Rating Curves) have been prepared considering the different water levels in reservoir up to the FRL (EL. 1585.00m). The details of these Stage-Discharge Curves can be referred from **Para-5 above.** The reservoir can be regulated as per these curves to assess the time required for filling/ evacuation of Reservoir and Water Conductor System.

- Discharge rating curve of Right Bank Flushing Tunnel
- Discharge rating curve of Power tunnel Intake
- Discharge rating curve of Left Bank Spillway Tunnel No.-1
- Discharge rating curve of Left Bank Spillway Tunnel No.-2
- Discharge rating curve of Left Bank Chute Spillway

10. MONITORING:

The following instruments readings shall be monitored before, after, during the filling and suspended period during filling. The locations of the various instruments provided in various Project Components are tabulated below:

Dam Complex, Geotechnical Instrumentation List

Location	RD/Elevation	Instrument Type	No of Instruments
Adit to Spillway-2 (At crossing with DT)	RD 63m, El 1527m (vertically downward at invert of the adit)	MPBX (2,4,6m)	MPBX=1
Adit to HRT DS (At crossing with Flushing Tunnel)	RD 139m, EL 1541m (Vertically downward at invert of the adit)	MPBX (2,4,6m)	MPBX=1
Desilting Chamber-1	31m D/S of Adit-0 at Crown	MPBX (3,6,9m) and Load Cell	MPBX=1
			Load Cell=1
	31m D/S of Adit-0 at Left wall, EL 1546m		MPBX=1
			Load Cell=1
	31m D/S of Adit-0 at Right wall, EL		MPBX=1

Dam Complex, Geotechnical Instrumentation List			
Location	**RD/Elevation**	**Instrument Type**	**No of Instruments**
	1546m		Load Cell=1
	171m D/S of Adit-0 at crown		MPBX=1 Load Cell=1
	171m D/S of Adit-0 at Left wall, EL 1546		MPBX=1 TCS=1 Load Cell=1
	171m D/S of Adit-0 at Right wall, EL-1546m		MPBX=1 TCS=1
			Load Cell=1
	109m U/S of Adit-0 at Crown		MPBX=1 Load Cell=1
	109m U/S of Adit-0 at Left wall, EL 1546		MPBX=1 Load Cell=1
	109m U/S of Adit-0 at Right wall, EL 1546		MPBX=1 Load Cell=1
Desilting Chamber-2	66m D/S of Construction Adit at crown	MPBX (3,6,9m) and Load Cell	MPBX=1 Load Cell=1
	66m D/S of Construction Adit at El 1546m, Left wall		MPBX=1 Load Cell=1
	66m D/S of Construction Adit at El 1546m, Right wall		MPBX=1 Load Cell=1
	73m U/S of Construction Adit at crown		MPBX=1 Load Cell=1
	73m U/S of Construction Adit at El 1546m, Right wall		MPBX=1 Load Cell=1
	73m U/S of Construction Adit at El 1546m, Left wall		MPBX=1 Load Cell=1
	213m U/S of Construction Adit at Crown		MPBX=1 Load Cell=1
	273m U/S of Construction Adit at El 1546, Left wall		MPBX=1 Load Cell=1
	273m U/S of Construction Adit at El 1546, Right wall		MPBX=1 Load Cell=1
	El 1650m		MPBX=1 Load Cell=1
	El 1620m (At Site, EL 1622m)		MPBX=1
Left Bank Dam Axis	El 1590	MPBX (5,10,15m)	MPBX=1
Near Portal of Access Tunnel Limb to ST-2 Inlet	RD 85m at crown	MPBX (3,6,9m), Load Cell and Tape convergence points	MPBX=1 Load Cell=1 TCS=3
Near Portal Acess Tunnel Limb to ST-1 Inlet	RD 233.263m at crown	MPBX (3,6,9m), Load Cell and Tape convergence	MPBX=1 Load Cell=1 TCS=3

Dam Complex, Geotechnical Instrumentation List			
Location	**RD/Elevation**	**Instrument Type**	**No of Instruments**
		points	
Access Tunnel Drift Anchor 2			MPBX=1
Access Tunnel Drift Anchor 3			MPBX=1
Access Tunnel Drift Anchor		MPBX (12,17,23)	MPBX=1
Dam	Ch. 115, El 1535m	Hydraulic Settlement Gauge	1
	Ch. 45, El 1571m		1
	Ch. 115, El 1560m		1
CFRD	SP1, CH-10,EL 1586(1.5m U/S of Dam Axis on Face Slab)	Surface Settlement Points	23
	SP2, CH-45,EL 1586(1.5m U/S of Dam Axis on Face Slab)		
	SP3, CH-80,EL 1586(1.5m U/S of Dam Axis on Face Slab)		
	SP4, CH-115,EL 1586(1.5m U/S of Dam Axis on Face Slab)		
	SP5, CH-150,EL 1586(1.5m U/S of Dam Axis on Face Slab)		
	SP6, CH-185,EL 1586(1.5m U/S of Dam Axis on Face Slab)		
	SP7, CH-2,EL 1591.50(Dam Axis Top of Parapet Wall)		
	SP8, CH-37,EL 1591.50 (Dam Axis Top of Parapet Wall)		
	SP9, CH-72,EL 1591.50 (Dam Axis Top of Parapet Wall)		
	SP10, CH-107,EL 1591.50(Dam Axis Top of Parapet Wall)		
	SP11, CH-142,EL 1591.50 (Dam Axis Top of Parapet Wall)		
	SP12, CH-177,EL 1591.50 (Dam Axis Top of Parapet Wall)		
	SP13, CH-205,EL 1591.50 (Dam Axis Top of Parapet Wall)		
	SP14, CH-10,EL 1560.00(71.2m D/S of Dam Axis)		
	SP15, CH-45,EL 1560.00(64.88m D/S of Dam Axis)		
	SP16, CH-80,EL 1560.00(64.88m D/S of Dam Axis)		
	SP17, CH-115,EL 1560.00(59.94m D/S of Dam Axis)		

Dam Complex, Geotechnical Instrumentation List			
Location	**RD/Elevation**	**Instrument Type**	**No of Instruments**
	SP18, CH-150,EL 1560.00(59.94m D/S of Dam Axis)		
	SP19, CH-183,EL 1560.00(59.94m D/S of Dam Axis)		
	SP20, CH-45,EL 1540.00(109.09m D/S of Dam Axis)		
	SP21, CH-80,EL 1540.00(104.77m D/S of Dam Axis)		
	SP22, CH-115,EL 1540.00(99.83m D/S of Dam Axis)		
	SP23, CH-150,EL 1540.00(103.22m D/S of Dam Axis)		
CFRD	SPM1, CH-202.0	Stand Pipe Piezometers	7
	SPM2, CH-180.0		
	SPM3, CH-150.0		
	SPM4, CH-115.0		
	SPM5, CH-75.0		
	SPM6, CH-45.0		
	SPM7, CH-22.0		
CFRD Cut Off Wall	PJM1, CH-45.0	3-Dimensional Perimetric Joint Meters	8
	PJM2,CH-45.0		
	PJM3, CH-45.0		
	PJM4, CH-45.0		
	PJM5, CH-115.0		
	PJM6, CH-115.0		
	PJM7, CH-115.0		
	PJM8, CH-115.0		
CFRD-Face Slabe	JM1, CH.-2.0,	Joint Meter	6
	JM2, CH.-45.0,		
	JM3, CH.-115.0		
	JM4, CH.-185.0		
	JM5, CH.-15.0		

Dam Complex, Geotechnical Instrumentation List			
Location	**RD/Elevation**	**Instrument Type**	**No of Instruments**
	JM6, CH.-180.0		
CFRD Cut Off	PPG-1,Ch. 139.00, El 1525m, U/S of Cut Wall	Piezometer	10
	PPG-2, Ch. 139.00 , El 1525, D/S of Cut Wall		
	PPG-3,Ch. 89.00, El 1520m, D/S of Cut Wall		
	PPG-4, Ch. 89.00, El 1500m, U/S of Cut Wall		
	PPG-5, Ch. 89.00, El 1500m, D/S of Cut Wall		
	PPG-6, Ch. 34.00, El 1520m, D/S of Cut Wall		
	PPG-7, Ch. 34.00, El 1500m, U/S of Cut Wall		
	PPG-8, Ch. 34.00, El 1500m, D/S of Cut Wall		
	PPG-9, Ch. 4.00, El 1525m, U/S of Cut Wall		
	PPG-10, Ch. 4.00, El 1525, D/S of Cut Wall		
Chute Spillway	FP1,Left Channel RD -2.00m from Spillway Axis, El	Foundation Piezometers	4
	FP2,Right Channel RD -2.00m from Spillway Axis		
	FP3, Right Channel RD 30.00m from Spillway Axis		
	FP4, Left Channel RD 30.00m from Spillway Axis		
	PP1,Left Channel RD -2.00m from Spillway Axis,El 1562m	Pore Pressure Meters	4
	PP2,Right Channel RD -2.00m from Spillway Axis,El 1562m		
	PP3, Right Channel RD 30.00m from Spillway Axis,El 1559m		
	PP4, Right Channel RD 30.00m from Spillway Axis,El 1559m		
	Left Side Pier RD -13.00m from Spillway Axis,El 1588m	Tiltmeters	6
	Left Side Pier RD 30.00m from Spillway Axis,El 1584m		
	Central Line of Approach Channel RD -13.00m from Spillway Axis, El		
	Central Line of Approach Channel RD 30.00m from Spillway Axis, El 1585m		
	Right Side Pier RD -13.00m from Spillway Axis,El 1588m		

Dam Complex, Geotechnical Instrumentation List			
Location	**RD/Elevation**	**Instrument Type**	**No of Instruments**
	Right Side Pier RD 30.00m from Spillway Axis,El 1584m		
	Right channel of Spillway,Panel no.1	Survey Targets	10
	Light channel of Spillway,Panel no.1		
	Right channel of Spillway,Panel no.2A		
	Light channel of Spillway,Panel no.2A		
	Right channel of Spillway,Panel no.2B		
	Light channel of Spillway,Panel no.2B		
	Right channel of Spillway,Panel no.3		
	Light channel of Spillway,Panel no.3		
	Right channel of Spillway,Panel no.4		
	Light channel of Spillway,Panel no.4		
	SDI (Serial Digital Interface) at adjacent to control room above El 1590m	SDI	1
	DAS system in control room	DAS	1
DC-1	20m from end of U/S transition, Left side	Peizometer	2
	20m from end of U/S transition, Right side		2
	160m from end of U/S transition, Left side		2
	160m from end of U/S transition, Right side		2
	300m from end of U/S transition		4
DC-2	20m from end of U/S transition, Left side	Peizometer	2
	20m from end of U/S transition, Right side		2
	160m from end of U/S transition		4
	300m from end of U/S transition		4

Power House Complex, Geotechnical Instrumentation List			
Location	**RD/Elevation**	**Instrument Type**	**No. of Instrument Proposed**
Instrumentation Cum Drainage Gallery and its Access Tunnel	INTEXT-1,RD-14.454m,EL 806.00m	MPBX	1
	INTEXT-2, RD-17.148m, EL 806.00m		1
	INTEXT-3,RD- 167.489m,EL 822.45m		1
	INTEXT-4,RD-173.332m,EL 822.45m		1
	INTEXT-5, RD-184.545m, EL 822.45m		1
	INTEXT-7,RD-0.00m, EL 822.45m		1
	INTEXT-9,RD-85.00m, EL 822.45m		1
Power House Cavern Instrumentation	PHCP-1, RD-21.60m , EL 795.75m	Convergence Points	1
	PHCP-2, RD-21.60m, EL 791.00m		1
	PHCP-3,RD-21.60m, EL 783m		1
	PHCP-4,RD-69.6m, EL 795.75m		1

Power House Complex, Geotechnical Instrumentation List			
Location	**RD/Elevation**	**Instrument Type**	**No. of Instrument Proposed**
	PHCP-5,RD-69.6m, EL 791.00m		1
	PHCP-6,RD-69.6m, EL 784.927m		1
	PHCP-7,RD-69.6m, EL 776.399m		1
	PHCP-8,RD-107.603m, EL 795.75m		1
	PHCP-9,RD-107.603m, EL 791.00m		1
	PHCP-10,RD-107.603m, EL 784.927m		1
	PHCP-11, RD-107.603m, EL 776.399m		1
	PHCP-12,RD-129m, EL 795.75m		1
	PHCP-13,RD-153.407m, EL 791.00m		1
	PHCP-14,RD-153.407m, EL 783m		1
	PHCP-15,RD-153.407m, EL 776.3m		1
	PHCP-16,RD-193.603m, EL 795.75m		1
	PHCP-17,RD-193.603m, EL 791m		1
	PHCP-18,RD-193.603m, EL-783m		1
	PHCP-19,RD- 193.603m,EL 776.3m		1
Power House Cavern, Instrumentation	RD-21.6m,EL 822.0m, From instrumentation Gallery cross cuts in Downward direction.	MPBX No.-1	1
	RD-35.00m,EL 789.9m,U/S Wall of Service Bay crown	Load Cell	1
	RD-35.39m,EL 785.9m, PH-Connecting Tunnel (CT)	Load Cell	1
	RD-35.39m,EL 785.9m, Transformer Cavern(TC)- Connecting Tunnel (CT), at crown	Load Cell	1
	RD-48.4m, EL 786m,D/S wall	MPBX, (Addational directed at site).	1
	RD-49.00m, EL 776m, U/S Wall	MPBX, (Addational directed at site).	1
	RD-65.00m,EL 782m, D/S Wall	MPBX, (Addational directed at site).	1
Power House Cavern, Instrumentation	RD-65.00m,EL 782m, D/SWall	MPBX (Additional instrument directed at site)	1
	RD-69.00m, EL 802m, Crown	MPBX No.-2	1
	RD-72.6m, EL 786m,D/S Wall	MPBX No.-14	1

Power House Complex, Geotechnical Instrumentation List			
Location	**RD/Elevation**	**Instrument Type**	**No. of Instrument Proposed**
	RD-96.6m, EL 786m,D/S Wall	MPBX No.-15	1
	RD-107.0m, EL 795.75m, U/S Wall	MPBX No.-8 (15m,10m,5m)	1
	RD-107.0m, EL 795.75m, D/S Wall	MPBX No.-12 (15m,10m,5m)	1
	RD-107.0m, EL 822m, Downward direction from instrumentation Gallery	MPBX No. 3	1
	RD-107, EL 780m,U/S Wall	MPBX No.-10	1
	RD-108.63m,EL 784.4m, PH-BUS DUCT-3 Crown	Load Cell	1
	RD-120.6m,EL 786m, D/S Wall	MPBX No.-16	
	RD-129.0m,EL 802m, PH Crown	MPBX No.-4	
	RD-132.63m,EL 784.4m, PH-BUS DUCT-4 Crown	Load Cell	
	RD-132.63m,EL 784.4m, TC-BUS DUCT-4 Crown	Load Cell	
	RD-144.6m,EL 786.0m, D/S Wall	MPBX No.-17	
	RD-153.0m, EL 802.0m, PH Crown	MPBX No.-5	
	RD-168.6m, EL 786.0m, D/S Wall	MPBX No.-18	
	RD-177.1m, EL 802.0m, PH Crown	MPBX No.-6	
	RD-177.6m, EL 770.0m, U/S Wall	MPBX (Additional directed at Site)	
	RD-180.0m, EL 792.0m, D/S Wall	Load Cell	
	RD-180.63m,EL 784.4m, PH-BUS DUCT-6 Crown	Load Cell	
	RD-180.63m,EL 784.4m, TC-BUS DUCT-6 Crown	Load Cell	
	RD-192.6m,EL 786.0m, D/S Wall	MPBX No.-19	1
	RD-193.6m, EL 770.5m, U/S Wall	MPBX No.-9	1
	RD-193.6m,EL 795.75m, D/S Wall	MPBX No.-13	1

Power House Complex, Geotechnical Instrumentation List			
Location	**RD/Elevation**	**Instrument Type**	**No. of Instrument Proposed**
	RD-193.6m, EL 822.1m, Downward direction from instrumentation Gallery Cross Cut	MPBX No.-7	1
	RD-193.6m, EL 80.0m, U/S Wall	MPBX No.-11	1
Transformer and GIS Cavarns	RD-33.0m,EL 809.0m,GIS Cavarn	MPBX No.-2	1
	GIS RD-33.0m (TC RD- 118m)	Convergence Points (2a & 2b), EL 805m	1
	RD-34.6m,EL 806.0m, Cable Tunnel Crown	MPBX No.-1	1
	RD-110.0m,EL-809.0m, GIS Crown	MPBX No.-2	1
	RD-180.0m,EL 794.30m, TC Crown	MPBX No.-3	1
	RD-118.0m,EL 795.30m, Transformer Hall U/S Wall	MPBX No.-5	1
	RD-118.0m,EL 795.31m, Transformer Hall D/S Wall	MPBX No.-7	1
	RD-180.3m,EL 788.5m, Transformer Hall U/S Wall	MPBX No.-6	1
	RD-180.3m,EL 794.3m, Transformer Cavern Crown	MPBX	1
Pressure Shaft	**Location (Elevation)**	**Instrument Type**	**No. of Instrument Proposed**
	P4	MPBX	1
	P6 (El 1513.00)	MPBX	1
	P11	MPBX	1
	P14 (El 1512.00)	MPBX	1
	P17 (El 1513.00)	MPBX	1
	P19 (El 1505.00)	MPBX	1
	P20 (El 1517.00)	MPBX	1
	P20 (El 1511.00)	MPBX	1
	P28	MPBX	1
	P34 (El-1517.00)	MPBX	1

A record of the above instruments readings shall be maintained. Filling shall be suspended of the abnormal readings of the instruments shall be carried out and if required the remedial measures immediately, if abnormal increase or decrease in the readings is noticed. The detailed analysis shall be undertaken. The filling shall be resumed after necessary remedial measures.

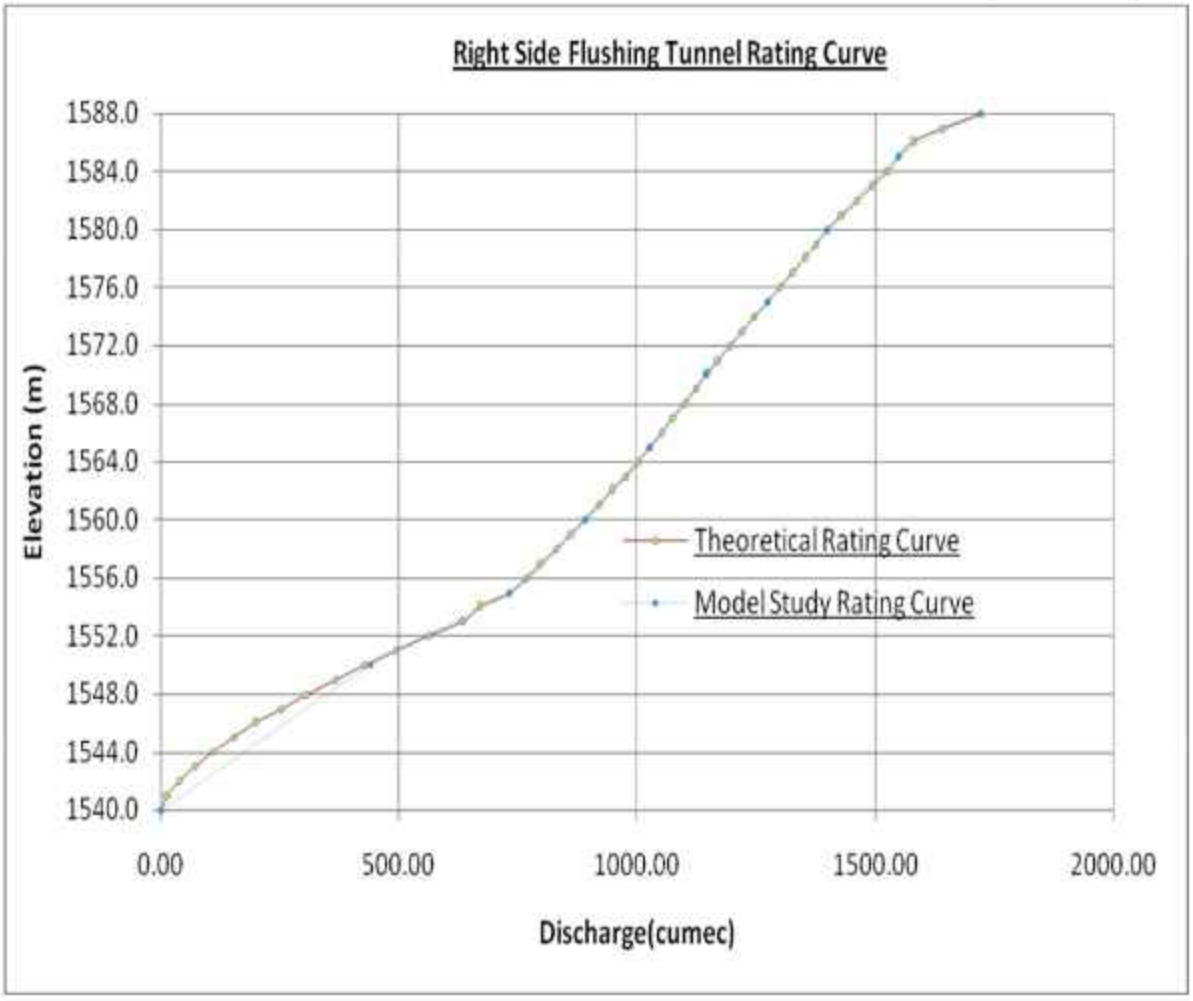
ANNEXURES (1 TO 10)

Annexure-1

Computations of Rating Curve of Right side flushing Tunnel (From EL. 1540 m to EL. 1588 m)

S.No.	Invert Level (m)	Reservoir Level (m)	Water Head (m)	C_d (Actual)	Actual Discharge (Cumec)	Remarks
1	1540.0	1540.0	0.0	0.51	0.00	
2	1540.0	1541.0	1.0	0.51	13.55	
3	1540.0	1542.0	2.0	0.51	38.34	
4	1540.0	1543.0	3.0	0.51	70.43	
5	1540.0	1544.0	4.0	0.51	108.43	
6	1540.0	1545.0	5.0	0.51	151.54	
7	1540.0	1546.0	6.0	0.51	199.20	
8	1540.0	1547.0	7.0	0.51	251.03	Free Flow Condition
9	1540.0	1548.0	8.0	0.51	306.69	
10	1540.0	1549.0	9.0	0.51	365.96	$Q=\frac{2}{3}\sqrt{2g}C_d LH^{3/2}$
11	1540.0	1550.0	10.0	0.51	428.62	
12	1540.0	1551.0	11.0	0.51	494.49	
13	1540.0	1552.0	12.0	0.51	563.43	
14	1540.0	1553.0	13.0	0.51	635.31	
15	1540.0	1554.0	9.4	0.59	668.86	
16	1540.0	1555.0	10.4	0.61	730.55	
17	1540.0	1556.0	11.4	0.61	765.66	
18	1540.0	1557.0	12.4	0.61	798.67	
19	1540.0	1558.0	13.4	0.61	830.38	
20	1540.0	1559.0	14.4	0.61	862.32	
21	1540.0	1560.0	15.4	0.61	891.86	
22	1540.0	1561.0	16.4	0.61	920.45	
23	1540.0	1562.0	17.4	0.61	948.18	
24	1540.0	1563.0	18.4	0.61	975.13	
25	1540.0	1564.0	19.4	0.61	1001.35	
26	1540.0	1565.0	20.4	0.61	1026.89	
27	1540.0	1566.0	21.4	0.61	1051.82	
28	1540.0	1567.0	22.4	0.61	1076.17	
29	1540.0	1568.0	23.4	0.61	1099.99	
30	1540.0	1569.0	24.4	0.61	1123.29	Orifice Flow condition
31	1540.0	1570.0	25.4	0.61	1146.13	
32	1540.0	1571.0	26.4	0.62	1170.42	
33	1540.0	1572.0	27.4	0.62	1194.36	$Q=C_d Lh\sqrt{2gH}$
34	1540.0	1573.0	28.4	0.62	1219.94	
35	1540.0	1574.0	29.4	0.62	1245.29	
36	1540.0	1575.0	30.4	0.62	1274.50	
37	1540.0	1576.0	31.4	0.63	1299.48	
38	1540.0	1577.0	32.4	0.63	1328.47	
39	1540.0	1578.0	33.4	0.63	1353.13	
40	1540.0	1579.0	34.4	0.63	1375.44	
41	1540.0	1580.0	35.4	0.64	1399.73	
42	1540.0	1581.0	36.4	0.64	1430.56	
43	1540.0	1582.0	37.4	0.65	1461.44	
44	1540.0	1583.0	38.4	0.65	1492.35	
45	1540.0	1584.0	39.4	0.66	1525.64	
46	1540.0	1585.0	40.4	0.66	1549.61	
47	1540.0	1586.0	41.4	0.66	1579.82	
48	1540.0	1587.0	42.4	0.68	1640.63	
49	1540.0	1588.0	43.4	0.71	1723.35	

Annexure-2



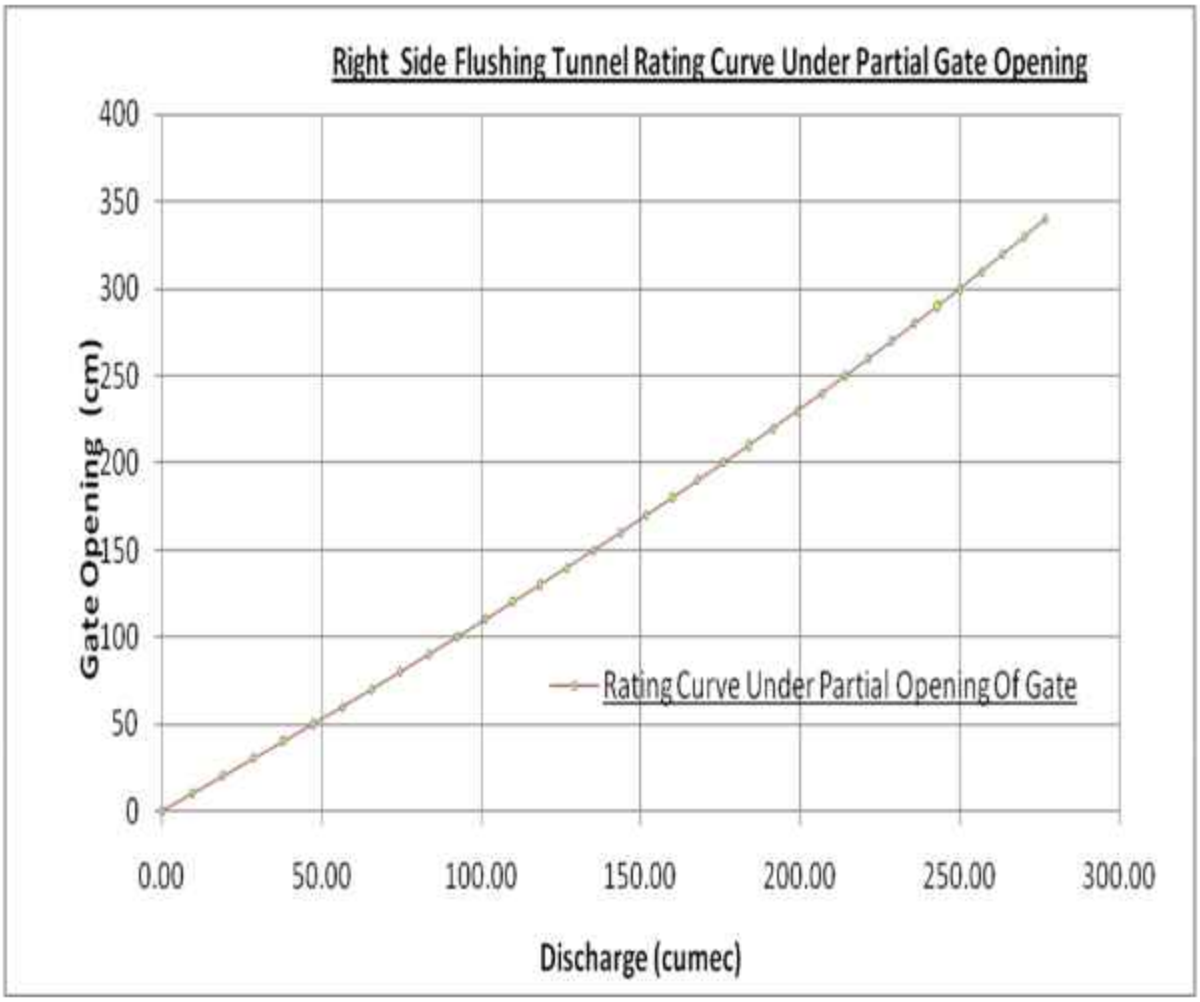
Where, Q – Discharge in m^3/s, C_d – Coefficient of discharge, H – Head of water in meter, L – Width of Gate in meter, h – Height of gate in meter.

Annexure-3

Rating Curve of Right Side Flushing Tunnel under Partial gate opening at Reservoir Level 1550m

S.No.	Invert Level (m)	Reservoir Level (m)	Gate opening (cm)	Cd	Discharge (cumec)	Remarks
1	1540	1550	0	0.77	0.00	
2	1540	1550	10	0.77	9.63	
3	1540	1550	20	0.76	19.18	
4	1540	1550	30	0.76	28.65	
5	1540	1550	40	0.76	38.02	
6	1540	1550	50	0.76	47.31	
7	1540	1550	60	0.76	56.51	
8	1540	1550	70	0.76	65.62	
9	1540	1550	80	0.76	74.65	
10	1540	1550	90	0.75	83.59	
11	1540	1550	100	0.75	92.42	
12	1540	1550	110	0.75	101.18	
13	1540	1550	120	0.75	109.85	Orifice Flow condition
14	1540	1550	130	0.75	118.42	
15	1540	1550	140	0.75	126.90	
16	1540	1550	150	0.74	135.29	$Q = C_d L h \sqrt{2gH}$
17	1540	1550	160	0.74	143.59	
18	1540	1550	170	0.74	151.80	
19	1540	1550	180	0.74	159.90	
20	1540	1550	190	0.74	167.91	
21	1540	1550	200	0.74	175.85	
22	1540	1550	210	0.73	183.68	
23	1540	1550	220	0.73	191.39	
24	1540	1550	230	0.73	199.04	
25	1540	1550	240	0.73	206.59	
26	1540	1550	250	0.73	214.03	
27	1540	1550	260	0.72	221.37	
28	1540	1550	270	0.72	228.62	
29	1540	1550	280	0.72	235.78	
30	1540	1550	290	0.72	242.85	
31	1540	1550	300	0.72	249.79	
32	1540	1550	310	0.71	256.68	
33	1540	1550	320	0.71	263.43	
34	1540	1550	330	0.71	270.09	
35	1540	1550	340	0.71	276.66	

Annexure-4



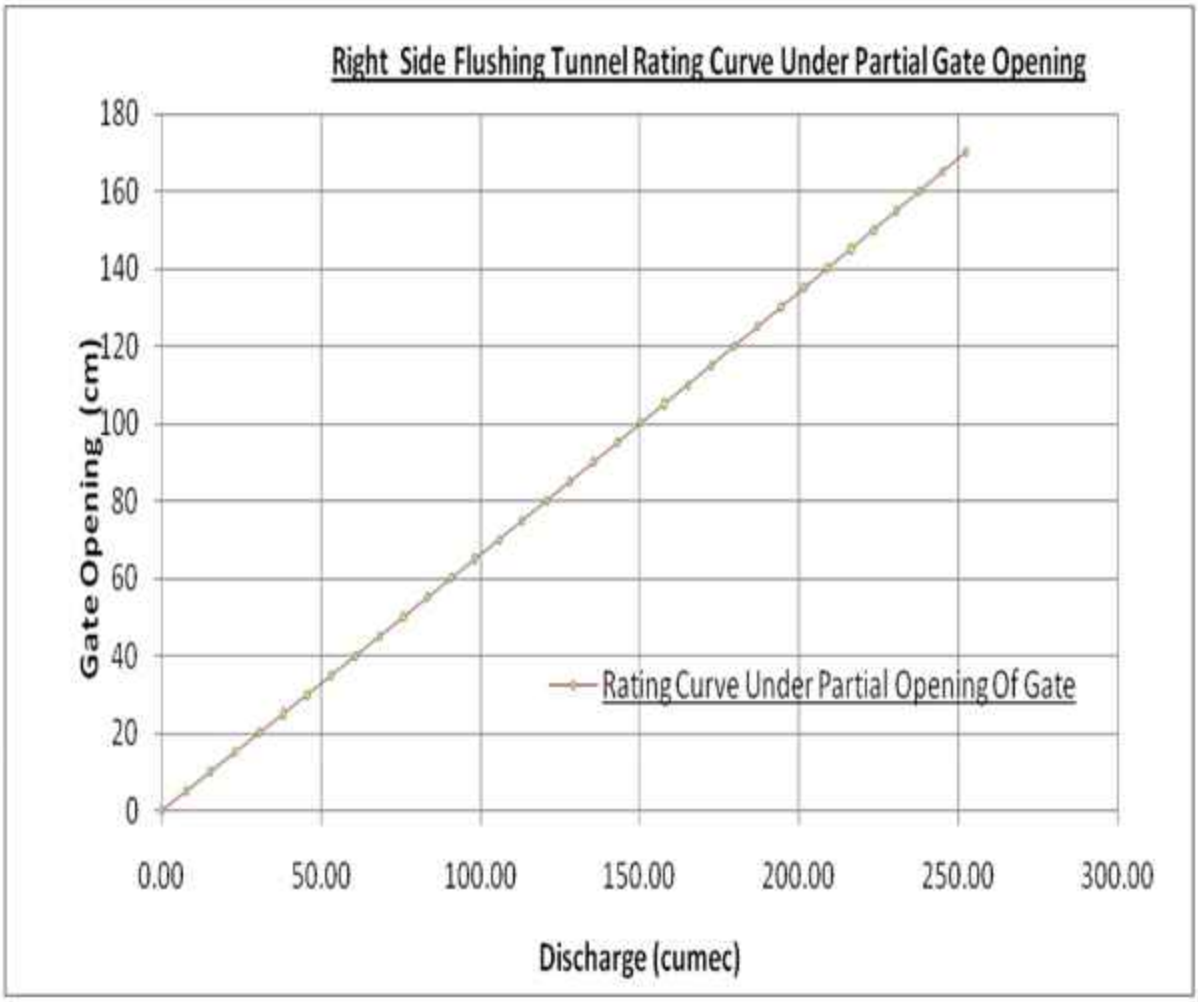
Where, Q – Discharge in m^3/s, C_d – Coefficient of discharge, H – Head of water in meter, L – Width of Gate in meter, h – Height of gate in meter.

Annexure-5

Rating Curve of Right Side Flushing Tunnel under Partial gate opening at Reservoir Level 1565 m

S.No.	Invert Level (m)	Reservoir Level (m)	Gate opening (cm)	Cd	Discharge (cumec)	Remarks
1	1540	1565	0	0.77	0.00	
2	1540	1565	5	0.77	7.64	
3	1540	1565	10	0.77	15.27	
4	1540	1565	15	0.77	22.89	
5	1540	1565	20	0.77	30.50	
6	1540	1565	25	0.77	38.09	
7	1540	1565	30	0.77	45.66	
8	1540	1565	35	0.77	53.22	
9	1540	1565	40	0.77	60.77	
10	1540	1565	45	0.77	68.31	
11	1540	1565	50	0.76	75.83	
12	1540	1565	55	0.76	83.34	
13	1540	1565	60	0.76	90.83	
14	1540	1565	65	0.76	98.31	
15	1540	1565	70	0.76	105.78	
16	1540	1565	75	0.76	113.23	Orifice Flow condition
17	1540	1565	80	0.76	120.67	
18	1540	1565	85	0.76	128.10	
19	1540	1565	90	0.76	135.51	$Q = C_d L h \sqrt{2gH}$
20	1540	1565	95	0.76	142.91	
21	1540	1565	100	0.76	150.30	
22	1540	1565	105	0.76	157.67	
23	1540	1565	110	0.76	165.03	
24	1540	1565	115	0.76	172.38	
25	1540	1565	120	0.76	179.71	
26	1540	1565	125	0.76	187.03	
27	1540	1565	130	0.76	194.33	
28	1540	1565	135	0.76	201.62	
29	1540	1565	140	0.76	208.87	
30	1540	1565	145	0.76	216.13	
31	1540	1565	150	0.76	223.38	
32	1540	1565	155	0.76	230.62	
33	1540	1565	160	0.76	237.84	
34	1540	1565	165	0.76	245.05	
35	1540	1565	170	0.76	252.25	

Annexure-6



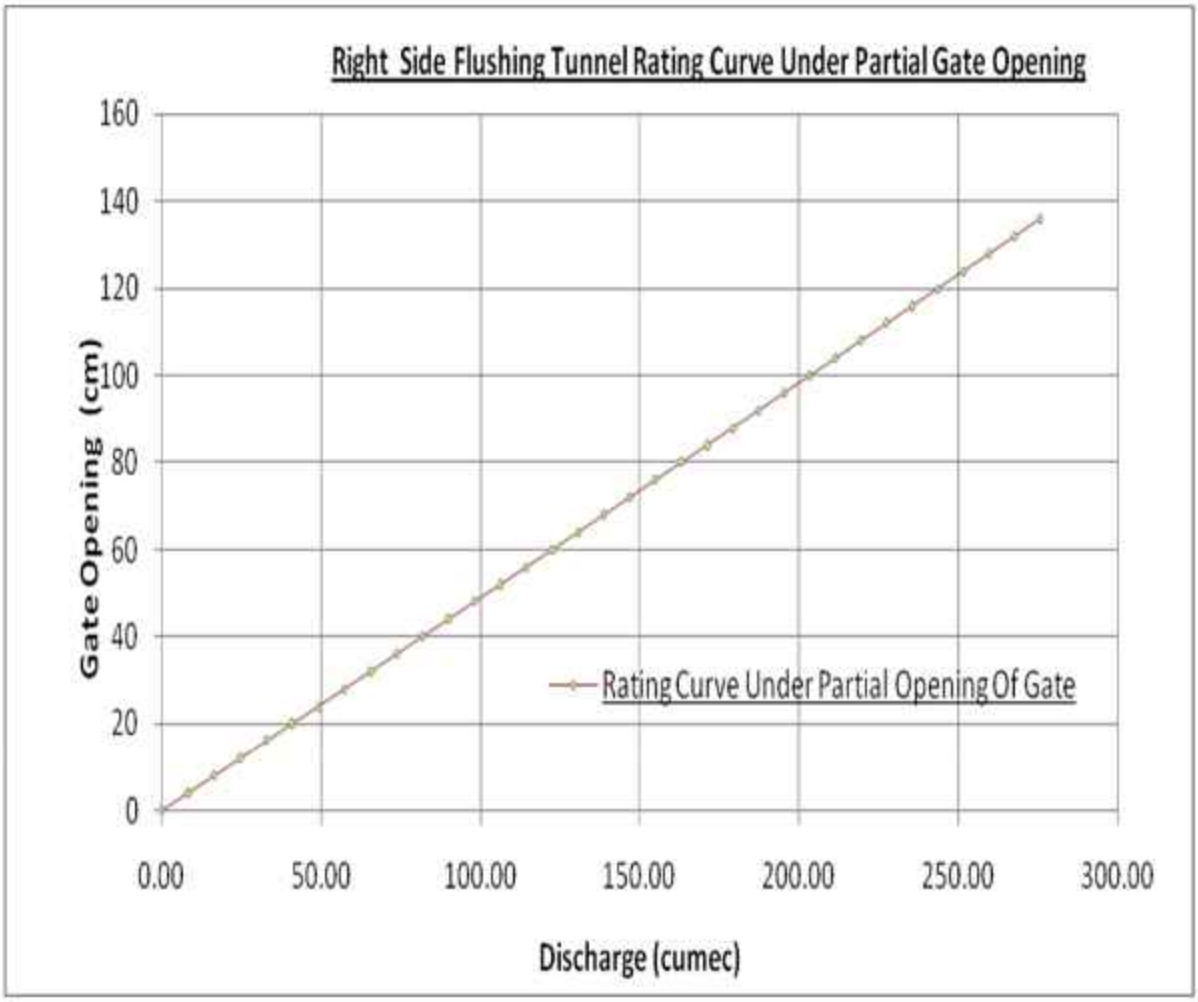
Where, Q – Discharge in m^3/s, C_d – Coefficient of discharge, H – Head of water in meter, L – Width of Gate in meter, h – Height of gate in meter.

Annexure-7

Rating Curve of Right Side Flushing Tunnel under Partial gate opening at Reservoir Level 1585 m

S.No.	Invert Level (m)	Reservoir Level (m)	Gate opening (cm)	Cd	Discharge (cumec)	Remarks
1	1540	1585	0	0.77	0.00	
2	1540	1585	4	0.77	8.21	
3	1540	1585	8	0.77	16.41	
4	1540	1585	12	0.77	24.61	
5	1540	1585	16	0.77	32.80	
6	1540	1585	20	0.77	40.98	
7	1540	1585	24	0.77	49.16	
8	1540	1585	28	0.77	57.33	
9	1540	1585	32	0.77	65.49	
10	1540	1585	36	0.77	73.64	
11	1540	1585	40	0.77	81.80	
12	1540	1585	44	0.77	89.95	
13	1540	1585	48	0.77	98.08	
14	1540	1585	52	0.77	106.21	
15	1540	1585	56	0.77	114.34	
16	1540	1585	60	0.77	122.45	Orifice Flow condition
17	1540	1585	64	0.77	130.57	
18	1540	1585	68	0.77	138.68	
19	1540	1585	72	0.77	146.76	$Q = C_d Lh\sqrt{2gH}$
20	1540	1585	76	0.77	154.86	
21	1540	1585	80	0.77	162.95	
22	1540	1585	84	0.76	171.02	
23	1540	1585	88	0.76	179.10	
24	1540	1585	92	0.76	187.17	
25	1540	1585	96	0.76	195.22	
26	1540	1585	100	0.76	203.28	
27	1540	1585	104	0.76	211.34	
28	1540	1585	108	0.76	219.36	
29	1540	1585	112	0.76	227.40	
30	1540	1585	116	0.76	235.44	
31	1540	1585	120	0.76	243.44	
32	1540	1585	124	0.76	251.46	
33	1540	1585	128	0.76	259.48	
34	1540	1585	132	0.76	267.46	
35	1540	1585	136	0.76	275.47	

Annexure-8



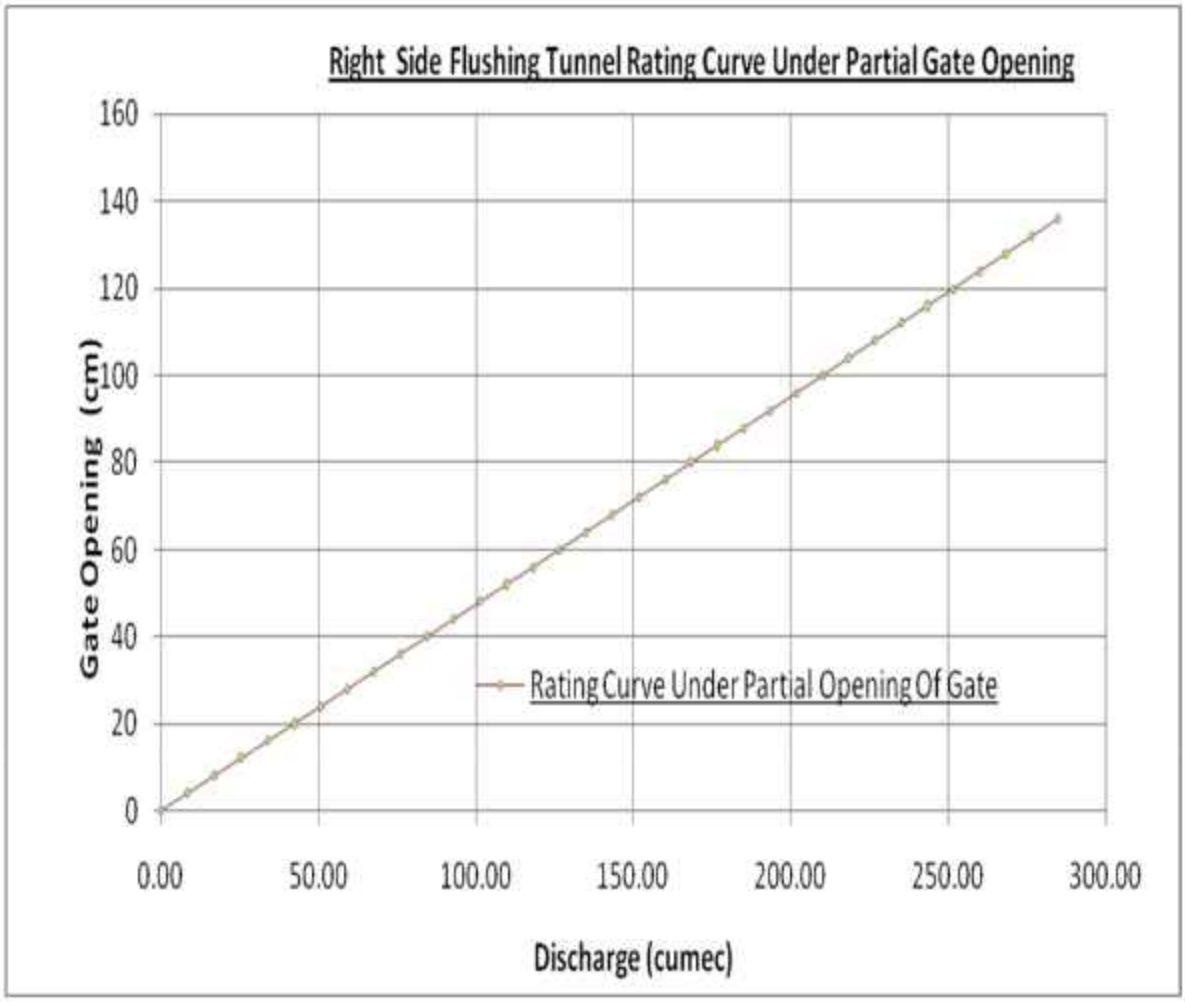
Where, Q – Discharge in m^3/s, C_d – Coefficient of discharge, H – Head of water in meter, L – Width of Gate in meter, h – Height of gate in meter.

Annexure-9

Rating Curve of Right Side Flushing Tunnel under Partial gate opening at Reservoir Level 1588 m

S.No.	Invert Level (m)	Reservoir Level (m)	Gate opening (cm)	Cd	Discharge (cumec)	Remarks
1	1540	1588	0	0.77	0.00	
2	1540	1588	4	0.77	8.48	
3	1540	1588	8	0.77	16.95	
4	1540	1588	12	0.77	25.41	
5	1540	1588	16	0.77	33.87	
6	1540	1588	20	0.77	42.33	
7	1540	1588	24	0.77	50.78	
8	1540	1588	28	0.77	59.21	
9	1540	1588	32	0.77	67.65	
10	1540	1588	36	0.77	76.08	
11	1540	1588	40	0.77	84.50	
12	1540	1588	44	0.77	92.91	
13	1540	1588	48	0.77	101.32	
14	1540	1588	52	0.77	109.73	
15	1540	1588	56	0.77	118.13	
16	1540	1588	60	0.77	126.52	Orifice Flow condition
17	1540	1588	64	0.77	134.90	
18	1540	1588	68	0.77	143.28	
19	1540	1588	72	0.77	151.65	$Q = C_i L h \sqrt{2gH}$
20	1540	1588	76	0.77	160.03	
21	1540	1588	80	0.77	168.37	
22	1540	1588	84	0.77	176.73	
23	1540	1588	88	0.77	185.08	
24	1540	1588	92	0.76	193.43	
25	1540	1588	96	0.76	201.74	
26	1540	1588	100	0.76	210.07	
27	1540	1588	104	0.76	218.40	
28	1540	1588	108	0.76	226.73	
29	1540	1588	112	0.76	235.01	
30	1540	1588	116	0.76	243.32	
31	1540	1588	120	0.76	251.63	
32	1540	1588	124	0.76	259.92	
33	1540	1588	128	0.76	268.18	
34	1540	1588	132	0.76	276.47	
35	1540	1588	136	0.76	284.75	

Annexure-10



Where, Q – Discharge in m^3/s, C_d – Coefficient of discharge, H – Head of water in meter, L – Width of Gate in meter, h – Height of gate in meter.

APPENDIX (A, B, C, D, E, F & G)

Appendix-A

Salient Features of Teesta- III HE Project (1200 MW)

1. Location	
State, District	Sikkim, North District
Village	Dam near Chungthang village and Power House near Sanklan Village
River	Teesta
Coordinate:- Dam: Longitude & Latitude Powerhouse: Longitude & Latitude	 88° 39' E, 27° 36' N 88° 32' E, 27° 31' N
Access to the Project	
By Road	a) From Siliguri (210/ 178 km) via Rangpo/ Dikchu b) From Gangtok (130 km) via Mangan
Rail Head	a) New Jalpaiguri (broad gauge) (220/188 km) via Rangpo/ Dikchu b) Siliguri (meter gauge) (210/178 km) via Rangpo/ Dikchu
Airport	Bagdogra
2. Hydrology, Seismology and Climate	
Catchment area	2786.7 km^2
Probable maximum Flood	7000 m^3/s
Seismic Zone	IV as per IS:1893-1 (2002)
Maximum & Minimum annual rainfall in Catchment	2747 mm & 762 mm respectively
Maximum & Minimum observed flow at Dam Site	706 (Jul,86) & 18.5 (Jan,78) respectively
3. Reservoir	
Maximum Reservoir Level (M.R.L.) – PMF Case	EL. 1588.0 m
Full Reservoir Level (F.R.L.)	EL. 1585 m
Minimum Draw-down Level (M.D.D.L.)	EL. 1565 m
Gross Storage (EL.1530.0 to EL.1585.0 m)	5.08 MCM
Live Storage (EL. 1565.0 to EL. 1585.0 m)	3.33 MCM
4. Project Structures	
4.1 Dam	
Type of dam	Concrete Faced Rock-fill Dam (CFRD)
Maximum Height above river bed level	60 m
Top width of dam	10 m
Total length of dam at Top	260 m
Dam foundation	Cut-off wall made of Plastic Concrete
Maximum depth of Cut off wall	65 m (1 m to be Socketed to Sound Rock)
4.2 Diversion Tunnel (DT)	
Location	On left bank
Number	1
Size and shape	10 m diameter horse shoe
Length	992 m
4.3 Spillways	

Total number of Spillway arrangements		4
Type of Spillways		Two Nos. Tunnel spillway on Left Bank (DT to act as One Tunnel Spillway), One No. Chute spillway on left bank with 2 radial gate, One No. Flushing Tunnel spillway on right bank
4.3.1	**Diversion/Spillway Tunnel-1**	
	Size, Shape & Length	: 10.0 m ϕ, Horse-shoe shaped & 952 m
	Flow type, Discharge & Velocity	: Free Flowing, 1028 m^3/s & 12 m/s
	Crest Elevation	: EL.1537.0 m for diversion mode & : EL. 1555.0 m for Spillway mode
4.3.2	**Spillway Tunnel-2**	
	Size, Shape & Length	: 10.0 m ϕ, Horse-shoe shaped & 1089 m
	Flow type, Discharge & Velocity	: Free Flowing, 1400 m^3/s & 16.88 m/s
	Crest Elevation	: EL. 1572.0 m
4.3.3	**Chute Spillway**	
	Nos. of Bays & Gate Type	: 2 Nos. of 11.0 m width, Radial Gates
	Discharge & Velocity	: 3500 m^3/s and 24.0 m/s respectively
	Crest Elevation	: EL. 1565.5 m
	Energy dissipation	: Flip bucket with plunge pool
	Chute spillway length	: 296 m
4.3.4	**Flushing cum Spillway Tunnel**	
	Size, Shape & Length	: 11.0 m ϕ, Horse-shoe shaped & 1357 m
	Flow type, Discharge & Velocity	: Free Flowing, 1750 m^3/s & 25.0 m/s
	Crest Elevation	: EL. 1540.0 m
4.4 Intake		
Number (s) and Location		One intake on right bank immediate upstream of Flushing cum spillway tunnel.
Size and shape		7.5 m horseshoe, 150.78 m long
Sill level & Discharge		EL. 1549.0 m & 202 m^3/s
4.5 De-silting Chambers		
Number, Shape and Size		2 Nos. Oval Shaped, 320 m x 17 m x 23 m (LXBXH)
Upstream & Downstream Transition Length		40.0 & 10.0 m respectively
Flow through velocity		0.35 m/s
Flushing Discharge		27.0 m^3/s (15% of 175 m^3/s)
4.6 Head Race Tunnel		
Number, Size and Shape		One Nos. 7.5 m Diameter Horseshoe Shaped
Design discharge and velocity		175 m^3/s & 3.75 m/s
Length		13816m (from D/s of De-silting Chamber)
Bed Slope		1 in 285 to 1 in 353
4.7 Surge Shaft		
Type		Open to Sky, Circular Shaped Restricted Orifice Surge Shaft
Diameter& Height		13 m and 158 m respectively
Floor level		EL. 1506.25 m
4.8 Pressure Shaft		
Number and Type		2 Nos. Steel lined

Alignment	Horizontal-vertical-inclined-horizontal
Size	4 m /3.25 m/2.5 m ϕ
Length	Pressure Shaft 1 – 1450.80 m, Pressure Shaft 2 – 1431.71 m
Discharge and velocity through each shaft	87.5 m^3/s and 6.96 m/s
4.9 Powerhouse	
Type and Installed Capacity	Underground, 1200 MW
Machine Hall Dimensions (LXWXH)	214.3 m x 21.3 m x 44.8 m
Transformer Hall Dimensions (LXWXH)	187.88 m x 15.8 m x 16.0 m
Centre Line of Units	EL. 768.0 m
Service bay Level	EL. 777.9 m
Type of Turbine	Vertical Axis Peloton
Type of Generator	Vertical Shaft, water wheel driven, AC 3 phase synchronous generator Suspended type
Capacity of Transformer & Nos.	82 MVA, Single phase, 3x6 + 1 spare = 19 Nos.
Nos. of Units & Rated Capacity per Unit	6 Nos. and 200 MW each
Head	Maximum Gross Head : 817.0 m Rated Head : 780.33 m
4.10 Main Tailrace Tunnel	
Number, Size and Shape	One, 8.2 m (W) X 8.0 m (H), D-Shaped
Length and Slope	1327.552 m and 1:590.64 respectively
Type	Free Flowing
4.11 Pothead Yard	
Type, Area	Outdoor on Left Bank, 59.2 (L) x 31.0 (W) m
5. Energy Generation	
Annual Energy 90% Dependable Year	5329.37 Gwh
Annual Energy 50% Dependable Year	5767.74 Gwh
Design Energy	5228.00 Gwh

Appendix-B

10 Daily discharge of Teesta River at Diversion Dam Site

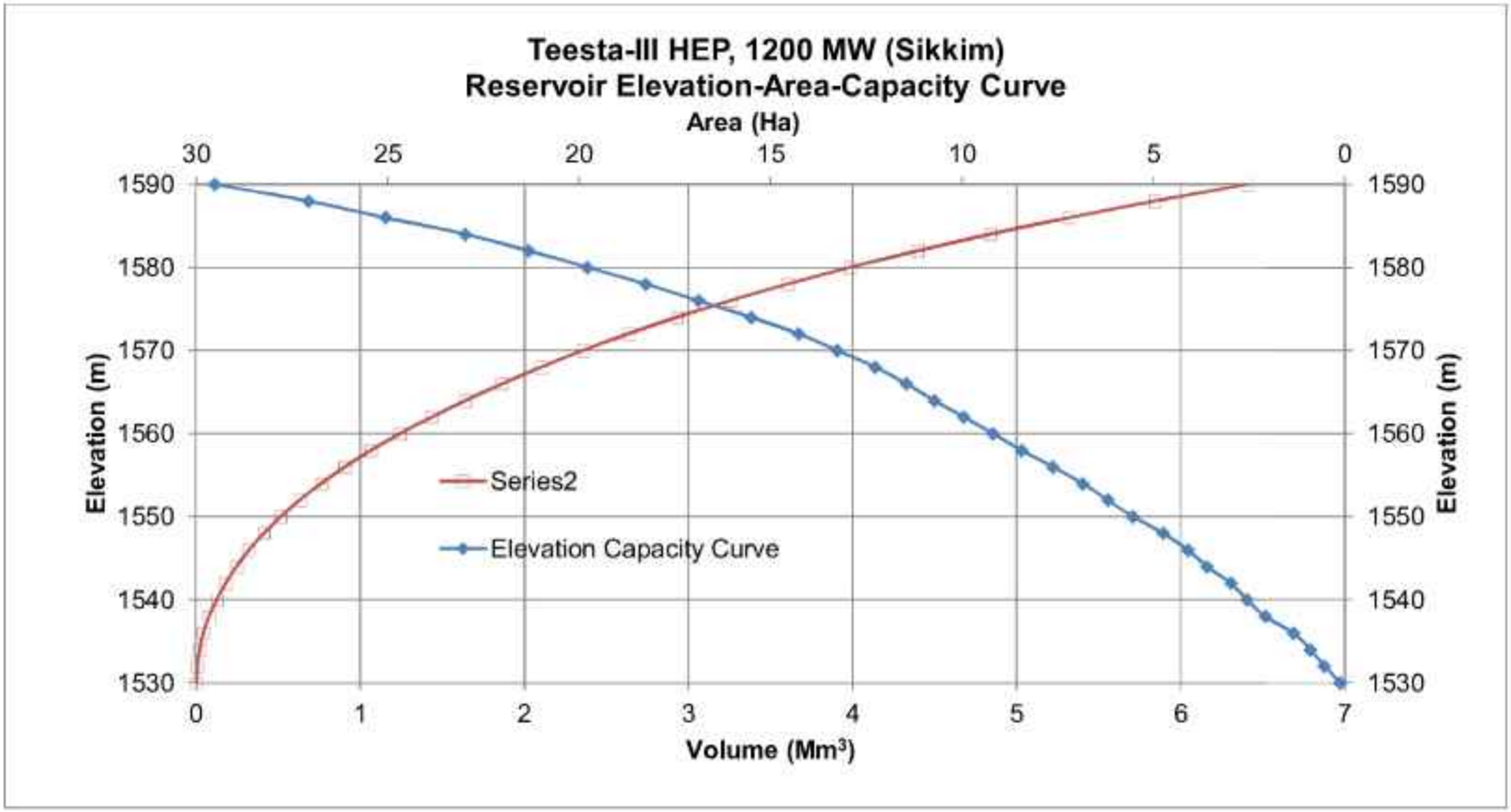
Year	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	Average inflow
Month	Inflows	Inflow s	Inflow s	Inflow s	Inflow s	Inflow s	Inflow s	Inflow s	Inflow s	Inflow s	Inflow s	Inflows	Inflow s	Inflow s	Inflow s	Inflow s	Inflow s	Inflow s	Inflow s	Inflow s	Inflow s	Inflow s	Inflow s	Inflow s	Inflow s	Inflows
	(Cumecs)	(Cumecs)	(Cumecs)	(Cumecs)	(Cumecs)	(Cumecs)	(Cumecs)	(Cumecs)	(Cumecs)	(Cumecs)	(Cumecs)	(Cumecs)	(Cumec)	(Cumec)	(Cumec)	(Cumec)	(Cumec)	(Cumec)	(Cumec)	(Cumec)	(Cumec)	(Cumec)	(Cumec)	(Cumec)	(Cumec)	(Cumec)
Jun. I	99.40	113.60	140.00	125.80	137.80	138.50	128.30	188.20	168.60	281.61	149.22	220.60	119.84	158.77	193.98	117.83	84.16	127.35	194.09	208.37	171.47	118.85	130.60	108.67	140.98	**150.50**
Jun. II	167.60	210.80	150.90	136.20	181.60	166.40	140.90	182.00	161.68	304.21	203.80	266.41	195.98	216.31	196.93	173.26	82.68	150.85	241.12	261.44	182.54	207.08	207.72	180.67	168.67	**189.18**
Jun. III	129.90	264.80	200.80	192.20	205.20	235.59	163.10	265.60	155.20	311.57	367.93	299.53	182.67	221.80	210.29	170.47	142.83	183.26	240.13	250.19	250.04	250.43	227.27	217.35	208.00	**219.33**
July. I	139.20	198.70	177.90	240.90	264.70	281.20	154.20	303.70	175.00	249.61	338.12	287.97	231.97	230.47	190.92	179.02	152.16	284.28	231.17	211.30	240.20	274.70	258.28	203.74	194.26	**226.97**
July. II	120.00	230.40	175.20	227.50	235.10	249.20	170.30	279.40	175.00	280.08	342.58	279.24	229.58	228.78	266.63	189.12	150.28	277.26	222.52	183.53	277.74	244.79	229.20	196.84	212.66	**225.84**
July. III	127.20	245.50	206.50	251.80	255.00	231.90	190.90	294.70	175.00	251.50	319.01	284.99	221.13	217.51	240.67	186.21	154.73	292.07	226.03	143.54	249.00	207.08	256.59	209.93	191.27	**224.39**
Aug. I	136.70	188.70	236.60	183.30	240.40	222.70	143.90	203.20	189.00	221.74	284.05	270.70	207.93	211.64	224.55	193.92	178.82	316.88	211.64	139.30	243.62	229.24	266.51	167.43	216.41	**213.51**
Aug. II	139.90	195.50	162.80	176.00	228.10	236.50	143.40	213.60	142.90	226.12	269.50	279.10	220.77	202.10	247.96	187.36	160.26	304.40	209.59	145.53	241.54	253.21	269.68	203.44	201.14	**211.42**
Aug. III	143.10	208.60	139.40	180.20	229.20	230.60	151.80	202.70	178.20	262.72	268.33	247.87	225.71	211.17	181.00	146.15	183.25	307.25	217.95	157.30	229.25	187.54	259.15	230.08	202.21	**207.15**
Sep. I	142.40	151.80	125.40	142.40	212.00	214.90	132.50	198.70	199.60	244.46	253.43	274.02	108.32	193.41	96.06	171.10	157.40	266.86	176.35	137.61	231.65	200.30	208.45	173.48	218.17	**183.81**
Sep. II	107.40	108.80	155.40	126.90	195.70	194.30	164.90	201.90	168.50	216.59	270.43	226.93	75.88	181.94	100.65	144.90	158.11	235.59	165.31	131.74	208.85	219.60	147.32	123.71	170.89	**167.88**
Sep. III	30.80	101.60	126.80	105.10	179.40	186.80	132.90	283.60	136.80	196.84	222.22	237.29	63.60	138.42	98.64	122.78	120.77	238.32	127.22	141.93	179.26	194.70	138.68	118.68	138.36	**149.02**
Oct. I	80.30	137.90	117.90	176.30	124.80	151.80	108.40	145.90	105.10	165.08	210.41	202.29	108.08	124.02	99.79	104.16	107.52	198.34	102.83	125.19	167.99	124.52	120.41	107.61	100.44	**132.70**
Oct. II	52.80	99.30	90.40	124.40	105.00	126.70	94.80	184.10	146.10	151.46	194.75	160.26	82.70	99.38	94.06	99.25	102.18	170.35	73.93	121.05	140.01	82.88	106.89	101.77	92.80	**115.49**
Oct. III	44.70	69.10	76.30	81.60	99.10	116.00	82.20	128.60	109.00	139.36	168.47	138.67	77.19	83.60	86.34	80.98	85.90	127.73	80.79	95.71	109.29	89.07	101.89	72.52	74.57	**96.04**
Nov. I	47.80	62.20	63.60	77.00	86.90	108.10	77.50	110.30	98.60	124.82	143.10	113.62	66.27	72.98	62.79	60.91	72.96	98.09	66.13	89.61	93.01	54.74	72.18	61.95	65.21	**81.28**
Nov. II	44.60	56.90	60.30	66.80	80.30	90.90	71.90	116.30	81.80	115.10	121.06	94.33	57.36	65.50	60.50	49.51	59.20	91.47	40.85	81.73	80.02	50.05	62.84	42.79	61.65	**71.34**
Nov. III	39.50	48.00	47.50	68.40	77.40	80.10	69.30	99.10	67.10	105.66	100.88	81.41	46.91	54.59	46.81	42.92	51.27	82.83	36.88	58.41	70.16	45.86	55.33	40.30	554.14	**82.91**
Dec. I	30.50	44.40	45.50	62.60	69.40	73.30	65.90	96.70	59.20	97.92	92.99	68.81	36.11	47.55	41.85	39.40	49.08	76.38	74.01	49.82	62.04	44.65	48.54	36.65	47.87	**58.41**
Dec. II	27.50	43.40	39.50	56.50	61.50	66.60	59.40	82.30	53.60	92.26	86.51	61.86	48.37	47.00	31.55	34.72	43.67	74.36	45.69	48.09	56.33	44.31	41.82	32.69	44.31	**52.80**
Dec. III	24.80	39.40	36.00	48.80	56.10	52.20	54.50	76.80	50.50	86.32	72.11	55.14	50.42	39.44	26.70	35.66	34.79	68.69	38.76	46.23	52.96	44.35	37.74	29.46	43.46	**48.15**
Jan. I	24.20	34.30	34.60	44.70	47.80	37.80	42.00	49.80	71.19	80.52	64.77	52.96	51.82	33.89	26.37	34.53	33.87	60.87	38.96	42.60	49.85	45.06	34.20	27.99	37.63	**44.26**
Jan. II	22.80	31.50	31.30	41.50	42.20	26.60	31.80	47.70	68.23	76.60	61.26	52.42	51.31	26.70	26.17	31.57	32.80	59.11	39.93	41.16	48.18	44.10	31.56	25.60	31.81	**42.31**
Jan. III	22.80	30.30	30.70	43.30	37.60	23.80	29.40	46.90	67.06	73.45	58.54	50.19	42.94	23.16	25.61	30.26	30.64	57.16	40.42	39.13	47.24	43.91	31.59	28.32	35.57	**39.62**
Feb. I	23.40	30.60	28.70	42.50	42.00	23.10	28.60	47.40	68.70	64.19	56.13	48.37	42.11	22.26	27.17	31.01	29.29	56.00	38.56	37.71	35.22	42.31	29.94	28.96	39.97	**36.57**
Feb. II	24.60	29.90	28.30	42.50	41.50	23.40	28.50	48.40	69.23	63.59	56.12	49.62	36.77	22.16	28.26	29.52	32.05	53.29	41.00	37.88	33.87	42.45	29.26	29.02	39.37	**36.38**
Feb. III	27.20	27.60	29.70	44.50	45.00	23.60	30.50	49.40	70.56	64.43	54.98	54.70	36.21	22.58	27.59	28.43	30.84	53.33	42.25	41.77	33.54	43.49	30.93	25.10	39.45	**39.09**
Mar. I	24.00	26.70	30.70	45.30	44.80	25.40	35.50	64.90	79.56	80.27	52.80	59.72	47.53	23.33	31.82	32.77	31.10	65.27	54.34	40.94	34.90	44.26	31.69	26.41	39.11	**43.32**
Mar. II	29.90	29.20	31.90	46.70	47.70	31.30	53.20	74.20	88.91	94.14	52.55	64.43	57.16	24.78	31.79	37.68	32.46	66.01	60.41	55.30	40.65	44.95	33.53	31.71	40.80	**47.04**
Mar. III	31.90	32.90	37.70	59.90	63.90	52.00	52.00	81.20	89.30	102.99	58.29	71.30	77.02	28.59	35.97	47.72	32.47	68.36	92.64	60.71	57.59	49.13	35.88	37.16	50.42	**56.56**
Apr. I	40.30	38.40	55.90	63.60	52.00	73.50	52.90	79.20	103.25	101.79	101.68	85.86	80.59	28.61	53.36	50.69	46.84	82.19	90.80	65.85	80.79	62.82	42.22	55.47	58.91	**64.31**
Apr. II	34.40	49.30	55.40	84.40	63.60	62.00	51.20	83.20	126.98	108.89	83.92	93.06	100.69	57.93	49.24	65.99	54.34	73.64	102.79	80.74	83.19	61.32	48.67	54.84	66.07	**71.35**
Apr. III	42.30	54.40	69.70	103.50	79.20	76.80	60.90	93.60	150.15	92.30	84.27	94.81	115.37	86.04	54.23	53.69	65.41	83.88	138.17	90.23	81.48	66.10	88.35	62.27	68.34	**80.79**
May. I	42.10	72.50	109.60	95.50	98.50	92.90	89.70	103.50	146.75	103.32	104.93	90.15	142.55	82.58	64.17	56.39	92.32	95.04	166.10	116.23	71.68	77.93	87.70	85.07	61.99	**95.93**
May. II	48.60	111.20	129.60	90.30	139.60	96.30	102.40	124.10	161.84	108.58	144.32	100.03	140.09	130.26	81.82	69.50	87.03	97.76	214.95	139.33	90.67	92.15	70.84	84.96	89.96	**110.04**
May. III	85.00	126.20	113.40	93.10	132.20	94.70	133.30	151.10	179.35	112.75	174.42	143.89	164.44	118.88	102.37	71.26	90.10	154.85	201.06	188.51	96.52	134.80	143.86	106.19	144.89	**129.54**

Appendix-C (Sheet-1)

RESERVOIR AREA-CAPACITY CURVE:

Elevation (m)	Area (Ha)	Volume in (Ha-m)	Cumulative Volume (Ha-m)	Cumulative Volume (Mm^3)
1530.00	0.12	0.00	0.00	**0.00**
1532.00	0.53	0.65	0.65	**0.01**
1534.00	0.90	1.43	2.08	**0.02**
1536.00	1.34	2.24	4.32	**0.04**
1538.00	2.08	3.42	7.75	**0.08**
1540.00	2.56	4.64	12.39	**0.12**
1542.00	2.98	5.54	17.93	**0.18**
1544.00	3.60	6.58	24.51	**0.25**
1546.00	4.11	7.71	32.21	**0.32**
1548.00	4.75	8.85	41.07	**0.41**
1550.00	5.54	10.28	51.35	**0.51**
1552.00	6.19	11.73	63.07	**0.63**
1554.00	6.85	13.04	76.11	**0.76**
1556.00	7.62	14.47	90.58	**0.91**
1558.00	8.45	16.07	106.65	**1.07**
1560.00	9.19	17.64	124.29	**1.24**
1562.00	9.95	19.14	143.43	**1.43**
1564.00	10.72	20.68	164.11	**1.64**
1566.00	11.45	22.18	186.28	**1.86**
1568.00	12.27	23.72	210.00	**2.10**
1570.00	13.26	25.53	235.54	**2.36**
1572.00	14.27	27.53	263.07	**2.63**
1574.00	15.51	29.77	292.84	**2.93**
1576.00	16.89	32.40	325.24	**3.25**
1578.00	18.26	35.15	360.39	**3.60**
1580.00	19.79	38.05	398.44	**3.98**
1582.00	21.31	41.10	439.54	**4.40**
1584.00	22.98	44.29	483.83	**4.84**
1586.00	25.07	48.04	531.88	**5.32**
1588.00	27.07	52.13	584.01	**5.84**
1590.00	29.53	56.59	640.60	**6.41**

Appendix-C (Sheet-2)

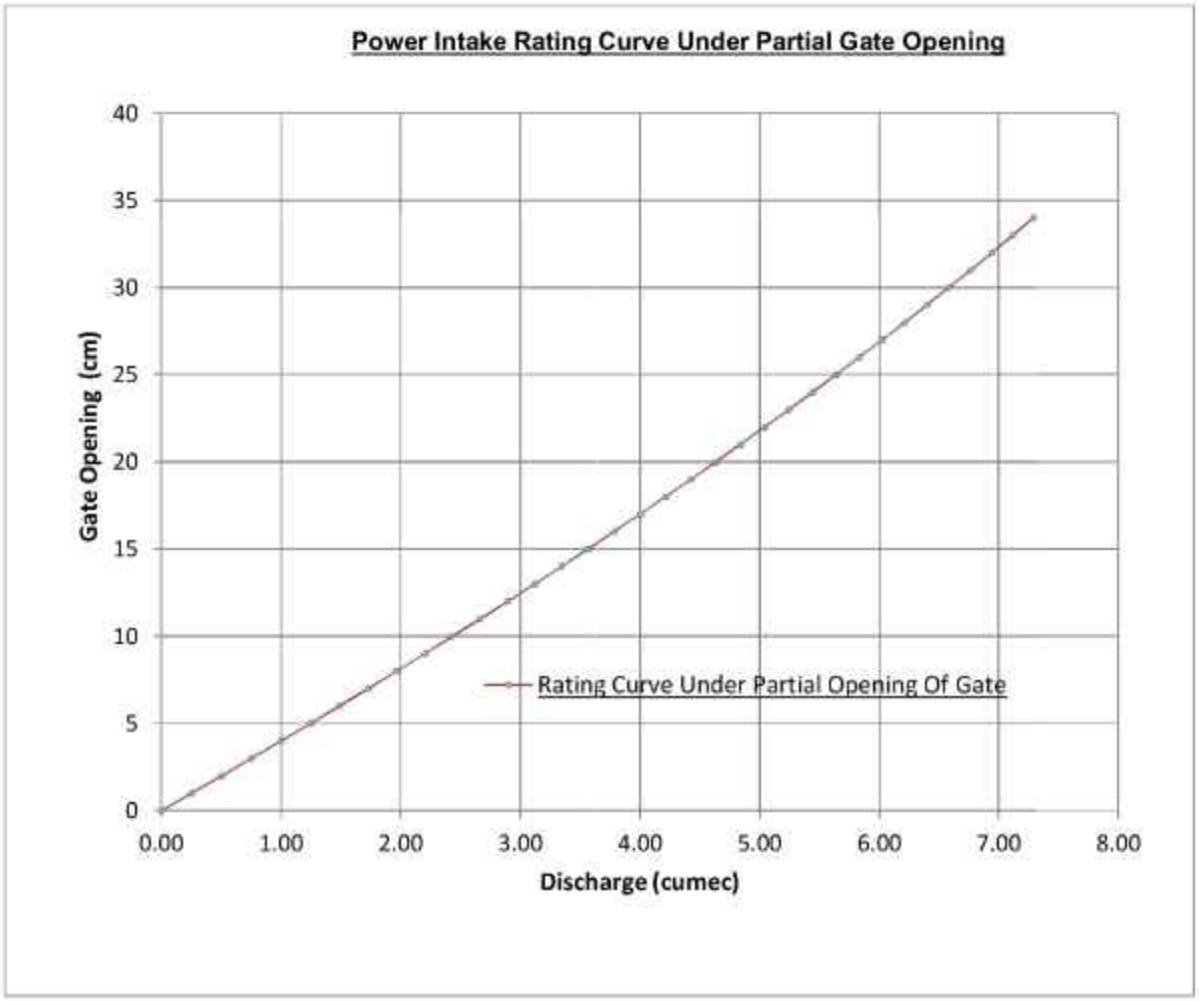


Appendix- D (Sheet-1)

Rating Curve of Power Intake under Partial gate opening at Reservoir Level 1550 m

S.No.	Invert Level (m)	Reservoir Level (m)	Gate opening (cm)	Cd	Discharge (cumec)	Remarks
1	1549	1550	0	0.77	0.00	
2	1549	1550	1	0.77	0.25	
3	1549	1550	2	0.76	0.51	
4	1549	1550	3	0.76	0.75	
5	1549	1550	4	0.76	1.00	
6	1549	1550	5	0.76	1.25	
7	1549	1550	6	0.76	1.49	
8	1549	1550	7	0.76	1.73	
9	1549	1550	8	0.76	1.97	
10	1549	1550	9	0.75	2.20	
11	1549	1550	10	0.75	2.44	
12	1549	1550	11	0.75	2.67	
13	1549	1550	12	0.75	2.89	
14	1549	1550	13	0.75	3.12	
15	1549	1550	14	0.75	3.34	
16	1549	1550	15	0.74	3.57	Orifice Flow condition
17	1549	1550	16	0.74	3.78	
18	1549	1550	17	0.74	4.00	$Q = C_d Lh\sqrt{2gH}$
19	1549	1550	18	0.74	4.21	
20	1549	1550	19	0.74	4.42	
21	1549	1550	20	0.74	4.63	
22	1549	1550	21	0.73	4.84	
23	1549	1550	22	0.73	5.04	
24	1549	1550	23	0.73	5.25	
25	1549	1550	24	0.73	5.44	
26	1549	1550	25	0.73	5.64	
27	1549	1550	26	0.72	5.83	
28	1549	1550	27	0.72	6.02	
29	1549	1550	28	0.72	6.21	
30	1549	1550	29	0.72	6.40	
31	1549	1550	30	0.72	6.58	
32	1549	1550	31	0.71	6.76	
33	1549	1550	32	0.71	6.94	
34	1549	1550	33	0.71	7.12	
35	1549	1550	34	0.71	7.29	

Appendix- D (Sheet-2)



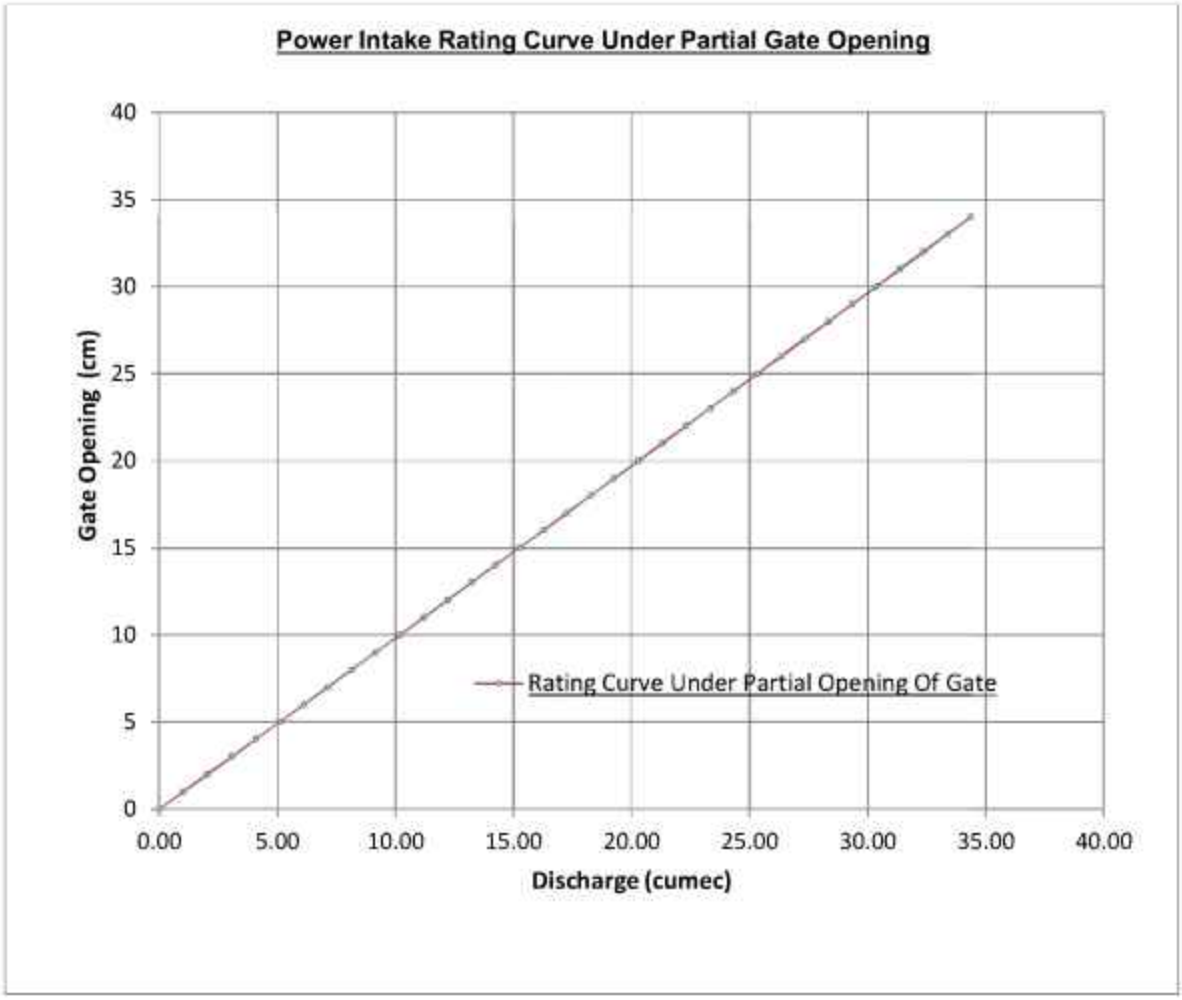
Where, Q – Discharge in m^3/s, C_d – Coefficient of discharge, H – Head of water in meter, L – Width of Gate in meter, h – Height of gate in meter.

Appendix- D (Sheet-3)

Rating Curve of Power Intake under Partial gate opening at Reservoir Level 1565 m

S.No.	Invert Level (m)	Reservoir Level (m)	Gate opening (cm)	Cd	Discharge (cumec)	Remarks
1	1549	1565	0	0.77	0.00	
2	1549	1565	1	0.77	1.02	
3	1549	1565	2	0.77	2.04	
4	1549	1565	3	0.77	3.06	
5	1549	1565	4	0.77	4.08	
6	1549	1565	5	0.77	5.09	
7	1549	1565	6	0.77	6.11	
8	1549	1565	7	0.77	7.13	
9	1549	1565	8	0.77	8.14	
10	1549	1565	9	0.77	9.16	
11	1549	1565	10	0.77	10.17	
12	1549	1565	11	0.77	11.19	
13	1549	1565	12	0.77	12.20	
14	1549	1565	13	0.77	13.21	
15	1549	1565	14	0.77	14.23	
16	1549	1565	15	0.77	15.24	Orifice Flow condition
17	1549	1565	16	0.77	16.25	
18	1549	1565	17	0.77	17.26	
19	1549	1565	18	0.77	18.27	$Q = C_d L h \sqrt{2gH}$
20	1549	1565	19	0.77	19.28	
21	1549	1565	20	0.77	20.29	
22	1549	1565	21	0.77	21.30	
23	1549	1565	22	0.77	22.31	
24	1549	1565	23	0.77	23.31	
25	1549	1565	24	0.77	24.32	
26	1549	1565	25	0.77	25.33	
27	1549	1565	26	0.77	26.33	
28	1549	1565	27	0.77	27.34	
29	1549	1565	28	0.77	28.34	
30	1549	1565	29	0.77	29.35	
31	1549	1565	30	0.76	30.35	
32	1549	1565	31	0.76	31.35	
33	1549	1565	32	0.76	32.35	
34	1549	1565	33	0.76	33.36	
35	1549	1565	34	0.76	34.36	

Appendix- D (Sheet-4)



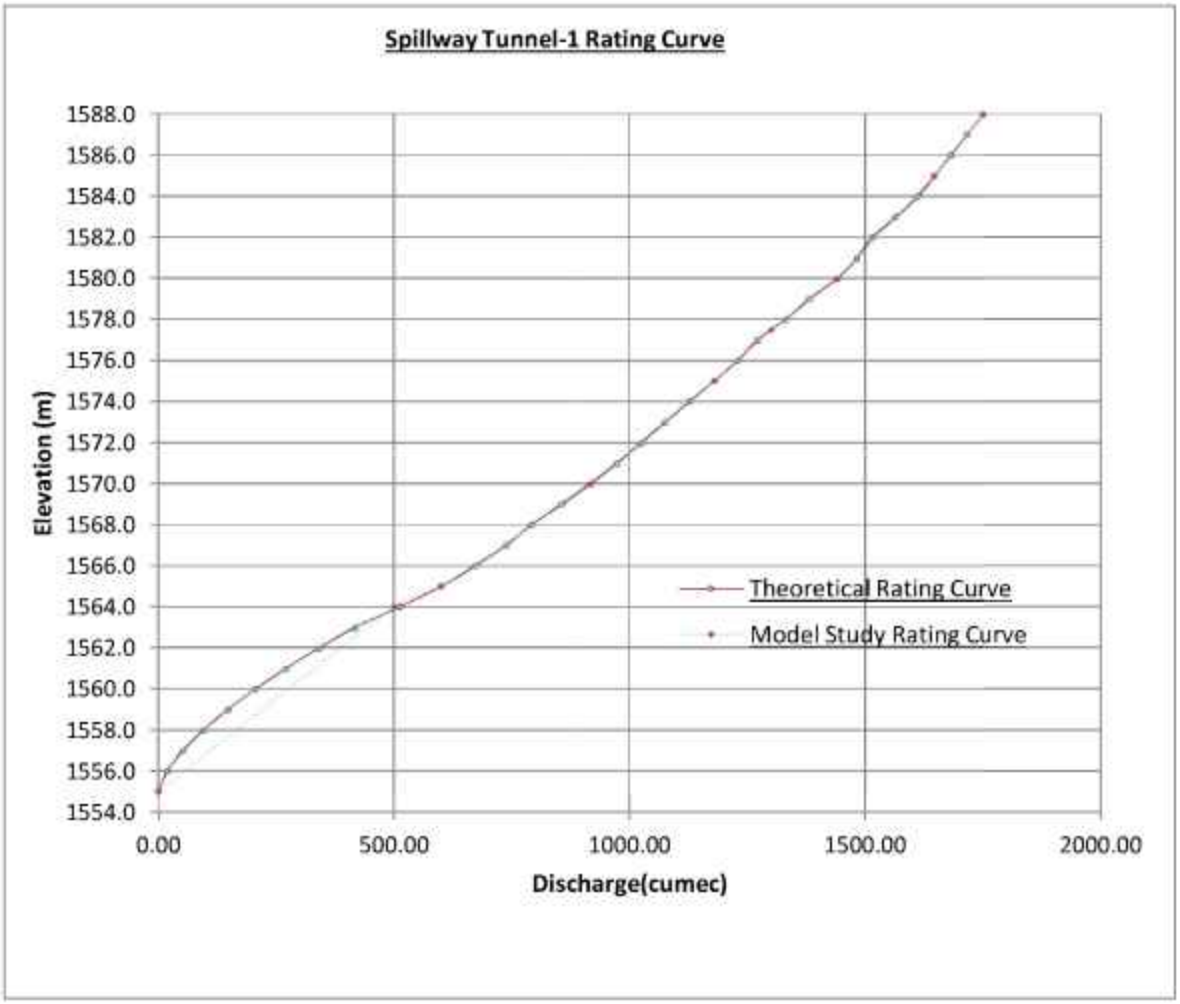
Where, Q – Discharge in m^3/s, C_d – Coefficient of discharge, H – Head of water in meter, L – Width of Gate in meter, h – Height of gate in meter.

Appendix- E (Sheet-1)

Computations of Rating Curve of Spillway Tunnel No. 1 (From EL. 1555 m to EL. 1588 m)

S.No.	Invert Level (m)	Reservoir Level (m)	Water Head (m)	C_d (Actual)	Actual Discharge (Cumec)	Remarks
1	1555.0	1555.0	0.0	0.52	0.00	
2	1555.0	1556.0	1.0	0.52	18.43	
3	1555.0	1557.0	2.0	0.52	52.12	
4	1555.0	1558.0	3.0	0.52	95.75	
5	1555.0	1559.0	4.0	0.52	147.41	
6	1555.0	1560.0	5.0	0.52	206.01	
7	1555.0	1561.0	6.0	0.52	270.81	Free Flow Condition
8	1555.0	1562.0	7.0	0.52	341.26	
9	1555.0	1563.0	8.0	0.52	416.94	$Q=\frac{2}{3}\sqrt{2g}C_d LH^{3/2}$
10	1555.0	1564.0	9.0	0.54	511.87	
11	1555.0	1565.0	10.0	0.54	599.51	
12	1555.0	1566.0	7.5	0.66	672.52	
13	1555.0	1567.0	8.5	0.68	737.64	
14	1555.0	1568.0	9.5	0.69	791.30	
15	1555.0	1569.0	10.5	0.71	856.02	
16	1555.0	1570.0	11.5	0.73	917.30	
17	1555.0	1571.0	12.5	0.74	973.45	
18	1555.0	1572.0	13.5	0.75	1025.31	
19	1555.0	1573.0	14.5	0.76	1076.78	
20	1555.0	1574.0	15.5	0.77	1127.94	
21	1555.0	1575.0	16.5	0.78	1180.38	Orifice Flow condition
22	1555.0	1576.0	17.5	0.79	1229.63	
23	1555.0	1577.0	18.5	0.80	1272.28	
24	1555.0	1578.0	19.5	0.81	1330.86	$Q=C_d Lh\sqrt{2gH}$
25	1555.0	1579.0	20.5	0.82	1381.40	
26	1555.0	1580.0	21.5	0.84	1440.57	
27	1555.0	1581.0	22.5	0.84	1482.52	
28	1555.0	1582.0	23.5	0.84	1515.10	
29	1555.0	1583.0	24.5	0.85	1565.42	
30	1555.0	1584.0	25.5	0.86	1612.08	
31	1555.0	1585.0	26.5	0.86	1647.21	
32	1555.0	1586.0	27.5	0.86	1681.91	
33	1555.0	1587.0	28.5	0.86	1716.19	
34	1555.0	1588.0	29.5	0.87	1750.08	

Appendix- E (Sheet-2)



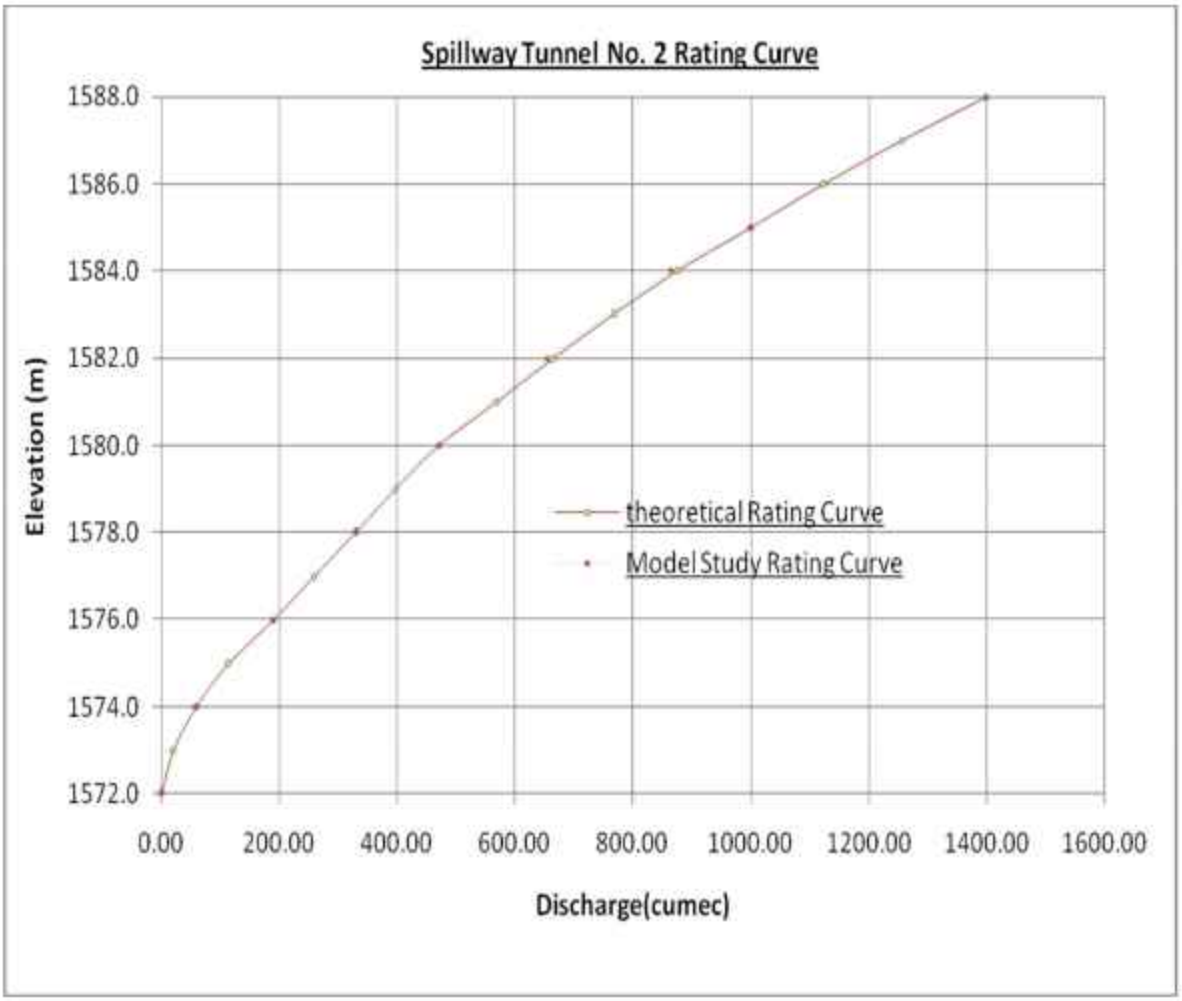
Where, Q – Discharge in m^3/s, C_d – Coefficient of discharge, H – Head of water in meter, L – Width of Gate in meter, h – Height of gate in meter.

Appendix- F (Sheet-1)

Computations of Rating Curve of Spillway Tunnel-2 (From EL. 1572 m to EL. 1588 m)

S.No.	Invert Level (m)	Reservoir Level (m)	Water Head (m)	C_d (Actual)	Actual Discharge (Cumec)	Remarks
1	1572.0	1572.0	0.0	0.65	0.00	
2	1572.0	1573.0	1.0	0.65	21.11	
3	1572.0	1574.0	2.0	0.65	59.72	
4	1572.0	1575.0	3.0	0.68	114.77	
5	1572.0	1576.0	4.0	0.73	189.70	
6	1572.0	1577.0	5.0	0.71	257.85	
7	1572.0	1578.0	6.0	0.69	329.40	Free Flow Condition
8	1572.0	1579.0	7.0	0.66	397.05	
9	1572.0	1580.0	8.0	0.64	470.40	$Q=\frac{2}{3}\sqrt{2g}C_d L H^{1/2}$
10	1572.0	1581.0	9.0	0.65	568.32	
11	1572.0	1582.0	10.0	0.65	665.62	
12	1572.0	1583.0	11.0	0.65	767.92	
13	1572.0	1584.0	12.0	0.65	877.68	
14	1572.0	1585.0	13.0	0.66	1000.30	
15	1572.0	1586.0	14.0	0.66	1124.15	
16	1572.0	1587.0	15.0	0.67	1255.22	
17	1572.0	1588.0	16.0	0.67	1399.09	

Appendix- F (Sheet-2)



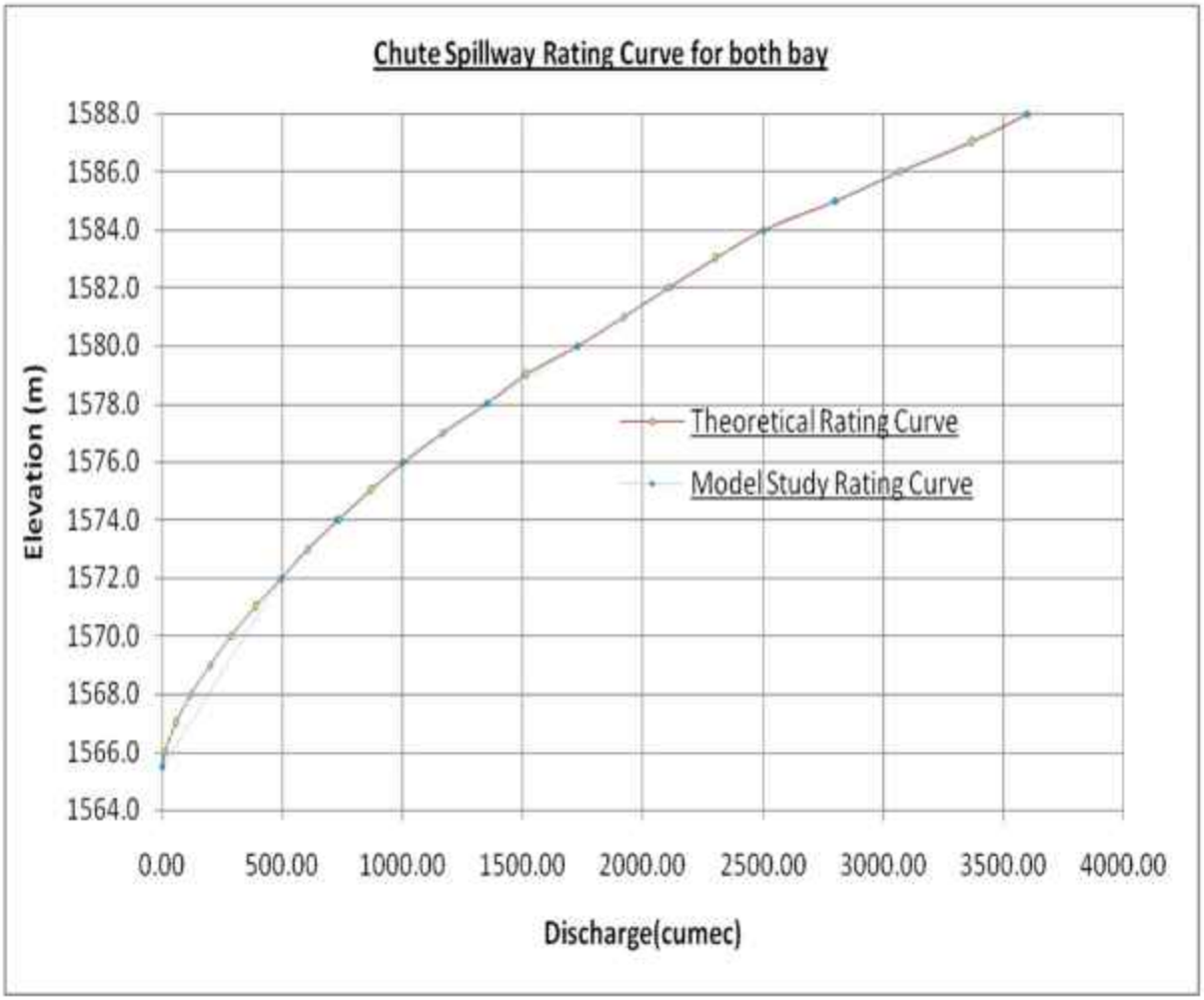
Where, Q – Discharge in m^3/s, C_d – Coefficient of discharge, H – Head of water in meter, L – Width of Gate in meter, h – Height of gate in meter.

Appendix- G (Sheet-1)

Computations of Rating Curve of Chute Spillway with both gate open
(From EL. 1565.5m to EL. 1588m)

S.No.	Invert Level (m)	Reservoir Level (m)	Water Head (m)	C_d (Actual)	Actual Discharge (Cumec)	Remarks
1	1565.5	1565.5	0.0	0.46	0.00	
2	1565.5	1566.0	0.5	0.46	10.57	
3	1565.5	1567.0	1.5	0.46	54.90	
4	1565.5	1568.0	2.5	0.46	118.13	
5	1565.5	1569.0	3.5	0.46	195.68	
6	1565.5	1570.0	4.5	0.46	285.27	
7	1565.5	1571.0	5.5	0.46	385.46	
8	1565.5	1572.0	6.5	0.46	495.23	
9	1565.5	1573.0	7.5	0.46	607.13	
10	1565.5	1574.0	8.5	0.46	732.52	
11	1565.5	1575.0	9.5	0.46	865.52	Free Flow Condition
12	1565.5	1576.0	10.5	0.46	1005.72	
13	1565.5	1577.0	11.5	0.46	1165.43	$Q=\frac{2}{3}\sqrt{2g}C_d LH^{3/2}$
14	1565.5	1578.0	12.5	0.47	1349.41	
15	1565.5	1579.0	13.5	0.47	1514.54	
16	1565.5	1580.0	14.5	0.48	1725.35	
17	1565.5	1581.0	15.5	0.48	1918.77	
18	1565.5	1582.0	16.5	0.48	2107.43	
19	1565.5	1583.0	17.5	0.48	2301.88	
20	1565.5	1584.0	18.5	0.48	2501.98	
21	1565.5	1585.0	19.5	0.50	2802.66	
22	1565.5	1586.0	20.5	0.51	3075.26	
23	1565.5	1587.0	21.5	0.52	3367.77	
24	1565.5	1588.0	22.5	0.54	3601.83	

Appendix- G (Sheet-2)



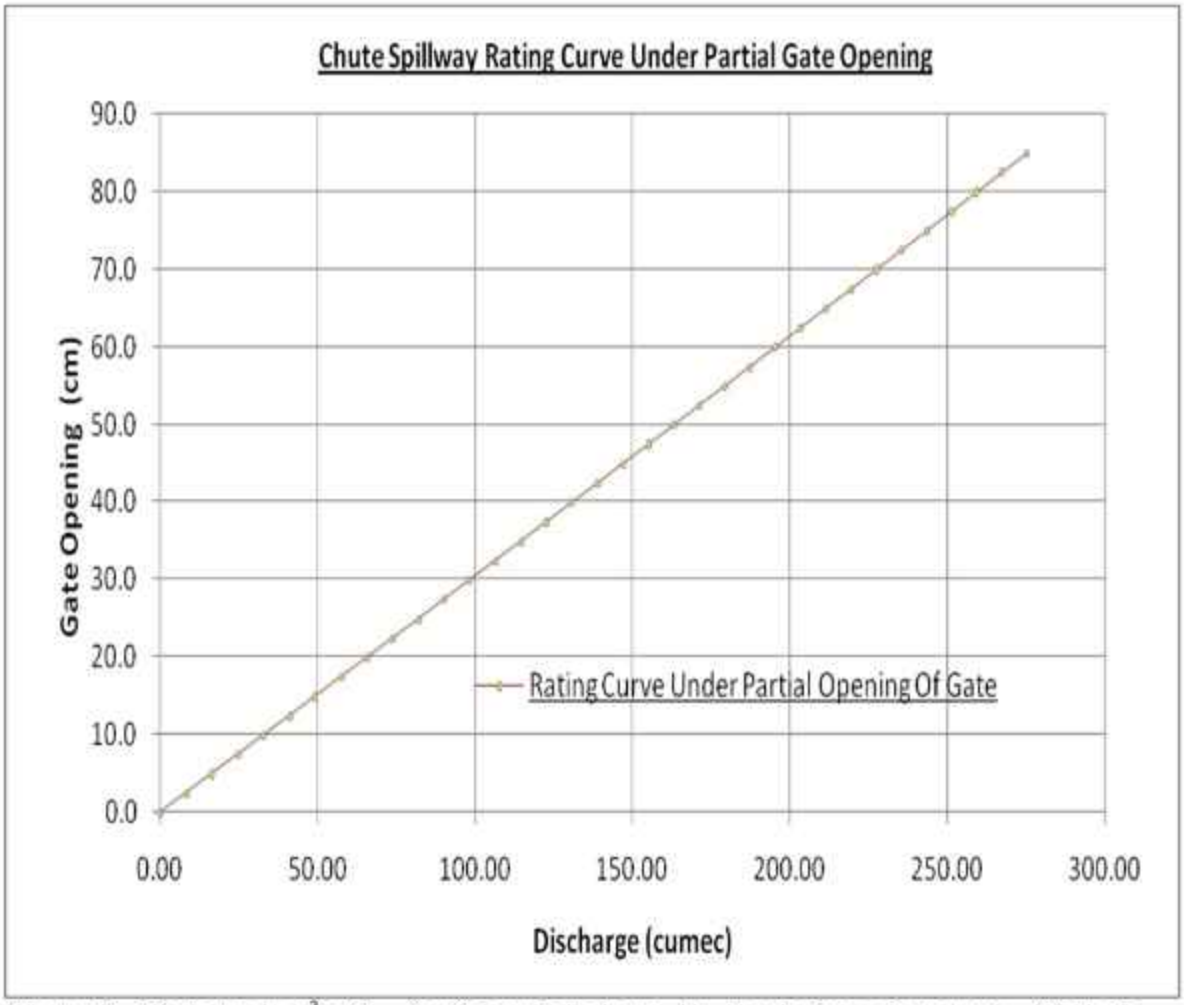
Where, Q – Discharge in m^3/s, C_d – Coefficient of discharge, H – Head of water in meter, L – Width of Gate in meter, h – Height of gate in meter.

Appendix- G (Sheet-3)

Rating Curve of Chute Spillway under Partial gate opening at Reservoir Level 1585 m

S.No.	Invert Level (m)	Reservoir Level (m)	Gate opening (cm)	Cd	Discharge (cumec)	Remarks
1	1565.5	1585	0.0	0.77	0.00	
2	1565.5	1585	2.5	0.77	8.25	
3	1565.5	1585	5.0	0.77	16.50	
4	1565.5	1585	7.5	0.77	24.73	
5	1565.5	1585	10.0	0.77	32.96	
6	1565.5	1585	12.5	0.77	41.18	
7	1565.5	1585	15.0	0.77	49.39	
8	1565.5	1585	17.5	0.77	57.58	
9	1565.5	1585	20.0	0.77	65.77	
10	1565.5	1585	22.5	0.77	73.95	
11	1565.5	1585	25.0	0.77	82.12	
12	1565.5	1585	27.5	0.77	90.28	
13	1565.5	1585	30.0	0.77	98.43	
14	1565.5	1585	32.5	0.77	106.57	
15	1565.5	1585	35.0	0.77	114.70	
16	1565.5	1585	37.5	0.76	122.84	Orifice Flow condition
17	1565.5	1585	40.0	0.76	130.95	
18	1565.5	1585	42.5	0.76	139.05	
19	1565.5	1585	45.0	0.76	147.15	$Q = C_d Lh\sqrt{2gH}$
20	1565.5	1585	47.5	0.76	155.23	
21	1565.5	1585	50.0	0.76	163.30	
22	1565.5	1585	52.5	0.76	171.37	
23	1565.5	1585	55.0	0.76	179.42	
24	1565.5	1585	57.5	0.76	187.47	
25	1565.5	1585	60.0	0.76	195.50	
26	1565.5	1585	62.5	0.76	203.53	
27	1565.5	1585	65.0	0.76	211.55	
28	1565.5	1585	67.5	0.76	219.55	
29	1565.5	1585	70.0	0.76	227.55	
30	1565.5	1585	72.5	0.76	235.54	
31	1565.5	1585	75.0	0.76	243.52	
32	1565.5	1585	77.5	0.76	251.52	
33	1565.5	1585	80.0	0.76	259.48	
34	1565.5	1585	82.5	0.76	267.43	
35	1565.5	1585	85.0	0.76	275.37	

Appendix- G (Sheet-4)



Where, Q – Discharge in m^3/s, C_d – Coefficient of discharge, H – Head of water in meter, L – Width of Gate in meter, h – Height of gate in meter.

DRAWING OF VARIOUS STRUCTURES

Drawing List of Various Structure of TEESTA-III HE Project

Sl. No.	Title of Drawing	Drawing Number
I	**Dam**	
1	Dam Complex -Concrete Face Rock Fill Dam-General Arrangement Plan	T3-2DC-41-DD-007
2	Dam Complex - Concrete Face Rock Fill Dam-General Arrangement L-Section	T3-2DC-41-DD-009
3	Dam Complex - Concrete Face Rock Fill Dam-General Arrangement Cross Section	T3-2DC-41-DD-008
II	**Chute Spillway**	
1	Dam Complex - Chute Spillway -General Arrangement Plan & L-Section	T3-2SC-41-DD-007
2	Dam Complex - Chute Spillway -General Arrangement Cross Sections	T3-2SC-41-DD-008
III	**Spillway Tunnel**	
1	Dam Complex - Spillway Tunnel No.1- Layout Plan	T3-2BC-41-GA-207
2	Dam Complex - Spillway Tunnel No.2- L-Section	T3-2BC-41-DD-208
3	Dam Complex - Left Side Diversion /Spillway Tunnel L-Section	T3-2BC-41-DD-102
IV	**Flushing Tunnel**	
1	Dam Complex - Right Side Flushing/Spillway Tunnel-L-Section	T3-2KC-41-DD-002
2	Dam Complex - Flushing Tunnel Inlet and Power Intake General Arrangement Plan	T3-2GC-41-DD-031
V	**De-silting Chamber**	
1	De-silting Chamber Complex Layout Plan	T3-2HC-41-DD-001
2	De-silting Chamber Complex Plan & L- Section	T3-2HC-41-DD-002
VI	**Head Race Tunnel**	
1	Head Race Tunnel General Layout Plan	T3-1AC-41-GA-001
2	Head Race Tunnel L-Section	T3-3CC-41-DD-002
VII	**Power House Complex**	
1	Power House Complex & Pressure Shaft General Layout Plan	T3-4BC-41-DD-174
2	Power House Complex –Floor Plan EL.777.90 m	T3-4CC-41-DD-007
3	H-M Drawing Pressure Shaft Steel Liner General Arrangement Drawings (2 Nos)	-

ANNEXURE-E4: E4_ACCESS TUNNEL LOAD CELL AND MPBX OBSERVATION

Annexure-IV

ACCESS TUNNEL LOAD CELL AND MPBX OBSERVATION

INSTRUMENT	LOAD CELL	MPBX			LOAD CELL	MPBX				LOAD CELL	MPBX				INSTRUMENT
INSTALLATION	Vertical	Vertically Upward			Horizontally Inclined Upward	Horizontally inclined Upward				Horizontally Inclined Upward	Horizontally inclined Upward				INSTALLATION
LOCATION	Access Tunnel, RD-157.294,Crown	Access Tunnel, RD- 157.294, Crown			Access Tunnel, RD-157.294,Left Side	Access Tunnel, RD- 157.294, Left Side				Access Tunnel, RD-157.294, Right Side	Access Tunnel, RD- 157.294, Right Side				LOCATION
INST TAG	L2CRLC	L2CRMP			L2LSLC	L2LSMP				L2RSLC	L2RSMP				INST TAG
Sign convention	Negative sign shows compression	Positive sign shows compression			Negative sign shows compression	Positive sign shows compression				Negative sign shows compression	Positive sign shows compression				Sign convention
Anchor depth	6m	15m	5m		6m	15m	10m	5m		6m	9m	6m	3m		Anchor depth
Channel No.	Ch 22	Ch 248	Ch 250		Ch 21	Ch 245	Ch 246	Ch 247		Ch 23	Ch 251	Ch 252	Ch 253		Channel No.
DATE	kN	mm	mm	°C	kN	mm	mm	mm	°C	kN	mm	mm	mm	°C	DATE
13-Sep-2022	20.57	-1.576	-0.808	17	-3.41	-0.467	-0.350	-0.443	17	6.02	0.129	0.151	-0.153	17	13-Sep-2022
19-Sep-2022	19.22	-1.569	-0.813	17	-3.84	-0.469	-0.354	-0.455	17	5.48	0.139	0.150	-0.157	17	19-Sep-2022
3-Oct-2022	29.14	-1.561	-0.108	17	6.13	-0.428	-0.367	-0.440	17	6.13	-0.428	-0.367	-0.440	17	3-Oct-2022
8-Oct-2022	27.11	-1.539	-0.769	11	-4.11	-0.458	-0.350	-0.445	11	-4.11	-0.458	-0.350	-0.445	11	8-Oct-2022
13-Oct-2022	22.41	-1.534	-0.771	15	-1.07	-0.464	-0.356	-0.418	15	-1.07	-0.464	-0.356	-0.418	15	13-Oct-2022
19-Oct-2022	19.82	-1.516	-0.761	15	-3.68	-0.469	-0.356	-0.241	15	-3.68	-0.469	-0.356	-0.241	15	19-Oct-2022
6-Nov-2022	22.09	-1.550	-0.758	12	0.69	-0.465	-0.358	-0.402	12	6.45	0.128	0.165	-0.129	12	6-Nov-2022
12-Nov-2022	21.17	-1.546	-0.577	13	-4.48	-0.463	-0.358	-0.399	13	5.53	0.134	0.168	-0.130	13	12-Nov-2022
18-Nov-2022	21.55	-1.559	-0.755	13	-3.47	-0.466	-0.364	-0.402	13	5.70	0.134	0.168	-0.130	13	18-Nov-2022
24-Nov-2022	21.76	-1.555	-0.752	13	-4.64	-0.465	-0.366	-0.400	13	5.82	0.136	0.167	-0.129	13	24-Nov-2022
3-Dec-2022	25.77	-1.458	-0.478	13	3.68	-0.162	-0.363	-0.395	13	10.15	0.137	0.170	-0.125	13	3-Dec-2022
8-Dec-2022	22.85	-1.543	-0.744	13	-3.84	-0.460	-0.363	-0.394	13	6.23	0.138	0.170	-0.127	13	8-Dec-2022
13-Dec-2022	22.90	-1.561	-0.450	12	-3.36	-0.463	-0.463	-0.400	12	11.44	0.143	0.169	-0.13	12	13-Dec-2022
19-Dec-2022	21.76	-1.562	-0.750	13	-4.58	-0.461	-0.461	-0.399	13	5.96	0.143	0.169	-0.131	13	19-Dec-2022
1-Jan-2023	22.74	-1.525	-0.720	10	-4.34	-0.449	-0.362	-0.382	10	5.91	0.139	0.174	-0.116	10	1-Jan-2023
9-Jan-2023	20.44	-1.543	-0.729	14	-3.60	-0.454	-0.369	-0.384	14	10.43	0.136	0.176	-0.120	14	9-Jan-2023
14-Jan-2023	25.29	-1.552	-0.731	12	-4.11	-0.450	0.370	-0.387	12	17.11	0.134	0.179	-0.124	12	14-Jan-2023
21-Jan-2023	25.12	-1.550	-0.728	12	12.79	-0.447	-0.372	-0.388	12	17.63	0.130	0.177	-0.127	12	21-Jan-2023
4-Feb-2023	29.27	-1.582	-0.758	11	-0.19	-0.456	-0.385	-0.414	11	6.13	0.14	0.192	-0.135	11	4-Feb-2023
11-Feb-2023	23.17	-1.737	-0.737	11	-2.99	-0.448	-0.378	-0.402	11	6.77	0.144	0.170	-0.131	11	11-Feb-2023
15-Feb-2023	21.91	-1.750	-0.75	13	-5.6	-0.453	-0.375	-0.409	13	5.75	0.140	0.170	-0.135	13	15-Feb-2023
22-Feb-2023	24.25	-1.566	-0.743	13	-6.13	-0.447	-0.386	-0.409	13	7.52	0.133	0.170	-0.134	13	22-Feb-2023
4-Mar-2023	28.87	-1.512	-0.763	13	23.35	-0.455	-0.401	-0.426	13	9.08	0.147	0.166	-0.166	13	4-Mar-2023
10-Mar-2023	25.14	-1.621	-0.786	13	-3.15	-0.462	-0.418	-0.442	13	11.43	0.138	0.184	-0.184	13	11-Mar-2023
16-Mar-2023	26.11	-1.585	-0.752	14	-8.42	-0.449	-0.498	-0.418	14	7.22	0.136	0.166	-0.134	14	16-Mar-2023
21-Mar-2023	22.14	-1.580	-0.743	12	-3.41	-0.448	-0.396	-0.410	12	5.48	0.142	0.170	-0.134	12	21-Mar-2023
4-Apr-2023	22.25	-1.614	-0.771	13	-3.20	-0.456	-0.408	-0.431	13	6.29	0.153	0.163	-0.144	13	4-Apr-2023
10-Apr-2023	22.09	-1.621	-0.759	13	-3.15	-0.449	-0.411	-0.457	13	7.01	0.160	0.148	-0.137	13	10-Apr-2023
15-Apr-2023	21.82	-1.642	-0.793	15	-3.36	-0.461	-0.418	-0.515	15	7.90	0.156	0.152	-0.152	15	15-Apr-2023
21-Apr-2023	29.40	-1.631	-0.783	14	-2.72	-0.458	-0.415	-0.434	14	9.56	0.147	0.147	0.159	14	21-Apr-2023
4-May-2023	21.76	-1.614	-0.784	17	-2.77	-0.428	-0.431	-0.451	17	5.02	0.149	0.156	-0.157	17	4-May-2023
9-May-2023	21.39	-1.647	-0.784	14	-2.88	-0.285	-0.318	-0.486	14	6.29	0.113	0.155	-0.148	14	9-May-2023
17-May-2023	22.11	-1.643	-0.719	13	-3.14	-0.400	-0.398	-0.450	13	10.14	0.142	0.151	-0.154	13	17-May-2023
23-May-2023	23.06	-1.661	-0.816	15	1.97	-0.469	-0.433	-0.453	15	19.13	0.153	0.152	-0.162	15	23-May-2023
8-Jun-2023	20.11	-1.719	-0.845	16	-3.73	-0.472	-0.450	-0.463	16	5.70	0.141	0.161	-0.18	16	8-Jun-2023
17-Jun-2023	22.00	-1.724	-0.840	15	-2.11	-0.469	-0.456	-0.461	15	11.24	0.136	0.164	-0.182	14	17-Jun-2023
19-Jun-2023	21.91	-1.750	-0.750	13	-5.6	-0.453	-0.375	-0.409	13	5.75	0.140	0.170	-0.135	13	19-Jun-2023
23-Jun-2023	22.01	-1.665	-0.753	13	-3.11	-0.448	-0.414	-0.453	13	7.03	0.162	0.149	-0.136	13	23-Jun-2023
5-Jul-2023	11.75	-1.721	-0.854	18	-9.44	-0.473	-0.451	-0.455	18	-0.11	0.142	0.162	-0.181	18	5-Jul-2023
10-Jul-2023	22.31	-1.748	-0.865	14	-3.25	-0.477	-0.460	-0.474	14	6.49	0.139	0.158	0.188	14	10-Jul-2023
17-Jul-2023	27.50	-1.728	-0.857	17	-2.99	-0.477	-0.460	-0.446	17	13.92	-0.137	-0.155	-0.185	17	17-Jul-2023
24-Jul-2023	28.10	-1.765	-0.857	18	-2.72	-0.478	-0.460	-0.447	18	12.04	-0.140	0.157	-0.188	17	24-Jul-2023
1-Aug-2023	25.55	-1.780	-0.881	19	1.65	-0.438	-0.470	-0.469	19	9.51	0.134	0.162	-0.197	19	1-Aug-2023
7-Aug-2023	25.29	-1.739	-0.872	18	2.23	-0.479	-0.464	-0.433	18	-9.23	0.137	0.131	-0.193	18	7-Aug-2023
14-Aug-2023	24.63	-1.735	-0.866	18	-0.75	-0.477	-0.462	-0.429	18	0.70	0.151	0.133	-0.189	18	14-Aug-2023
21-Aug-2023	26.20	-1.732	-0.866	18	0.43	-0.477	-0.463	-0.441	18	10.37	0.140	0.133	-0.19	18	21-Aug-2023
28-Aug-2023	23.82	-1.704	-0.865	17	-1.6	-0.478	-0.460	-0.431	17	7.31	0.137	0.139	-0.137	17	28-Aug-2023
4-Sep-2023	22.14	-1.719	-0.888	18	-3.04	-0.484	-0.471	-0.473	18	5.7	0.137	0.149	-0.193	18	4-Sep-2023
14-Sep-2023	22.60	-1.712	-0.866	18	-3.21	-0.487	-0.460	-0.455	18	5.63	0.144	0.134	-0.193	18	14-Sep-2023
22-Sep-2023	21.93	-1.712	-0.869	18	-3.63	-0.476	-0.460	-0.455	18	4.51	0.143	0.136	-0.188	18	22-Sep-2023
26-Sep-2023	22.14	-1.712	-0.853	18	-3.47	-0.473	-0.455	-0.442	18	5.8	0.144	0.138	-0.185	18	26-Sep-2023
Note:															

~~237~~

Annexure-IV

NEL LOAD CELL AND MPBX OBSERVATION

LOAD CELL	MPBX				LOAD CELL	MPBX				LOAD CELL	MPBX			
Vertically Upward	Vertically Upward				Horizontally Inclined Upward	Horizontally inclined Upward				Horizontally Inclined Upward	Horizontally inclined Upward			
Access Tunnel, ST-1 Portal (Crown)	Access Tunnel, RD- 395.194, Crown				Access Tunnel, RD-395.194, Left Side	Access Tunnel, RD- 395.194, Left Side				Access Tunnel, RD-395.194, Right Side	Access Tunnel, RD- 395.194, Right Side			
L3STILC	**L4CRMP**				**L4LSLC**	**L4LSMP**				**L4RSLC**	**L4RSMP**			
Negative sign shows compression	Positive sign shows compression				Negative sign shows compression	Positive sign shows compression				Negative sign shows compression	Positive sign shows compression			
6m	15m	10m	5m		6m	9m	6m	3m		6m	9m	6m	3m	
Ch 24	**Ch 236**	**Ch 237**	**Ch 238**		**Ch 25**	**Ch 233**	**Ch 234**	**Ch 235**		**Ch 27**	**Ch 239**	**Ch 240**	**Ch 241**	
kN	**mm**	**mm**	**mm**	**°C**	**kN**	**mm**	**mm**	**mm**	**°C**	**kN**	**mm**	**mm**	**mm**	**°C**
916.97	0.402	-0.344	-0.423	15	3.48	-0.287	-0.906	-0.885	15	26.3	-0.364	-0.310	-0.345	15
916.97	0.396	-0.352	-0.438	17	1.43	-0.292	-0.921	-0.888	17	16.04	-0.368	-0.316	-0.368	17
916.97	0.414	-0.344	-0.415	17	10.43	-0.287	-0.97	-0.874	17	7.18	-0.366	-0.373	-0.357	17
916.97	0.421	-0.340	-0.414	11	7.3	-0.282	-0.889	-0.870	11	-13.15	-0.360	-0.367	-0.369	11
916.97	0.434	-0.330	-0.419	15	2.12	-0.280	-1.008	-0.865	15	-10.38	-0.368	-0.248	-0.480	15
916.97	0.436	-0.315	-0.409	15	0.95	-0.278	-1.262	-0.862	15	-3.88	-0.404	-0.276	-0.119	15
916.97	0.397	-0.298	-0.386	13	0.37	-0.308	-1.245	-0.824	13	15.08	-0.427	-0.251	0.510	13
916.97	0.376	-0.304	-0.390	13	1.80	-0.317	-1.233	-0.845	13	-0.42	-0.401	-0.253	0.377	13
916.97	0.409	-0.296	-0.382	16	1.48	-0.315	-1.226	-0.839	16	17.04	-0.396	-0.233	0.462	16
916.97	0.403	-0.299	-0.386	15	9.63	-0.320	-1.221	-0.840	15	13.06	-0.374	-0.235	0.439	15
916.97	0.412	-0.294	-0.377	13	1.59	-0.316	-1.222	-0.836	13	-170.52	-0.370	-0.225	0.500	13
916.97	0.410	-0.295	-0.378	13	1.75	-0.323	-1.222	-0.836	13	-96.12	-0.364	-0.229	0.810	13
916.97	0.399	-0.302	-0.383	12	2.22	-0.331	-1.229	-0.839	12	-206.33	-0.364	-0.238	0.236	12
916.97	0.399	-0.381	-0.381	13	2.01	-0.333	-1.236	-0.840	13	-115.42	-0.361	-0.242	0.381	13
916.97	0.437	-0.272	-0.354	13	2.12	-0.324	-1.291	-0.814	13	-55.81	-0.378	-0.187	2.761	13
916.97	0.410	-0.297	-0.368	12	5.60	-0.336	-1.206	-0.852	12	-25.46	-0.357	-0.209	3.052	12
916.97	0.399	-0.294	-0.367	12	3.39	-0.338	-1.228	-0.853	12	-102.88	-0.358	-0.201	3.048	12
916.97	0.400	-0.300	-0.386	11	2.44	-0.340	-1.290	-0.800	11	-83.69	-0.376	-0.233	3.100	11
916.97	0.393	-0.309	-0.372	11	3.51	-0.348	-1.232	-0.867	11	15.17	-0.348	-0.234	3.014	11
916.97	0.396	-0.308	-0.372	12	2.48	-0.351	-1.233	-0.869	12	-10.06	-0.351	-0.227	3.11	12
916.97	0.393	-0.310	-0.372	12	2.96	-0.548	-1.233	-0.870	12	-15.20	-0.351	-0.231	3.118	12
916.97	0.379	-0.318	-0.378	13	3.17	-0.354	-1.237	-0.877	13	20.27	-0.348	-0.237	3.136	13
916.97	0.379	-0.322	-0.239	16	1.56	-0.361	-1.240	-0.880	16	17.04	-0.348	-0.241	3.136	16
916.97	0.384	-0.32	-0.381	13	2.24	-0.364	-1.240	-0.879	13	2.15	-0.354	-0.241	3.099	13
916.97	0.396	-0.311	-0.384	14	3.55	-0.359	-1.235	-0.875	14	21.18	-0.366	-0.232	-0.090	14
916.97	0.399	-0.309	-0.388	13	9.21	-0.370	-1.249	-0.882	13	1.47	-0.399	-0.245	3.024	13
916.97	0.376	-0.324	-0.379	17	3.55	-0.374	-1.248	-0.888	17	-56.87	-0.371	-0.249	2.965	17
916.97	0.379	-0.320	-0.381	16	2.89	-0.365	-1.240	-0.881	16	-35.11	-0.366	-0.241	2.090	16
916.97	0.368	-0.334	-0.388	18	3.18	-0.385	-1.250	-0.894	18	-48.63	-0.354	-0.268	2.815	18
916.97	0.365	-0.337	0.390	19	13.6	-0.390	-1.251	-0.894	19	22.17	-0.353	-0.258	1.387	19
916.97	0.378	-2.332	-0.404	18	3.44	-0.393	-1.256	-0.895	18	-77.1	-0.373	-0.26	-0.201	18
916.97	0.377	-2.330	0.406	14	2.54	-0.394	-1.259	-0.568	14	-64.11	-0.376	-0.262	-0.281	14
916.97	0.356	-2.337	-0.406	12	2.18	-0.390	-1.255	-0.507	12	-74.23	-0.371	-0.269	-0.251	12
916.97	0.349	-0.348	-0.402	13	6.86	-0.397	-0.260	-0.900	13	-51.94	-0.366	-0.271	-0.176	13
916.97	0.314	-0.367	-0.447	14	4.71	-0.428	-1.275	-0.919	14	147.36	-0.380	-0.304	-0.219	14
916.97	0.319	-0.365	-0.440	15	3.12	-0.420	-1.278	-0.890	15	132.11	-0.385	-0.311	-0.200	15
916.97	0.393	-0.310	-0.372	12	2.96	-0.548	-1.233	-0.870	12	-15.20	-0.351	-0.231	-0.213	12
916.97	0.38	-0.322	-0.386	14	2.9	-0.360	-1.248	-0.885	14	-35.10	-0.360	-0.247	2.089	13
916.97	0.302	-0.376	-0.461	18	22.12	-0.424	-1.268	-0.911	18	**-1051.42**	-0.381	-0.217	-0.389	18
916.97	0.291	-0.385	-0.471	16	2.38	-0.430	-1.278	-0.915	16	**-1051.42**	-0.390	-0.233	-0.407	16
916.97	0.203	-0.376	-0.460	18	22.65	-0.424	-1.266	-0.912	18	**-98.60**	-0.383	-0.234	-0.391	18
916.97	0.295	-0.381	-0.461	18	8.31	-0.429	-1.272	-0.914	18	**-392.56**	-0.396	-0.239	-0.366	18
916.97	0.286	-0.389	-0.466	19	11.16	-0.441	-1.279	-0.919	19	**-169.24**	-0.400	-0.378	-0.022	19
916.97	0.298	-0.382	-0.448	18	6.3	-0.438	-1.275	-0.917	18	**-0.79**	-0.329	-0.379	-0.079	18
916.97	0.294	-0.384	-0.452	18	4.87	-0.438	-1.270	-0.917	18	**-4.89**	-0.398	-0.387	-0.066	18
916.97	0.300	-0.386	-0.446	18	2.28	-0.448	-1.274	-0.918	18	**142.00**	-0.400	-0.398	-0.093	18
916.97	0.312	-0.378	-0.378	18	4.44	-0.439	-1.271	-0.914	18	**-174.90**	-0.399	-0.386	-0.197	18
916.97	-0.296	-0.385	-0.433	16	-2.75	-0.415	-1.282	-0.923	16	**-186.56**	-0.409	-0.379	-0.024	16
916.97	-0.298	-0.383	-0.423	15	2.96	-0.448	-1.282	-0.919	15	**244.18**	-0.403	-0.363	-0.043	15
916.97	-0.313	-0.380	-0.418	15	-2.86	-0.453	-1.287	-0.922	15	**150.21**	-0.339	-0.341	-0.070	15
916.97	-0.324	-0.347	-0.414	16	3.49	-0.446	-1.279	-0.915	16	**141.14**	-0.339	-0.338	-0.231	16

~~208~~

Annexure-IV

ACCESS TUNNEL LOAD CELL AND MPBX OBSERVATION															ACCESS TUNN
INSTRUMENT	LOAD CELL	MPBX			LOAD CELL	MPBX				LOAD CELL	MPBX				INSTRUMENT
INSTALLATION	Vertical	Vertically Upward			Horizontally Inclined Upward	Horizontally inclined Upward				Horizontally Inclined Upward	Horizontally inclined Upward				INSTALLATION
LOCATION	Access Tunnel, RD-157.294,Crown	Access Tunnel, RD- 157.294, Crown			Access Tunnel, RD-157.294,Left Side	Access Tunnel, RD- 157.294, Left Side				Access Tunnel, RD-157.294, Right Side	Access Tunnel, RD- 157.294, Right Side				LOCATION
INST TAG	L2CRLC	L2CRMP			L2LSLC	L2LSMP				L2RSLC	L2RSMP				INST TAG
Sign convention	Negative sign shows compression	Positive sign shows compression			Negative sign shows compression	Positive sign shows compression				Negative sign shows compression	Positive sign shows compression				Sign convention
Anchor depth	6m	15m	5m		6m	15m	10m	5m		6m	9m	6m	3m		Anchor depth
Channel No.	Ch 22	Ch 248	Ch 250		Ch 21	Ch 245	Ch 246	Ch 247		Ch 23	Ch 251	Ch 252	Ch 253		Channel No.
DATE	kN	mm	mm	°C	kN	mm	mm	mm	°C	kN	mm	mm	mm	°C	DATE
13-Sep-2022	20.57	-1.576	-0.808	17	-3.41	-0.467	-0.350	-0.443	17	6.02	0.129	0.151	-0.153	17	13-Sep-2022
19-Sep-2022	19.22	-1.569	-0.813	17	-3.84	-0.469	-0.354	-0.455	17	5.48	0.139	0.150	-0.157	17	19-Sep-2022
3-Oct-2022	29.14	-1.561	-0.108	17	6.13	-0.428	-0.367	-0.440	17	6.13	-0.428	-0.367	-0.440	17	3-Oct-2022
8-Oct-2022	27.11	-1.539	-0.769	11	-4.11	-0.458	-0.350	-0.445	11	-4.11	-0.458	-0.350	-0.445	11	8-Oct-2022
13-Oct-2022	22.41	-1.534	-0.771	15	-1.07	-0.464	-0.356	-0.418	15	-1.07	-0.464	-0.356	-0.418	15	13-Oct-2022
19-Oct-2022	19.82	-1.516	-0.761	15	-3.68	-0.469	-0.356	-0.241	15	-3.68	-0.469	-0.356	-0.241	15	19-Oct-2022
6-Nov-2022	22.09	-1.550	-0.758	12	0.69	-0.465	-0.358	-0.402	12	6.45	0.128	0.165	-0.129	12	6-Nov-2022
12-Nov-2022	21.17	-1.546	-0.577	13	-4.48	-0.463	-0.358	-0.399	13	5.53	0.134	0.168	-0.130	13	12-Nov-2022
18-Nov-2022	21.55	-1.559	-0.755	13	-3.47	-0.466	-0.364	-0.402	13	5.70	0.134	0.168	-0.130	13	18-Nov-2022
24-Nov-2022	21.76	-1.555	-0.752	13	-4.64	-0.465	-0.366	-0.400	13	5.82	0.136	0.167	-0.129	13	24-Nov-2022
3-Dec-2022	25.77	-1.458	-0.478	13	3.68	-0.162	-0.363	-0.395	13	10.15	0.137	0.170	-0.125	13	3-Dec-2022
8-Dec-2022	22.85	-1.543	-0.744	13	-3.84	-0.460	-0.363	-0.394	13	6.23	0.138	0.170	-0.127	13	8-Dec-2022
13-Dec-2022	22.90	-1.561	-0.450	12	-3.36	-0.463	-0.463	-0.400	12	11.44	0.143	0.169	-0.13	12	13-Dec-2022
19-Dec-2022	21.76	-1.562	-0.750	13	-4.58	-0.461	-0.461	-0.399	13	5.96	0.143	0.169	-0.131	13	19-Dec-2022
1-Jan-2023	22.74	-1.525	-0.720	10	-4.34	-0.449	-0.362	-0.382	10	5.91	0.139	0.174	-0.116	10	1-Jan-2023
9-Jan-2023	20.44	-1.543	-0.729	14	-3.60	-0.454	-0.369	-0.384	14	10.43	0.136	0.176	-0.120	14	9-Jan-2023
14-Jan-2023	25.29	-1.552	-0.731	12	-4.11	-0.450	0.370	-0.387	12	17.11	0.134	0.179	-0.124	12	14-Jan-2023
21-Jan-2023	25.12	-1.550	-0.728	12	12.79	-0.447	-0.372	-0.388	12	17.63	0.130	0.177	-0.127	12	21-Jan-2023
4-Feb-2023	29.27	-1.582	-0.758	11	-0.19	-0.456	-0.385	-0.414	11	6.13	0.14	0.192	-0.135	11	4-Feb-2023
11-Feb-2023	23.17	-1.737	-0.737	11	-2.99	-0.448	-0.378	-0.402	11	6.77	0.144	0.170	-0.131	11	11-Feb-2023
15-Feb-2023	21.91	-1.750	-0.75	13	-5.6	-0.453	-0.375	-0.409	13	5.75	0.140	0.170	-0.135	13	15-Feb-2023
22-Feb-2023	24.25	-1.566	-0.743	13	-6.13	-0.447	-0.386	-0.409	13	7.52	0.133	0.170	-0.134	13	22-Feb-2023
4-Mar-2023	28.87	-1.512	-0.763	13	23.35	-0.455	-0.401	-0.426	13	9.08	0.147	0.166	-0.166	13	4-Mar-2023
10-Mar-2023	25.14	-1.621	-0.786	13	-3.15	-0.462	-0.418	-0.442	13	11.43	0.138	0.184	-0.184	13	11-Mar-2023
16-Mar-2023	26.11	-1.585	-0.752	14	-8.42	-0.449	-0.498	-0.418	14	7.22	0.136	0.166	-0.134	14	16-Mar-2023
21-Mar-2023	22.14	-1.580	-0.743	12	-3.41	-0.448	-0.396	-0.410	12	5.48	0.142	0.170	-0.134	12	21-Mar-2023
4-Apr-2023	22.25	-1.614	-0.771	13	-3.20	-0.456	-0.408	-0.431	13	6.29	0.153	0.163	-0.144	13	4-Apr-2023
10-Apr-2023	22.09	-1.621	-0.759	13	-3.15	-0.449	-0.411	-0.457	13	7.01	0.160	0.148	-0.137	13	10-Apr-2023
15-Apr-2023	21.82	-1.642	-0.793	15	-3.36	-0.461	-0.418	-0.515	15	7.90	0.156	0.152	-0.152	15	15-Apr-2023
21-Apr-2023	29.40	-1.631	-0.783	14	-2.72	-0.458	-0.415	-0.434	14	9.56	0.147	0.147	0.159	14	21-Apr-2023
4-May-2023	21.76	-1.614	-0.784	17	-2.77	-0.428	-0.431	-0.451	17	5.02	0.149	0.156	-0.157	17	4-May-2023
9-May-2023	21.39	-1.647	-0.784	14	-2.88	-0.285	-0.318	-0.486	14	6.29	0.113	0.155	-0.148	14	9-May-2023
17-May-2023	22.11	-1.643	-0.719	13	-3.14	-0.400	-0.398	-0.450	13	10.14	0.142	0.151	-0.154	13	17-May-2023
23-May-2023	23.06	-1.661	-0.816	15	1.97	-0.469	-0.433	-0.453	15	19.13	0.153	0.152	-0.162	15	23-May-2023
8-Jun-2023	20.11	-1.719	-0.845	16	-3.73	-0.472	-0.450	-0.463	16	5.70	0.141	0.161	-0.18	16	8-Jun-2023
17-Jun-2023	22.00	-1.724	-0.840	15	-2.11	-0.469	-0.456	-0.461	15	11.24	0.136	0.164	-0.182	14	17-Jun-2023
19-Jun-2023	21.91	-1.750	-0.750	13	-5.6	-0.453	-0.375	-0.409	13	5.75	0.140	0.170	-0.135	13	19-Jun-2023
23-Jun-2023	22.01	-1.665	-0.753	13	-3.11	-0.448	-0.414	-0.453	13	7.03	0.162	0.149	-0.136	13	23-Jun-2023
5-Jul-2023	11.75	-1.721	-0.854	18	-9.44	-0.473	-0.451	-0.455	18	-0.11	0.142	0.162	-0.181	18	5-Jul-2023
10-Jul-2023	22.31	-1.748	-0.865	14	-3.25	-0.477	-0.460	-0.474	14	6.49	0.139	0.158	0.188	14	10-Jul-2023
17-Jul-2023	27.50	-1.728	-0.857	17	-2.99	-0.477	-0.460	-0.446	17	13.92	-0.137	-0.155	-0.185	17	17-Jul-2023
24-Jul-2023	28.10	-1.765	-0.857	18	-2.72	-0.478	-0.460	-0.447	18	12.04	-0.140	0.157	-0.188	17	24-Jul-2023
1-Aug-2023	25.55	-1.780	-0.881	19	1.65	-0.438	-0.470	-0.469	19	9.51	0.134	0.162	-0.197	19	1-Aug-2023
7-Aug-2023	25.29	-1.739	-0.872	18	2.23	-0.479	-0.464	-0.433	18	-9.23	0.137	0.131	-0.193	18	7-Aug-2023
14-Aug-2023	24.63	-1.735	-0.866	18	-0.75	-0.477	-0.462	-0.429	18	0.70	0.151	0.133	-0.189	18	14-Aug-2023
21-Aug-2023	26.20	-1.732	-0.866	18	0.43	-0.477	-0.463	-0.441	18	10.37	0.140	0.133	-0.19	18	21-Aug-2023
28-Aug-2023	23.82	-1.704	-0.865	17	-1.6	-0.478	-0.460	-0.431	17	7.31	0.137	0.139	-0.137	17	28-Aug-2023
4-Sep-2023	22.14	-1.719	-0.888	18	-3.04	-0.484	-0.471	-0.473	18	5.7	0.137	0.149	-0.193	18	4-Sep-2023
14-Sep-2023	22.60	-1.712	-0.866	18	-3.21	-0.487	-0.460	-0.455	18	5.63	0.144	0.134	-0.193	18	14-Sep-2023
22-Sep-2023	21.93	-1.712	-0.869	18	-3.63	-0.476	-0.460	-0.455	18	4.51	0.143	0.136	-0.188	18	22-Sep-2023
26-Sep-2023	22.14	-1.712	-0.853	18	-3.47	-0.473	-0.455	-0.442	18	5.8	0.144	0.138	-0.185	18	26-Sep-2023
Note:															

Annexure-IV

NEL LOAD CELL AND MPBX OBSERVATION

LOAD CELL	MPBX				LOAD CELL	MPBX				LOAD CELL	MPBX			
Vertically Upward	Vertically Upward				Horizontally Inclined Upward	Horizontally inclined Upward				Horizontally Inclined Upward	Horizontally inclined Upward			
Access Tunnel, ST-1 Portal (Crown)	Access Tunnel, RD- 395.194, Crown				Access Tunnel, RD-395.194, Left Side	Access Tunnel, RD- 395.194, Left Side				Access Tunnel, RD-395.194, Right Side	Access Tunnel, RD- 395.194, Right Side			
L3STILC	**L4CRMP**				**L4LSLC**	**L4LSMP**				**L4RSLC**	**L4RSMP**			
Negative sign shows compression	Positive sign shows compression				Negative sign shows compression	Positive sign shows compression				Negative sign shows compression	Positive sign shows compression			
6m	15m	10m	5m		6m	9m	6m	3m		6m	9m	6m	3m	
Ch 24	**Ch 236**	**Ch 237**	**Ch 238**		**Ch 25**	**Ch 233**	**Ch 234**	**Ch 235**		**Ch 27**	**Ch 239**	**Ch 240**	**Ch 241**	
kN	**mm**	**mm**	**mm**	**°C**	**kN**	**mm**	**mm**	**mm**	**°C**	**kN**	**mm**	**mm**	**mm**	**°C**
916.97	0.402	-0.344	-0.423	15	3.48	-0.287	-0.906	-0.885	15	26.3	-0.364	-0.310	-0.345	15
916.97	0.396	-0.352	-0.438	17	1.43	-0.292	-0.921	-0.888	17	16.04	-0.368	-0.316	-0.368	17
916.97	0.414	-0.344	-0.415	17	10.43	-0.287	-0.97	-0.874	17	7.18	-0.366	-0.373	-0.357	17
916.97	0.421	-0.340	-0.414	11	7.3	-0.282	-0.889	-0.870	11	-13.15	-0.360	-0.367	-0.369	11
916.97	0.434	-0.330	-0.419	15	2.12	-0.280	-1.008	-0.865	15	-10.38	-0.368	-0.248	-0.480	15
916.97	0.436	-0.315	-0.409	15	0.95	-0.278	-1.262	-0.862	15	-3.88	-0.404	-0.276	-0.119	15
916.97	0.397	-0.298	-0.386	13	0.37	-0.308	-1.245	-0.824	13	15.08	-0.427	-0.251	0.510	13
916.97	0.376	-0.304	-0.390	13	1.80	-0.317	-1.233	-0.845	13	-0.42	-0.401	-0.253	0.377	13
916.97	0.409	-0.296	-0.382	16	1.48	-0.315	-1.226	-0.839	16	17.04	-0.396	-0.233	0.462	16
916.97	0.403	-0.299	-0.386	15	9.63	-0.320	-1.221	-0.840	15	13.06	-0.374	-0.235	0.439	15
916.97	0.412	-0.294	-0.377	13	1.59	-0.316	-1.222	-0.836	13	-170.52	-0.370	-0.225	0.500	13
916.97	0.410	-0.295	-0.378	13	1.75	-0.323	-1.222	-0.836	13	-96.12	-0.364	-0.229	0.810	13
916.97	0.399	-0.302	-0.383	12	2.22	-0.331	-1.229	-0.839	12	-206.33	-0.364	-0.238	0.236	12
916.97	0.399	-0.381	-0.381	13	2.01	-0.333	-1.236	-0.840	13	-115.42	-0.361	-0.242	0.381	13
916.97	0.437	-0.272	-0.354	13	2.12	-0.324	-1.291	-0.814	13	-55.81	-0.378	-0.187	2.761	13
916.97	0.410	-0.297	-0.368	12	5.60	-0.336	-1.206	-0.852	12	-25.46	-0.357	-0.209	3.052	12
916.97	0.399	-0.294	-0.367	12	3.39	-0.338	-1.228	-0.853	12	-102.88	-0.358	-0.201	3.048	12
916.97	0.400	-0.300	-0.386	11	2.44	-0.340	-1.290	-0.800	11	-83.69	-0.376	-0.233	3.100	11
916.97	0.393	-0.309	-0.372	11	3.51	-0.348	-1.232	-0.867	11	15.17	-0.348	-0.234	3.014	11
916.97	0.396	-0.308	-0.372	12	2.48	-0.351	-1.233	-0.869	12	-10.06	-0.351	-0.227	3.11	12
916.97	0.393	-0.310	-0.372	12	2.96	-0.548	-1.233	-0.870	12	-15.20	-0.351	-0.231	3.118	12
916.97	0.379	-0.318	-0.378	13	3.17	-0.354	-1.237	-0.877	13	20.27	-0.348	-0.237	3.136	13
916.97	0.379	-0.322	-0.239	16	1.56	-0.361	-1.240	-0.880	16	17.04	-0.348	-0.241	3.136	16
916.97	0.384	-0.32	-0.381	13	2.24	-0.364	-1.240	-0.879	13	2.15	-0.354	-0.241	3.099	13
916.97	0.396	-0.311	-0.384	14	3.55	-0.359	-1.235	-0.875	14	21.18	-0.366	-0.232	-0.090	14
916.97	0.399	-0.309	-0.388	13	9.21	-0.370	-1.249	-0.882	13	1.47	-0.399	-0.245	3.024	13
916.97	0.376	-0.324	-0.379	17	3.55	-0.374	-1.248	-0.888	17	-56.87	-0.371	-0.249	2.965	17
916.97	0.379	-0.320	-0.381	16	2.89	-0.365	-1.240	-0.881	16	-35.11	-0.366	-0.241	2.090	16
916.97	0.368	-0.334	-0.388	18	3.18	-0.385	-1.250	-0.894	18	-48.63	-0.354	-0.268	2.815	18
916.97	0.365	-0.337	0.390	19	13.6	-0.390	-1.251	-0.894	19	22.17	-0.353	-0.258	1.387	19
916.97	0.378	-2.332	-0.404	18	3.44	-0.393	-1.256	-0.895	18	-77.1	-0.373	-0.26	-0.201	18
916.97	0.377	-2.330	0.406	14	2.54	-0.394	-1.259	-0.568	14	-64.11	-0.376	-0.262	-0.281	14
916.97	0.356	-2.337	-0.406	12	2.18	-0.390	-1.255	-0.507	12	-74.23	-0.371	-0.269	-0.251	12
916.97	0.349	-0.348	-0.402	13	6.86	-0.397	-0.260	-0.900	13	-51.94	-0.366	-0.271	-0.176	13
916.97	0.314	-0.367	-0.447	14	4.71	-0.428	-1.275	-0.919	14	147.36	-0.380	-0.304	-0.219	14
916.97	0.319	-0.365	-0.440	15	3.12	-0.420	-1.278	-0.890	15	132.11	-0.385	-0.311	-0.200	15
916.97	0.393	-0.310	-0.372	12	2.96	-0.548	-1.233	-0.870	12	-15.20	-0.351	-0.231	-0.213	12
916.97	0.38	-0.322	-0.386	14	2.9	-0.360	-1.248	-0.885	14	-35.10	-0.360	-0.247	2.089	13
916.97	0.302	-0.376	-0.461	18	22.12	-0.424	-1.268	-0.911	18	**-1051.42**	-0.381	-0.217	-0.389	18
916.97	0.291	-0.385	-0.471	16	2.38	-0.430	-1.278	-0.915	16	**-1051.42**	-0.390	-0.233	-0.407	16
916.97	0.203	-0.376	-0.460	18	22.65	-0.424	-1.266	-0.912	18	**-98.60**	-0.383	-0.234	-0.391	18
916.97	0.295	-0.381	-0.461	18	8.31	-0.429	-1.272	-0.914	18	**-392.56**	-0.396	-0.239	-0.366	18
916.97	0.286	-0.389	-0.466	19	11.16	-0.441	-1.279	-0.919	19	**-169.24**	-0.400	-0.378	-0.022	19
916.97	0.298	-0.382	-0.448	18	6.3	-0.438	-1.275	-0.917	18	**-0.79**	-0.329	-0.379	-0.079	18
916.97	0.294	-0.384	-0.452	18	4.87	-0.438	-1.270	-0.917	18	**-4.89**	-0.398	-0.387	-0.066	18
916.97	0.300	-0.386	-0.446	18	2.28	-0.448	-1.274	-0.918	18	**142.00**	-0.400	-0.398	-0.093	18
916.97	0.312	-0.378	-0.378	18	4.44	-0.439	-1.271	-0.914	18	**-174.90**	-0.399	-0.386	-0.197	18
916.97	-0.296	-0.385	-0.433	16	-2.75	-0.415	-1.282	-0.923	16	**-186.56**	-0.409	-0.379	-0.024	16
916.97	-0.298	-0.383	-0.423	15	2.96	-0.448	-1.282	-0.919	15	**244.18**	-0.403	-0.363	-0.043	15
916.97	-0.313	-0.380	-0.418	15	-2.86	-0.453	-1.287	-0.922	15	**150.21**	-0.339	-0.341	-0.070	15
916.97	-0.324	-0.347	-0.414	16	3.49	-0.446	-1.279	-0.915	16	**141.14**	-0.339	-0.338	-0.231	16

~~240~~

Annexure-III(b)

ANNEXURE: E4: JOINT METERS OBSERVATIONS AT CFRD

JOINT METERS OBSERVATIONS AT CFRD

SIGN CONVENTION	Negative value shows compression & Positive value indicates extension												RESERVOIR CONDITION/LEVEL
JOINT METER	JM-1		JM-2		JM-3		JM-4		JM-5		JM-6		
LOCATION	CHAINAGE-2		CHAINAGE-45		CHAINAGE-115		CHAINAGE-185		CHAINAGE-15		CHAINAGE-180		
CHANNEL NO	224		225		226		227		228		229		
DATE	Sensor Length= ± 50mm	Temp. (°C)	Sensor Length= ± 50mm	Temp. (°C)	Sensor Length= ± 50mm	Temp. (°C)	Sensor Length= ± 50mm	Temp. (°C)	Sensor Length= ± 50mm	Temp. (°C)	Sensor Length= ± 50mm	Temp. (°C)	
15-Jul-2022	No Input	17	-8.7	17	-1.5	17	-6.6	17	2.1	17	0.5	17	1577.8
25-Jul-2022	No Input	19	-8.4	19	-1.6	19	-6.6	19	2.2	19	0.5	19	1580.4
3-Aug-2022	No Input	19	-8.8	19	-1.6	19	-6.6	19	2.2	19	0.5	19	1578.8
9-Aug-2022	No Input	19	-8.8	19	-1.6	19	-6.8	19	2.1	19	0.5	19	1579.4
16-Aug-2022	No Input	21	-8.8	21	-1.6	21	-6.8	21	4.8	21	0.5	21	1578.9
22-Aug-2022	No Input	18	-8.8	18	-1.4	18	-6.9	18	2.1	18	0.5	18	1575.9
3-Sep-2022	No Input	19	-8.8	19	-1.5	19	-6.5	19	2.2	19	0.5	19	1578.6
8-Sep-2022	No Input	17	-8.8	17	-1.4	17	-6.3	17	2.2	17	0.5	17	1579.2
13-Sep-2022	No Input	17	-8.9	17	-1.5	17	-6.3	17	2.2	17	0.5	17	1578.0
19-Sep-2022	No Input	18	-8.8	18	-1.5	18	-6.6	18	2.2	18	0.5	18	1576.8
3-Oct-2022	No Input	17	-8.9	17	-1.4	17	-5.7	17	2.2	17	0.7	17	1581.5
8-Oct-2022	No Input	17	-9.0	17	-1.6	17	-6.0	17	3.5	17	0.5	17	1579.4
13-Oct-2022	No Input	18	-9.0	18	-1.7	18	-5.9	18	2.3	18	0.6	18	1579.5
19-Oct-2022	No Input	19	-9.2	19	-1.7	19	-5.8	19	1.8	19	0.8	19	1573
6-Nov-2022	No Input	15	-9.4	15	-1.8	15	-4.9	15	2.7	15	1.9	15	1579.8
12-Nov-2022	No Input	13	-9.4	13	-1.7	13	-4.8	13	2.6	13	0.8	13	1581.6
18-Nov-2022	No Input	12	-9.3	12	-1.7	12	-4.6	12	2.6	12	1.2	12	1565.4
24-Nov-2022	No Input	8	-9.4	8	-1.5	8	-4.1	8	3.1	8	1.0	8	1565.8
3-Dec-2022	No Input	13	-9.6	13	-1.8	13	-4.3	13	2.9	13	1.1	13	1565.8
8-Dec-2022	No Input	8	-9.3	8	-1.5	8	-4.3	8	2.9	8	1.0	8	1565.2
13-Dec-2022	No Input	10	-9.4	10	-1.6	10	-4.5	10	2.6	10	1.0	10	1565.9
19-Dec-2022	No Input	10	-9.1	10	-1.6	10	-4.5	10	2.7	10	1.0	10	1567.2
1-Jan-2023	No Input	5	-9.4	5	-1.4	5	-3.7	5	3.3	5	1.3	5	1569
9-Jan-2023	No Input	4	-9.4	4	-1.6	4	-3.1	4	3.8	4	1.5	4	1567.3
14-Jan-2023	No Input	5	-9.5	5	-1.6	5	-3.4	5	3.4	5	1.3	5	1567
21-Jan-2023	No Input	5	-9.1	5	-1.5	5	-3.3	5	3.1	5	1.0	5	1567.2
4-Feb-2023	No Input	13	-9.2	13	-1.8	13	-4.5	13	2.0	13	1.0	13	1565.3
11-Feb-2023	No Input	12	-9.7	12	-1.7	12	-4.3	12	2.0	12	1.0	12	1567.7
15-Feb-2023	No Input	15	-9.7	15	-1.9	15	-4.9	15	6.0	15	1.0	15	1566
22-Feb-2023	No Input	14	-9.7	14	-1.7	14	-4.8	14	6.0	14	1.0	14	1568.1
4-Mar-2023	No Input	17	-9.8	17	-1.9	17	-3.5	17	6.0	17	0.9	17	1567.7
10-Mar-2023	No Input	13	-9.8	13	-1.9	13	-5.6	13	2.0	13	1.1	13	1576.9
16-Mar-2023	No Input	11	-9.7	11	-1.6	11	-4.9	11	2.4	11	1.1	11	1569.2
21-Mar-2023	No Input	16	-9.7	16	-1.7	16	-5.1	16	2.0	16	1.2	16	1573.5
4-Apr-2023	No Input	12	-9.1	12	-1.5	12	-5.4	12	4.2	12	1.1	12	1573.5
10-Apr-2023	No Input	14	-9.7	14	-1.5	14	-4.8	14	-0.9	14	0.9	14	1570.9
15-Apr-2023	No Input	14	-9.9	14	-1.4	14	-6.0	14	-4.9	14	0.9	14	1573.4
21-Apr-2023	No Input	19	-10.0	19	-1.7	19	-6.3	19	6.7	19	0.8	19	1572.6
4-May-2023	No Input	13	-10.0	13	-1.4	13	-5.6	13	8.8	13	1.2	13	1573.7
9-May-2023	No Input	19	-9.9	19	-1.7	19	-6.3	19	-3.6	19	0.9	19	1576.1
17-May-2023	No Input	18	-9.0	18	-1.6	18	-6.4	18	-3.4	18	0.5	18	1576.8
23-May-2023	No Input	21	-9.9	21	-1.6	21	-6.5	21	-3.4	21	0.9	21	1580.9
8-Jun-2023	No Input	18	-9.6	18	-1.4	18	-7.0	18	-3.0	18	0.9	18	1577
17-Jun-2023	No Input	16	-9.9	16	-1.4	16	-2.5	16	-2.8	16	0.8	16	1577.1
19-Jun-2023	No Input	19	-9.9	19	-6.9	19	-6.9	19	-9.1	19	0.9	19	1578.2
23-Jun-2023	No Input	19	-9.9	19	-1.8	19	-7.4	19	-9.0	19	0.8	19	1578.9
5-Jul-2023	No Input	23	-10.0	23	-1.8	23	-7.0	23	10.4	23	0.8	23	1578.6
10-Jul-2023	No Input	21	-9.8	21	-1.6	21	-7.2	22	3.3	22	0.7	22	1578.2
17-Jul-2023	No Input	17	-9.9	17	-1.4	17	-6.7	17	7.5	15	0.7	15	1578.2
24-Jul-2023	No Input	21	-9.8	21	-1.5	21	-7.2	21	-8.0	21	0.7	21	1578.4
1-Aug-2023	No Input	27	-9.8	27	-1.9	27	-7.8	27	4.0	27	4	27	1578.3
7-Aug-2023	No Input	24	-9.9	24	-1.7	24	-7.3	24	10.5	24	0.7	24	1578.2
14-Aug-2023	No Input	20	-9.8	20	-1.5	20	-7.1	20	4.8	20	0.7	20	1578.3
21-Aug-2023	No Input	20	-9.7	20	-1.5	20	-7.2	20	3.4	20	0.8	20	1578.2
28-Aug-2023	No Input	12	-9.8	12	-1.4	12	-6.8	12	3.5	12	0.7	12	1578.5
2/9/2023 (Before flushing)	No Input	25	-9.8	25	-1.7	25	-7.4	25	-9.9	25	0.8	25	1578.3
3/9/2023 (During flushing)	No Input	13	-9.8	13	-1.5	13	-7.3	13	3.3	13	0.9	13	Freeflow
4/9/2023 (After flushing)	No Input	15	-9.8	15	-1.2	15	-7.1	15	1.7	15	0.8	15	1579.2
14-Sep-23	No Input	24	-9.12	24	-1.6	24	-7.7	24	7.5	24	0.9	24	1578.1
22-Sep-23	No Input	18	-9.6	18	-1.3	18	-7.2	18	7.7	18	0.8	18	1575.8
26-Sep-23	No Input	20	-9.8	20	-1.5	20	-6.9	20	7.4	20	0.8	20	1577

~~211~~

Annexure-III(b)

JOINT METERS OBSERVATIONS AT CFRD

SIGN CONVENTION	Negative value shows compression & Positive value indicates extension												RESERVOIR CONDITION/LEVEL
JOINT METER	JM-1		JM-2		JM-3		JM-4		JM-5		JM-6		
LOCATION	CHAINAGE-2		CHAINAGE-45		CHAINAGE-115		CHAINAGE-185		CHAINAGE-15		CHAINAGE-180		
CHANNEL NO	224		225		226		227		228		229		
DATE	Sensor Length= ± 50mm	Temp. (°C)	Sensor Length= ± 50mm	Temp. (°C)	Sensor Length= ± 50mm	Temp. (°C)	Sensor Length= ± 50mm	Temp. (°C)	Sensor Length= ± 50mm	Temp. (°C)	Sensor Length= ± 50mm	Temp. (°C)	
15-Jul-2022	No Input	17	-8.7	17	-1.5	17	-6.6	17	2.1	17	0.5	17	1577.8
25-Jul-2022	No Input	19	-8.4	19	-1.6	19	-6.6	19	2.2	19	0.5	19	1580.4
3-Aug-2022	No Input	19	-8.8	19	-1.6	19	-6.6	19	2.2	19	0.5	19	1578.8
9-Aug-2022	No Input	19	-8.8	19	-1.6	19	-6.8	19	2.1	19	0.5	19	1579.4
16-Aug-2022	No Input	21	-8.8	21	-1.6	21	-6.8	21	4.8	21	0.5	21	1578.9
22-Aug-2022	No Input	18	-8.8	18	-1.4	18	-6.9	18	2.1	18	0.5	18	1575.9
3-Sep-2022	No Input	19	-8.8	19	-1.5	19	-6.5	19	2.2	19	0.5	19	1578.6
8-Sep-2022	No Input	17	-8.8	17	-1.4	17	-6.3	17	2.2	17	0.5	17	1579.2
13-Sep-2022	No Input	17	-8.9	17	-1.5	17	-6.3	17	2.2	17	0.5	17	1578.0
19-Sep-2022	No Input	18	-8.8	18	-1.5	18	-6.6	18	2.2	18	0.5	18	1576.8
3-Oct-2022	No Input	17	-8.9	17	-1.4	17	-5.7	17	2.2	17	0.7	17	1581.5
8-Oct-2022	No Input	17	-9.0	17	-1.6	17	-6.0	17	3.5	17	0.5	17	1579.4
13-Oct-2022	No Input	18	-9.0	18	-1.7	18	-5.9	18	2.3	18	0.6	18	1579.5
19-Oct-2022	No Input	19	-9.2	19	-1.7	19	-5.8	19	1.8	19	0.8	19	1573
6-Nov-2022	No Input	15	-9.4	15	-1.8	15	-4.9	15	2.7	15	1.9	15	1579.8
12-Nov-2022	No Input	13	-9.4	13	-1.7	13	-4.8	13	2.6	13	0.8	13	1581.6
18-Nov-2022	No Input	12	-9.3	12	-1.7	12	-4.6	12	2.6	12	1.2	12	1565.4
24-Nov-2022	No Input	8	-9.4	8	-1.5	8	-4.1	8	3.1	8	1.0	8	1565.8
3-Dec-2022	No Input	13	-9.6	13	-1.8	13	-4.3	13	2.9	13	1.1	13	1565.8
8-Dec-2022	No Input	8	-9.3	8	-1.5	8	-4.3	8	2.9	8	1.0	8	1565.2
13-Dec-2022	No Input	10	-9.4	10	-1.6	10	-4.5	10	2.6	10	1.0	10	1565.9
19-Dec-2022	No Input	10	-9.1	10	-1.6	10	-4.5	10	2.7	10	1.0	10	1567.2
1-Jan-2023	No Input	5	-9.4	5	-1.4	5	-3.7	5	3.3	5	1.3	5	1569
9-Jan-2023	No Input	4	-9.4	4	-1.6	4	-3.1	4	3.8	4	1.5	4	1567.3
14-Jan-2023	No Input	5	-9.5	5	-1.6	5	-3.4	5	3.4	5	1.3	5	1567
21-Jan-2023	No Input	5	-9.1	5	-1.5	5	-3.3	5	3.1	5	1.0	5	1567.2
4-Feb-2023	No Input	13	-9.2	13	-1.8	13	-4.5	13	2.0	13	1.0	13	1565.3
11-Feb-2023	No Input	12	-9.7	12	-1.7	12	-4.3	12	2.0	12	1.0	12	1567.7
15-Feb-2023	No Input	15	-9.7	15	-1.9	15	-4.9	15	6.0	15	1.0	15	1566
22-Feb-2023	No Input	14	-9.7	14	-1.7	14	-4.8	14	6.0	14	1.0	14	1568.1
4-Mar-2023	No Input	17	-9.8	17	-1.9	17	-3.5	17	6.0	17	0.9	17	1567.7
10-Mar-2023	No Input	13	-9.8	13	-1.9	13	-5.6	13	2.0	13	1.1	13	1576.9
16-Mar-2023	No Input	11	-9.7	11	-1.6	11	-4.9	11	2.4	11	1.1	11	1569.2
21-Mar-2023	No Input	16	-9.7	16	-1.7	16	-5.1	16	2.0	16	1.2	16	1573.5
4-Apr-2023	No Input	12	-9.1	12	-1.5	12	-5.4	12	4.2	12	1.1	12	1573.5
10-Apr-2023	No Input	14	-9.7	14	-1.5	14	-4.8	14	-0.9	14	0.9	14	1570.9
15-Apr-2023	No Input	14	-9.9	14	-1.4	14	-6.0	14	-4.9	14	0.9	14	1573.4
21-Apr-2023	No Input	19	-10.0	19	-1.7	19	-6.3	19	6.7	19	0.8	19	1572.6
4-May-2023	No Input	13	-10.0	13	-1.4	13	-5.6	13	8.8	13	1.2	13	1573.7
9-May-2023	No Input	19	-9.9	19	-1.7	19	-6.3	19	-3.6	19	0.9	19	1576.1
17-May-2023	No Input	18	-9.0	18	-1.6	18	-6.4	18	-3.4	18	0.5	18	1576.8
23-May-2023	No Input	21	-9.9	21	-1.6	21	-6.5	21	-3.4	21	0.9	21	1580.9
8-Jun-2023	No Input	18	-9.6	18	-1.4	18	-7.0	18	-3.0	18	0.9	18	1577
17-Jun-2023	No Input	16	-9.9	16	-1.4	16	-2.5	16	-2.8	16	0.8	16	1577.1
19-Jun-2023	No Input	19	-9.9	19	-6.9	19	-6.9	19	-9.1	19	0.9	19	1578.2
23-Jun-2023	No Input	19	-9.9	19	-1.8	19	-7.4	19	-9.0	19	0.8	19	1578.9
5-Jul-2023	No Input	23	-10.0	23	-1.8	23	-7.0	23	10.4	23	0.8	23	1578.6
10-Jul-2023	No Input	21	-9.8	21	-1.6	21	-7.2	22	3.3	22	0.7	22	1578.2
17-Jul-2023	No Input	17	-9.9	17	-1.4	17	-6.7	17	7.5	15	0.7	15	1578.2
24-Jul-2023	No Input	21	-9.8	21	-1.5	21	-7.2	21	-8.0	21	0.7	21	1578.4
1-Aug-2023	No Input	27	-9.8	27	-1.9	27	-7.8	27	4.0	27	4	27	1578.3
7-Aug-2023	No Input	24	-9.9	24	-1.7	24	-7.3	24	10.5	24	0.7	24	1578.2
14-Aug-2023	No Input	20	-9.8	20	-1.5	20	-7.1	20	4.8	20	0.7	20	1578.3
21-Aug-2023	No Input	20	-9.7	20	-1.5	20	-7.2	20	3.4	20	0.8	20	1578.2
28-Aug-2023	No Input	12	-9.8	12	-1.4	12	-6.8	12	3.5	12	0.7	12	1578.5
2/9/2023 (Before flushing)	No Input	25	-9.8	25	-1.7	25	-7.4	25	-9.9	25	0.8	25	1578.3
3/9/2023 (During flushing)	No Input	13	-9.8	13	-1.5	13	-7.3	13	3.3	13	0.9	13	Freeflow
4/9/2023 (After flushing)	No Input	15	-9.8	15	-1.2	15	-7.1	15	1.7	15	0.8	15	1579.2
14-Sep-23	No Input	24	-9.12	24	-1.6	24	-7.7	24	7.5	24	0.9	24	1578.1
22-Sep-23	No Input	18	-9.6	18	-1.3	18	-7.2	18	7.7	18	0.8	18	1575.8
26-Sep-23	No Input	20	-9.8	20	-1.5	20	-6.9	20	7.4	20	0.8	20	1577

~~242~~

Annexure-III(b)

JOINT METERS OBSERVATIONS AT CFRD

SIGN CONVENTION	Negative value shows compression & Positive value indicates extension												RESERVOIR CONDITION/LEVEL
JOINT METER	JM-1		JM-2		JM-3		JM-4		JM-5		JM-6		
LOCATION	CHAINAGE-2		CHAINAGE-45		CHAINAGE-115		CHAINAGE-185		CHAINAGE-15		CHAINAGE-180		
CHANNEL NO	224		225		226		227		228		229		
DATE	Sensor Length= ± 50mm	Temp. (°C)	Sensor Length= ± 50mm	Temp. (°C)	Sensor Length= ± 50mm	Temp. (°C)	Sensor Length= ± 50mm	Temp. (°C)	Sensor Length= ± 50mm	Temp. (°C)	Sensor Length= ± 50mm	Temp. (°C)	
15-Jul-2022	No Input	17	-8.7	17	-1.5	17	-6.6	17	2.1	17	0.5	17	1577.8
25-Jul-2022	No Input	19	-8.4	19	-1.6	19	-6.6	19	2.2	19	0.5	19	1580.4
3-Aug-2022	No Input	19	-8.8	19	-1.6	19	-6.6	19	2.2	19	0.5	19	1578.8
9-Aug-2022	No Input	19	-8.8	19	-1.6	19	-6.8	19	2.1	19	0.5	19	1579.4
16-Aug-2022	No Input	21	-8.8	21	-1.6	21	-6.8	21	4.8	21	0.5	21	1578.9
22-Aug-2022	No Input	18	-8.8	18	-1.4	18	-6.9	18	2.1	18	0.5	18	1575.9
3-Sep-2022	No Input	19	-8.8	19	-1.5	19	-6.5	19	2.2	19	0.5	19	1578.6
8-Sep-2022	No Input	17	-8.8	17	-1.4	17	-6.3	17	2.2	17	0.5	17	1579.2
13-Sep-2022	No Input	17	-8.9	17	-1.5	17	-6.3	17	2.2	17	0.5	17	1578.0
19-Sep-2022	No Input	18	-8.8	18	-1.5	18	-6.6	18	2.2	18	0.5	18	1576.8
3-Oct-2022	No Input	17	-8.9	17	-1.4	17	-5.7	17	2.2	17	0.7	17	1581.5
8-Oct-2022	No Input	17	-9.0	17	-1.6	17	-6.0	17	3.5	17	0.5	17	1579.4
13-Oct-2022	No Input	18	-9.0	18	-1.7	18	-5.9	18	2.3	18	0.6	18	1579.5
19-Oct-2022	No Input	19	-9.2	19	-1.7	19	-5.8	19	1.8	19	0.8	19	1573
6-Nov-2022	No Input	15	-9.4	15	-1.8	15	-4.9	15	2.7	15	1.9	15	1579.8
12-Nov-2022	No Input	13	-9.4	13	-1.7	13	-4.8	13	2.6	13	0.8	13	1581.6
18-Nov-2022	No Input	12	-9.3	12	-1.7	12	-4.6	12	2.6	12	1.2	12	1565.4
24-Nov-2022	No Input	8	-9.4	8	-1.5	8	-4.1	8	3.1	8	1.0	8	1565.8
3-Dec-2022	No Input	13	-9.6	13	-1.8	13	-4.3	13	2.9	13	1.1	13	1565.8
8-Dec-2022	No Input	8	-9.3	8	-1.5	8	-4.3	8	2.9	8	1.0	8	1565.2
13-Dec-2022	No Input	10	-9.4	10	-1.6	10	-4.5	10	2.6	10	1.0	10	1565.9
19-Dec-2022	No Input	10	-9.1	10	-1.6	10	-4.5	10	2.7	10	1.0	10	1567.2
1-Jan-2023	No Input	5	-9.4	5	-1.4	5	-3.7	5	3.3	5	1.3	5	1569
9-Jan-2023	No Input	4	-9.4	4	-1.6	4	-3.1	4	3.8	4	1.5	4	1567.3
14-Jan-2023	No Input	5	-9.5	5	-1.6	5	-3.4	5	3.4	5	1.3	5	1567
21-Jan-2023	No Input	5	-9.1	5	-1.5	5	-3.3	5	3.1	5	1.0	5	1567.2
4-Feb-2023	No Input	13	-9.2	13	-1.8	13	-4.5	13	2.0	13	1.0	13	1565.3
11-Feb-2023	No Input	12	-9.7	12	-1.7	12	-4.3	12	2.0	12	1.0	12	1567.7
15-Feb-2023	No Input	15	-9.7	15	-1.9	15	-4.9	15	6.0	15	1.0	15	1566
22-Feb-2023	No Input	14	-9.7	14	-1.7	14	-4.8	14	6.0	14	1.0	14	1568.1
4-Mar-2023	No Input	17	-9.8	17	-1.9	17	-3.5	17	6.0	17	0.9	17	1567.7
10-Mar-2023	No Input	13	-9.8	13	-1.9	13	-5.6	13	2.0	13	1.1	13	1576.9
16-Mar-2023	No Input	11	-9.7	11	-1.6	11	-4.9	11	2.4	11	1.1	11	1569.2
21-Mar-2023	No Input	16	-9.7	16	-1.7	16	-5.1	16	2.0	16	1.2	16	1573.5
4-Apr-2023	No Input	12	-9.1	12	-1.5	12	-5.4	12	4.2	12	1.1	12	1573.5
10-Apr-2023	No Input	14	-9.7	14	-1.5	14	-4.8	14	-0.9	14	0.9	14	1570.9
15-Apr-2023	No Input	14	-9.9	14	-1.4	14	-6.0	14	-4.9	14	0.9	14	1573.4
21-Apr-2023	No Input	19	-10.0	19	-1.7	19	-6.3	19	6.7	19	0.8	19	1572.6
4-May-2023	No Input	13	-10.0	13	-1.4	13	-5.6	13	8.8	13	1.2	13	1573.7
9-May-2023	No Input	19	-9.9	19	-1.7	19	-6.3	19	-3.6	19	0.9	19	1576.1
17-May-2023	No Input	18	-9.0	18	-1.6	18	-6.4	18	-3.4	18	0.5	18	1576.8
23-May-2023	No Input	21	-9.9	21	-1.6	21	-6.5	21	-3.4	21	0.9	21	1580.9
8-Jun-2023	No Input	18	-9.6	18	-1.4	18	-7.0	18	-3.0	18	0.9	18	1577
17-Jun-2023	No Input	16	-9.9	16	-1.4	16	-2.5	16	-2.8	16	0.8	16	1577.1
19-Jun-2023	No Input	19	-9.9	19	-6.9	19	-6.9	19	-9.1	19	0.9	19	1578.2
23-Jun-2023	No Input	19	-9.9	19	-1.8	19	-7.4	19	-9.0	19	0.8	19	1578.9
5-Jul-2023	No Input	23	-10.0	23	-1.8	23	-7.0	23	10.4	23	0.8	23	1578.6
10-Jul-2023	No Input	21	-9.8	21	-1.6	21	-7.2	22	3.3	22	0.7	22	1578.2
17-Jul-2023	No Input	17	-9.9	17	-1.4	17	-6.7	17	7.5	15	0.7	15	1578.2
24-Jul-2023	No Input	21	-9.8	21	-1.5	21	-7.2	21	-8.0	21	0.7	21	1578.4
1-Aug-2023	No Input	27	-9.8	27	-1.9	27	-7.8	27	4.0	27	4	27	1578.3
7-Aug-2023	No Input	24	-9.9	24	-1.7	24	-7.3	24	10.5	24	0.7	24	1578.2
14-Aug-2023	No Input	20	-9.8	20	-1.5	20	-7.1	20	4.8	20	0.7	20	1578.3
21-Aug-2023	No Input	20	-9.7	20	-1.5	20	-7.2	20	3.4	20	0.8	20	1578.2
28-Aug-2023	No Input	12	-9.8	12	-1.4	12	-6.8	12	3.5	12	0.7	12	1578.5
2/9/2023 (Before flushing)	No Input	25	-9.8	25	-1.7	25	-7.4	25	-9.9	25	0.8	25	1578.3
3/9/2023 (During flushing)	No Input	13	-9.8	13	-1.5	13	-7.3	13	3.3	13	0.9	13	Freeflow
4/9/2023 (After flushing)	No Input	15	-9.8	15	-1.2	15	-7.1	15	1.7	15	0.8	15	1579.2
14-Sep-23	No Input	24	-9.12	24	-1.6	24	-7.7	24	7.5	24	0.9	24	1578.1
22-Sep-23	No Input	18	-9.6	18	-1.3	18	-7.2	18	7.7	18	0.8	18	1575.8
26-Sep-23	No Input	20	-9.8	20	-1.5	20	-6.9	20	7.4	20	0.8	20	1577

~~2~~ 3

Annexure-III(b)

JOINT METERS OBSERVATIONS AT CFRD

SIGN CONVENTION	Negative value shows compression & Positive value indicates extension												RESERVOIR CONDITION/LEVEL
JOINT METER	JM-1		JM-2		JM-3		JM-4		JM-5		JM-6		
LOCATION	CHAINAGE-2		CHAINAGE-45		CHAINAGE-115		CHAINAGE-185		CHAINAGE-15		CHAINAGE-180		
CHANNEL NO	224		225		226		227		228		229		
DATE	Sensor Length= ± 50mm	Temp. (°C)	Sensor Length= ± 50mm	Temp. (°C)	Sensor Length= ± 50mm	Temp. (°C)	Sensor Length= ± 50mm	Temp. (°C)	Sensor Length= ± 50mm	Temp. (°C)	Sensor Length= ± 50mm	Temp. (°C)	
15-Jul-2022	No Input	17	-8.7	17	-1.5	17	-6.6	17	2.1	17	0.5	17	1577.8
25-Jul-2022	No Input	19	-8.4	19	-1.6	19	-6.6	19	2.2	19	0.5	19	1580.4
3-Aug-2022	No Input	19	-8.8	19	-1.6	19	-6.6	19	2.2	19	0.5	19	1578.8
9-Aug-2022	No Input	19	-8.8	19	-1.6	19	-6.8	19	2.1	19	0.5	19	1579.4
16-Aug-2022	No Input	21	-8.8	21	-1.6	21	-6.8	21	4.8	21	0.5	21	1578.9
22-Aug-2022	No Input	18	-8.8	18	-1.4	18	-6.9	18	2.1	18	0.5	18	1575.9
3-Sep-2022	No Input	19	-8.8	19	-1.5	19	-6.5	19	2.2	19	0.5	19	1578.6
8-Sep-2022	No Input	17	-8.8	17	-1.4	17	-6.3	17	2.2	17	0.5	17	1579.2
13-Sep-2022	No Input	17	-8.9	17	-1.5	17	-6.3	17	2.2	17	0.5	17	1578.0
19-Sep-2022	No Input	18	-8.8	18	-1.5	18	-6.6	18	2.2	18	0.5	18	1576.8
3-Oct-2022	No Input	17	-8.9	17	-1.4	17	-5.7	17	2.2	17	0.7	17	1581.5
8-Oct-2022	No Input	17	-9.0	17	-1.6	17	-6.0	17	3.5	17	0.5	17	1579.4
13-Oct-2022	No Input	18	-9.0	18	-1.7	18	-5.9	18	2.3	18	0.6	18	1579.5
19-Oct-2022	No Input	19	-9.2	19	-1.7	19	-5.8	19	1.8	19	0.8	19	1573
6-Nov-2022	No Input	15	-9.4	15	-1.8	15	-4.9	15	2.7	15	1.9	15	1579.8
12-Nov-2022	No Input	13	-9.4	13	-1.7	13	-4.8	13	2.6	13	0.8	13	1581.6
18-Nov-2022	No Input	12	-9.3	12	-1.7	12	-4.6	12	2.6	12	1.2	12	1565.4
24-Nov-2022	No Input	8	-9.4	8	-1.5	8	-4.1	8	3.1	8	1.0	8	1565.8
3-Dec-2022	No Input	13	-9.6	13	-1.8	13	-4.3	13	2.9	13	1.1	13	1565.8
8-Dec-2022	No Input	8	-9.3	8	-1.5	8	-4.3	8	2.9	8	1.0	8	1565.2
13-Dec-2022	No Input	10	-9.4	10	-1.6	10	-4.5	10	2.6	10	1.0	10	1565.9
19-Dec-2022	No Input	10	-9.1	10	-1.6	10	-4.5	10	2.7	10	1.0	10	1567.2
1-Jan-2023	No Input	5	-9.4	5	-1.4	5	-3.7	5	3.3	5	1.3	5	1569
9-Jan-2023	No Input	4	-9.4	4	-1.6	4	-3.1	4	3.8	4	1.5	4	1567.3
14-Jan-2023	No Input	5	-9.5	5	-1.6	5	-3.4	5	3.4	5	1.3	5	1567
21-Jan-2023	No Input	5	-9.1	5	-1.5	5	-3.3	5	3.1	5	1.0	5	1567.2
4-Feb-2023	No Input	13	-9.2	13	-1.8	13	-4.5	13	2.0	13	1.0	13	1565.3
11-Feb-2023	No Input	12	-9.7	12	-1.7	12	-4.3	12	2.0	12	1.0	12	1567.7
15-Feb-2023	No Input	15	-9.7	15	-1.9	15	-4.9	15	6.0	15	1.0	15	1566
22-Feb-2023	No Input	14	-9.7	14	-1.7	14	-4.8	14	6.0	14	1.0	14	1568.1
4-Mar-2023	No Input	17	-9.8	17	-1.9	17	-3.5	17	6.0	17	0.9	17	1567.7
10-Mar-2023	No Input	13	-9.8	13	-1.9	13	-5.6	13	2.0	13	1.1	13	1576.9
16-Mar-2023	No Input	11	-9.7	11	-1.6	11	-4.9	11	2.4	11	1.1	11	1569.2
21-Mar-2023	No Input	16	-9.7	16	-1.7	16	-5.1	16	2.0	16	1.2	16	1573.5
4-Apr-2023	No Input	12	-9.1	12	-1.5	12	-5.4	12	4.2	12	1.1	12	1573.5
10-Apr-2023	No Input	14	-9.7	14	-1.5	14	-4.8	14	-0.9	14	0.9	14	1570.9
15-Apr-2023	No Input	14	-9.9	14	-1.4	14	-6.0	14	-4.9	14	0.9	14	1573.4
21-Apr-2023	No Input	19	-10.0	19	-1.7	19	-6.3	19	6.7	19	0.8	19	1572.6
4-May-2023	No Input	13	-10.0	13	-1.4	13	-5.6	13	8.8	13	1.2	13	1573.7
9-May-2023	No Input	19	-9.9	19	-1.7	19	-6.3	19	-3.6	19	0.9	19	1576.1
17-May-2023	No Input	18	-9.0	18	-1.6	18	-6.4	18	-3.4	18	0.5	18	1576.8
23-May-2023	No Input	21	-9.9	21	-1.6	21	-6.5	21	-3.4	21	0.9	21	1580.9
8-Jun-2023	No Input	18	-9.6	18	-1.4	18	-7.0	18	-3.0	18	0.9	18	1577
17-Jun-2023	No Input	16	-9.9	16	-1.4	16	-2.5	16	-2.8	16	0.8	16	1577.1
19-Jun-2023	No Input	19	-9.9	19	-6.9	19	-6.9	19	-9.1	19	0.9	19	1578.2
23-Jun-2023	No Input	19	-9.9	19	-1.8	19	-7.4	19	-9.0	19	0.8	19	1578.9
5-Jul-2023	No Input	23	-10.0	23	-1.8	23	-7.0	23	10.4	23	0.8	23	1578.6
10-Jul-2023	No Input	21	-9.8	21	-1.6	21	-7.2	22	3.3	22	0.7	22	1578.2
17-Jul-2023	No Input	17	-9.9	17	-1.4	17	-6.7	17	7.5	15	0.7	15	1578.2
24-Jul-2023	No Input	21	-9.8	21	-1.5	21	-7.2	21	-8.0	21	0.7	21	1578.4
1-Aug-2023	No Input	27	-9.8	27	-1.9	27	-7.8	27	4.0	27	4	27	1578.3
7-Aug-2023	No Input	24	-9.9	24	-1.7	24	-7.3	24	10.5	24	0.7	24	1578.2
14-Aug-2023	No Input	20	-9.8	20	-1.5	20	-7.1	20	4.8	20	0.7	20	1578.3
21-Aug-2023	No Input	20	-9.7	20	-1.5	20	-7.2	20	3.4	20	0.8	20	1578.2
28-Aug-2023	No Input	12	-9.8	12	-1.4	12	-6.8	12	3.5	12	0.7	12	1578.5
2/9/2023 (Before flushing)	No Input	25	-9.8	25	-1.7	25	-7.4	25	-9.9	25	0.8	25	1578.3
3/9/2023 (During flushing)	No Input	13	-9.8	13	-1.5	13	-7.3	13	3.3	13	0.9	13	Freeflow
4/9/2023 (After flushing)	No Input	15	-9.8	15	-1.2	15	-7.1	15	1.7	15	0.8	15	1579.2
14-Sep-23	No Input	24	-9.12	24	-1.6	24	-7.7	24	7.5	24	0.9	24	1578.1
22-Sep-23	No Input	18	-9.6	18	-1.3	18	-7.2	18	7.7	18	0.8	18	1575.8
26-Sep-23	No Input	20	-9.8	20	-1.5	20	-6.9	20	7.4	20	0.8	20	1577

ANNEXURE: E4: LEFT BANK DRIFT ANCHOR ACCESS TUNNEL

LEFT BANK DRIFT ANCHOR ACCESS TUNNEL													
Instrument	**MPBX**						**Instrument**	**MPBX**				
Type of installation	**Horizontally inclined downward**						**Type of installation**	**Horizontally inclined downward**				
Location	DRIFT ANCHOR 02						**Location**	DRIFT04 ANCHOR				
Inst Tag #	MPDRIFT02						**Inst Tag #**	MPBXDFT04				
Sign convention	Negative sign shows compression						**Sign convention**	Positive sign shows compression				
Channel No.	**Ch 302**		**Ch 303**		**Ch 304**		**Channel No.**	**Ch 309**		**Ch 310**	**Ch 311**	
Inst Sr #	94211		094489		094347		**Inst Sr #**	Amil VW1		AMILVW2	AMILVW2	
Anchor depth	15m		10m		5m		**Anchor depth**	23 m		15 m	12 m	
Date of installation	30-Jan-11		30-Jan-11		30-Jan-11		**Date of installation**	07-Mar-11		07-Mar-11	07-Mar-11	
Date	mm	°C	**mm**	**°C**	**mm**	**Any physical activity / Remarks**	**Date**	**mm**	**°C**	**mm**	**mm**	**Any physical activity**
15-Jul-2022	-2.980	15	-1.962	15	-0.483		**15-Jul-2022**	No Input	No Input	3.266	0.369	
25-Jul-2022	2.985	14	-1.968	14	-0.482		**21-Jul-2022**	No Input	No Input	3.266	0.412	
3-Aug-2022	-2.983	17	-1.968	17	-0.482		**3-Aug-2022**	No Input	No Input	3.610	0.42	
9-Aug-2022	-2.987	16	-1.970	16	-0.485		**9-Aug-2022**	No Input	No Input	3.277	0.445	
16-Aug-2022	-2.980	17	-1.971	17	-0.484		**16-Aug-2022**	No Input	No Input	3.274	0.450	
22-Aug-2022	-2.985	16	-1.974	16	-0.488		**22-Aug-2022**	No Input	No Input	3.271	0.462	
3-Sep-2022	-2.970	13	-1.960	13	-0.395		**3-Sep-2022**	No Input	No Input	3.259	0.481	
8-Sep-2022	-2.977	16	-1.972	16	-0.399		**8-Sep-2022**	No Input	No Input	3.256	0.480	
13-Sep-2022	-2.972	12	-1.969	12	-0.480		**13-Sep-2022**	No Input	No Input	3.267	0.489	
19-Sep-2022	-2.974	12	-1.971	12	-0.483		**19-Sep-2022**	No Input	No Input	3.255	0.493	
03-Oct-22	-2.964	16	-1.966	16	-0.476		**03-Oct-22**	No Input	No Input	3.235	0.503	
08-Oct-22	-2.955	14	-1.961	14	-0.472		**08-Oct-22**	No Input	No Input	3.233	0.499	
13-Oct-22	-2.957	11	-1.961	11	-0.470		**13-Oct-22**	No Input	No Input	3.230	0.496	
19-Oct-22	-2.942	11	-1.952	11	-0.462		**19-Oct-22**	No Input	No Input	3.213	0.492	
6-Nov-2022	-2.931	13	-1.946	13	-0.451		**6-Nov-2022**	No Input	No Input	3.157	0.451	
12-Nov-2022	-2.927	13	-1.947	13	-0.452		**12-Nov-2022**	No Input	No Input	3.149	0.446	
18-Nov-2022	-2.923	10	-1.945	10	-0.451		**18-Nov-2022**	No Input	No Input	3.139	0.429	
24-Nov-2022	-2.998	9	-1.943	9	-0.448		**24-Nov-2022**	No Input	No Input	3.150	0.409	
3-Dec-2022	-2.914	13	-1.944	13	-0.446		**3-Dec-2022**	No Input	No Input	3.316	0.127	
8-Dec-2022	-2.916	13	-1.943	13	-0.446		**8-Dec-2022**	No Input	No Input	3.140	0.392	
13-Dec-2022	-2.914	9	-1.943	9	-0.446		**13-Dec-2022**	No Input	No Input	3.135	0.391	
19-Dec-2022	-2.913	13	-1.944	13	-0.466		**19-Dec-2022**	No Input	No Input	3.137	0.383	
1-Jan-2023	-2.893	19	-1.940	19	-0.437		**1-Jan-2023**	No Input	No Input	3.123	0.265	
9-Jan-2023	-2.891	12	-1.940	12	-0.434		**9-Jan-2023**	No Input	No Input	3.133	0.269	
14-Jan-2023	-2.89	12	-1.942	12	-0.430		**14-Jan-2023**	No Input	No Input	3.130	0.270	
21-Jan-2023	-2.891	11	-1.941	11	-0.434		**21-Jan-2023**	No Input	No Input	3.128	0.288	
4-Feb-2023	-2.89	12	-1.94	12	-0.437		**4-Feb-2023**	No Input	No Input	3.158	0.246	
11-Feb-2023	-2.87	13	-1.94	13	-0.435		**11-Feb-2023**	No Input	No Input	3.313	0.24	
15-Feb-2023	-2.893	12	-1.939	12	-0.435		**15-Feb-2023**	No Input	No Input	3.312	0.244	
22-Feb-2023	-2.893	12	-1.939	12	-0.435		**22-Feb-2023**	No Input	No Input	3.210	0.364	

~~246~~

Annexure-VII

LEFT BANK DRIFT ANCHOR ACCESS TUNNEL										
Instrument	**SPBX**			**Instrument**	**MPBX**					
Type of installation	**Horizontally inclined downward**			**Type of installation**	**Horizontally inclined downward**					
Location				**Location**	**Access Tunnel Drift 03**					
Inst Tag #	SPDRIFT02			**Inst Tag #**	MPDRIFT03					
Sign convention	Negative sign shows compression			**Sign convention**	Positive sign shows compression					
Channel No.	**Ch 300**			**Channel No.**	**Ch 306**		**Ch 307**		**Ch 308**	
Inst Sr #	94422				94186		094493		094393	
Anchor depth	15m			**Anchor depth**	15m		10m		5m	
Date of installation	30-Jun-11			**Date of installation**	30-Jun-11		30-Jun-11		30-Jun-11	
Date	**mm**	**°C**	**Any physical activity**	**Date**	mm	**°C**	**mm**	**°C**	**mm**	**Any physical activity**
15-Jul-2022	-0.084	15		**15-Jul-2022**	-4.337	15	-14.565	15	-12.198	
21-Jul-2022	-0.085	14		**21-Jul-2022**	-4.338	14	-14.566	14	-12.198	
3-Aug-2022	-0.079	17		**3-Aug-2022**	-4.339	17	-14.566	17	-12.188	
9-Aug-2022	-0.384	16		**9-Aug-2022**	-4.338	16	-14.565	16	-12.189	
16-Aug-2022	-0.081	17		**16-Aug-2022**	-4.337	17	-14.566	17	-12.186	
22-Aug-2022	-0.087	16		**22-Aug-2022**	-4.334	16	-14.564	16	-12.186	
3-Sep-2022	-0.080	13		**3-Sep-2022**	-4.310	13	-14.561	13	-12.182	
8-Sep-2022	-0.082	16		**8-Sep-2022**	-4.316	16	-14.564	16	-12.180	
13-Sep-2022	-0.079	12		**13-Sep-2022**	-4.308	12	-14.563	12	-12.176	
19-Sep-2022	-0.079	12		**19-Sep-2022**	-4.305	12	-14.563	12	-12.178	
03-Oct-22	-0.070	16		**03-Oct-22**	-4.296	16	-14.562	16	-12.170	
08-Oct-22	-0.072	14		**08-Oct-22**	-4.290	14	-14.560	14	-12.165	
13-Oct-22	-0.064	11		**13-Oct-22**	-4.292	11	-14.561	11	-12.164	
19-Oct-22	-0.053	11		**19-Oct-22**	-4.290	11	-14.559	11	-12.159	
6-Nov-2022	-0.029	13		**6-Nov-2022**	-4.286	13	-14.557	13	-12.146	
12-Nov-2022	-0.035	13		**12-Nov-2022**	-4.282	13	-14.557	13	-12.146	
18-Nov-2022	-0.033	10		**18-Nov-2022**	-4.285	10	-14.556	10	-12.138	
24-Nov-2022	-0.026	9		**24-Nov-2022**	-4.283	9	-14.556	9	-12.141	
3-Dec-2022	-0.023	13		**3-Dec-2022**	-4.282	13	-14.556	13	-12.138	
8-Dec-2022	-0.022	11		**8-Dec-2022**	4.281	11	-14.556	11	-12.138	
13-Dec-2022	-0.021	9		**13-Dec-2022**	-4.280	9	-14.555	9	-12.137	
19-Dec-2022	-0.091	13		**19-Dec-2022**	-4.278	13	-14.555	13	-12.136	
1-Jan-2023	-0.005	19		**1-Jan-2023**	4.227	19	-14.551	19	-12.125	
9-Jan-2023	0.000	12		**9-Jan-2023**	-4.275	12	-14.550	12	-12.121	
14-Jan-2023	-0.001	12		**14-Jan-2023**	-4.273	12	-14.500	12	-12.122	
21-Jan-2023	0.000	11		**21-Jan-2023**	-4.274	11	-14.549	11	-12.121	
4-Feb-2023	-0.003	12		**4-Feb-2023**	-4.272	12	-14.551	12	-12.121	
11-Feb-2023	-0.003	13		**11-Feb-2023**	-4.271	13	-14.550	13	-12.120	
15-Feb-2023	0.000	12		**15-Feb-2023**	-4.271	12	-14.550	12	-12.120	
22-Feb-2023	0.000	12		**22-Feb-2023**	-4.217	13	-14.551	13	-12.120	

Annexure-I(a)

ANNEXURE: E4: Perimetric joint meters

3D - PERIMETRIC JOINT METERS AT CFRD

SIGN CONVENTION																		
PERIMETRIC JOINT METER	PJM-5				PJM-6				PJM-7				PJM-8				RESERVOIR LEVEL	REMARKS
LOCATION	CHAINAGE-115				CHAINAGE-115				CHAINAGE-115				CHAINAGE-115					
CHANNEL NO	200	201	202		203	204	205		206	207	208		209	210	211			
DATE	X=± 25mm	Y=± 50mm	Z=± 50mm	Temp. (° C)	X=± 25mm	Y=± 50mm	Z=± 50mm	Temp. (° C)	X=± 25mm	Y=± 50mm	Z=± 50mm	Temp. (° C)	X=± 25mm	Y=± 50mm	Z=± 50mm	Temp. (° C)		
8-Oct-2022	-0.16	-1.57	NIP	13	NIP	-2.32	NIP	13	-0.18	NIP	NIP	13	-0.62	-0.60	NIP	13	1579.4	
13-Oct-2022	-0.60	-1.57	NIP	13	NIP	-2.31	NIP	13	-0.19	NIP	NIP	13	-0.63	-0.63	NIP	13	1579.5	
19-Oct-2022	-0.15	-1.58	NIP	17	NIP	-2.27	NIP	17	-0.18	NIP	NIP	17	-0.63	-0.59	NIP	17	1573	
6-Nov-2022	-0.09	-1.46	NIP	13	NIP	-2.31	NIP	13	-0.14	NIP	NIP	13	-0.56	-0.58	NIP	13	1579.8	
12-Nov-2022	-0.09	-1.45	NIP	18	NIP	-2.28	NIP	18	-0.12	NIP	NIP	18	-0.58	-0.5	NIP	18	1581.6	
18-Nov-2022	-0.08	-1.44	NIP	12	NIP	-2.27	NIP	12	-0.12	NIP	NIP	12	-0.58	-0.48	NIP	12	1565.4	
24-Nov-2022	-0.07	-1.44	NIP	12	NIP	-2.05	NIP	12	-0.11	NIP	NIP	12	-0.56	-0.47	NIP	12	1565.8	
3-Dec-2022	-0.07	-1.42	NIP	11	NIP	-2.19	NIP	11	-0.11	NIP	NIP	11	-0.57	-0.45	NIP	11	1565.2	
8-Dec-2022	-0.06	-1.41	NIP	11	NIP	-0.55	NIP	11	-0.10	NIP	NIP	11	-0.55	-0.55	NIP	11	1565.9	
13-Dec-2022	-0.06	-1.41	NIP	16	NIP	-2.25	NIP	16	-0.10	NIP	NIP	16	-0.56	-0.45	NIP	16	1567.2	
19-Dec-2022	-0.60	-1.39	NIP	11	NIP	-2.01	NIP	11	-0.10	NIP	NIP	11	-0.59	-0.42	NIP	11	1567.1	
1-Jan-2023	-0.05	-0.37	NIP	10	NIP	-2.60	NIP	10	-0.08	NIP	NIP	10	-0.53	-0.40	NIP	10	1569	
9-Jan-2023	-0.04	-1.36	NIP	10	NIP	-2.24	NIP	10	-0.08	NIP	NIP	10	-0.55	-0.39	NIP	10	1567.3	
14-Jan-2023	-0.03	-1.35	NIP	10	NIP	-2.26	NIP	10	-0.06	NIP	NIP	10	-0.53	-0.37	NIP	10	1567	
21-Jan-2023	-0.05	-1.39	NIP	11	NIP	-2.22	NIP	11	-0.11	NIP	NIP	11	-0.50	-0.41	NIP	11	1567.2	
4-Feb-2023	-0.04	-1.37	NIP	12	NIP	-2.22	NIP	12	-0.07	NIP	NIP	12	-0.53	-0.38	NIP	12	1565.3	
11-Feb-2023	-0.04	-1.37	NIP	12	NIP	-2.18	NIP	12	-0.07	NIP	NIP	12	-0.53	-0.38	NIP	12	1567.7	
15-Feb-2023	-0.04	-1.38	NIP	11	NIP	-2.28	NIP	11	-0.08	NIP	NIP	11	-0.55	-0.38	NIP	11	1566	
22-Feb-2023	-0.05	-1.40	NIP	14	NIP	-2.22	NIP	14	-0.08	NIP	NIP	14	-0.55	-0.40	NIP	14	1568.1	
4-Mar-2023	-0.05	-1.42	NIP	13	NIP	-2.29	NIP	13	-0.08	NIP	NIP	13	-0.55	-0.42	NIP	13	1567.7	
10-Mar-2023	-0.07	-1.44	NIP	16	NIP	-2.26	NIP	16	-0.10	NIP	NIP	16	-0.55	-0.30	NIP	16	1576.9	
16-Mar-2023	-0.03	-1.44	NIP	11	NIP	-2.88	NIP	11	-0.10	NIP	NIP	11	-0.54	-0.42	NIP	11	1569.2	
21-Mar-2023	-0.06	-1.43	NIP	10	NIP	-2.42	NIP	10	-0.10	NIP	NIP	10	-0.55	-0.44	NIP	10	1573.5	
4-Apr-2023	-0.06	-1.44	NIP	8	NIP	-2.03	NIP	8	-0.10	NIP	NIP	8	0.55	-0.46	NIP	8	1573.5	
10-Apr-2023	-0.05	-1.40	NIP	10	NIP	-2.26	NIP	10	-0.08	NIP	NIP	10	0.54	-0.42	NIP	10	1570.9	
15-Apr-2023	-0.07	-1.49	NIP	10	NIP	-2.70	NIP	10	-0.12	NIP	NIP	10	-0.58	-0.48	NIP	10	1573.4	
21-Apr-2023	-0.07	-1.50	NIP	9	NIP	-2.18	NIP	9	-0.12	NIP	NIP	9	-0.58	-0.45	NIP	9	1572.6	
4-May-2023	-0.07	-1.49	NIP	10	NIP	3.14	NIP	10	-0.11	NIP	NIP	10	-0.58	-0.88	NIP	10	1573.7	
9-May-2023	-0.08	-1.50	NIP	11	NIP	3.26	NIP	11	-0.11	NIP	NIP	11	-0.58	-0.58	NIP	11	1576.1	
17-May-2023	-0.08	-1.50	NIP	11	NIP	3.1	NIP	11	-0.17	NIP	NIP	11	-0.59	-0.49	NIP	11	1576.8	
23-May-2023	-0.08	-1.52	NIP	11	NIP	-2.47	NIP	11	-0.12	NIP	NIP	11	-0.60	-0.47	NIP	11	1580.9	
8-Jun-2023	-0.09	-1.57	NIP	10	NIP	-2.30	NIP	10	-0.11	NIP	NIP	10	-0.59	-0.49	NIP	10	1577	
17-Jun-2023	-0.09	-1.55	NIP	11	NIP	-2.43	NIP	11	-0.11	NIP	NIP	11	-0.58	-0.49	NIP	11	1577.1	
19-Jun-2023	-0.05	-1.56	NIP	11	NIP	-2.45	NIP	11	-0.11	NIP	NIP	11	-0.60	-0.59	NIP	11	1578.2	
23-Jun-2023	-0.10	-1.54	NIP	10	NIP	-2.32	NIP	10	-0.10	NIP	NIP	10	-0.60	-0.59	NIP	10	1578.9	
5-Jul-2023	-0.11	-1.59	NIP	7	NIP	-2.72	NIP	7	-0.11	NIP	NIP	7	-0.61	-0.51	NIP	7	1578..6	
10-Jul-2023	-0.11	-1.51	NIP	6	NIP	-2.21	NIP	6	-0.11	NIP	NIP	6	-0.61	-0.50	NIP	6	1578.2	
17-Jul-2023	-0.10	-1.59	NIP	19	NIP	-2.28	NIP	19	-0.11	NIP	NIP	19	-0.61	-0.51	NIP	19	1578.2	
24-Jul-2023	-0.10	-1.50	NIP	8	NIP	-2.19	NIP	8	-0.10	NIP	NIP	8	-0.61	-0.50	NIP	8	1578.4	
1-Aug-2023	-0.12	-0.49	NIP	12	NIP	-2.18	NIP	12	-0.09	NIP	NIP	12	-0.62	-0.56	NIP	12	1578.4	
7-Aug-2023	-0.11	-0.66	NIP	11	NIP	-2.13	NIP	11	-0.11	NIP	NIP	11	-0.61	-0.59	NIP	11	1578.4	
14-Aug-2023	-0.11	-1.60	NIP	11	NIP	-2.64	NIP	11	-0.30	NIP	NIP	11	-0.62	-0.51	NIP	11	1578.3	
21-Aug-2023	-0.11	-1.62	NIP	11	NIP	-2.20	NIP	11	-0.10	NIP	NIP	11	-0.61	-0.52	NIP	11	1578.2	
28-Aug-2023	-0.12	-1.63	NIP	10	NIP	-2.28	NIP	10	-0.09	NIP	NIP	10	-0.68	-0.51	NIP	10	1578.5	
2/9/2023(Before flushing)	-0.12	-1.64	NIP	13	NIP	-2.23	NIP	13	-0.06	NIP	NIP	13	-0.62	-0.52	NIP	13	1578.3	
3/9/2023(During flushing)	-0.10	-1.60	NIP	13	NIP	-2.14	NIP	13	-0.07	NIP	NIP	13	-0.60	-0.47	NIP	13	FREEFLOW	
4/9/2023(After flushing)	-0.12	-0.06	NIP	12	NIP	-2.12	NIP	12	-0.09	NIP	NIP	12	-0.63	-0.53	NIP	12	1579.2	
14-Sep-2023	-0.12	-1.64	NIP	8	NIP	-2.15	NIP	8	-0.09	NIP	NIP	8	-0.63	-0.63	NIP	8	1578.1	
22-Sep-2023	-0.12	-1.64	NIP	18	NIP	-2.22	NIP	18	-0.08	NIP	NIP	18	-0.63	-0.53	NIP	18	1578.1	
26-Sep-2023	-0.12	-1.36	NIP	12	NIP	-2.30	NIP	12	-0.08	NIP	NIP	12	-0.36	-0.52	NIP	12	1577.0	

- X-axis: Normal to joint to measure joint opening or closing.
- Y-axis: Parallel to joint (and concrete slab face) to measure joint shear in the plane of concrete face..
- Z-axis: Normal to concrete face to measure relative settlement of the concrete slabs.

PIEZOMETER AT CFRD CUT OFF WALL

					D/S OF CUT OFF WALL													
PIEZOMETER	PPG4		PPG7		PPG2		PPG3		PPG5		PPG6		PPG8		PPG10		RESERVOIR LEVEL	REMARKS
LOCATION	CHAINAGE-89 (PPG4)		CHAINAGE-34 (PPG7)		CHAINAGE-139 (PPG2)		CHAINAGE-89 (PPG3)		CHAINAGE-89 (PPG5)		CHAINAGE-34 (PPG6)		CHAINAGE-34 (PPG8)		CHAINAGE-4 (PPG10)			
CHANNEL NO	27		32		481		26		25		29		28		30			
DATE	Kg/cm²	Temp.(°C)	Kg/cm²	Temp.(°C)	Kg/cm²	Temp.(°C)	Kg/cm²	Temp.(°C)	Kg/cm²	Temp.(°C)	Kg/cm²	Temp.(°C)	Kg/cm²	Temp.(°C)	Kg/cm²	Temp.(°C)		
5-Apr-2022	4.31	8	5.23	8	2.87	8	0.53	8	2.58	8	1.62	8	3.81	8	0.88	8	1582.2	
8-Apr-2022	4.93	7	5.76	7	3.83	7	0.57	7	2.71	7	1.79	7	4.04	7	1.01	7	1569.1	
12-Apr-2022	4.59	8	5.46	8	3.35	8	0.53	8	2.64	8	1.65	8	3.89	8	0.92	8	1577.6	
16-Apr-2022	4.37	7	5.23	7	2.91	7	0.53	7	2.59	7	1.00	7	3.82	7	0.88	7	1574.8	
19-Apr-2022	4.42	9	4.19	9	3.51	9	0.56	9	2.73	9	1.66	9	3.84	9	0.97	9	1578.6	
22-Apr-2022	4.55	8	5.35	8	3.36	8	0.50	8	2.64	8	1.72	8	3.98	8	0.86	8	1574.4	
2-May-2022	4.40	10	5.27	10	3.11	10	0.52	10	2.62	10	1.64	10	3.84	10	0.89	10	1571.9	
6-May-2022	4.61	10	5.45	10	3.51	10	0.56	10	2.66	10	1.69	10	3.93	10	0.95	10	1575.2	
10-May-2022	4.49	10	5.35	10	3.33	10	0.55	10	2.64	10	1.73	10	1.73	10	0.92	10	1576.1	
14-May-2022	4.88	10	5.69	10	3.96	10	0.57	10	2.73	10	1.73	10	4.06	10	1.00	10	1575.7	
19-May-2022	4.73	9	5.54	9	3.68	9	0.58	9	2.68	9	4.06	9	4.00	9	0.99	9	1576.7	
1-Jun-2022	4.62	11	5.45	11	3.58	11	0.55	11	2.72	11	1.26	11	3.95	11	0.95	11	1574.3	
8-Jun-2022	4.97	17	5.68	17	4.04	17	0.61	17	2.83	17	1.83	17	2.13	17	1.05	17	1576.5	
15-Jun-2022	4.81	10	5.63	10	3.80	10	0.60	10	2.78	10	1.77	10	4.05	10	1.00	10	1579.2	
20-Jun-2022	4.80	9	5.68	9	3.79	9	0.58	9	2.79	9	1.75	9	4.03	9	0.98	9	1577.9	
2-Jul-2022	4.86	9	5.57	9	3.86	9	0.88	9	2.82	9	1.77	9	4.06	9	0.99	9	1578.5	
6-Jul-2022	4.79	8	5.59	8	3.73	8	0.57	8	2.81	8	1.74	8	4.03	8	0.98	8	1574.2	
11-Jul-2022	5.10	12	5.88	12	4.15	12	0.61	12	2.93	12	1.87	12	4.18	12	1.07	12	1577	
15-Jul-2022	4.84	11	5.66	11	4.74	11	0.58	11	2.84	11	1.77	11	4.06	11	0.99	11	1577.8	
25-Jul-2022	4.97	12	5.79	12	3.94	12	0.59	12	2.84	12	1.80	12	4.12	12	1.02	12	1581	
3-Aug-2022	4.86	13	5.70	13	3.76	13	0.58	13	2.81	13	1.76	13	4.06	13	0.98	13	1578.3	
9-Aug-2022	4.87	13	5.71	13	3.79	13	0.57	13	2.81	13	1.76	13	4.06	13	0.96	13	1579.2	
16-Aug-2022	4.55	13	5.70	13	3.75	13	0.57	13	2.81	13	1.75	13	4.05	13	0.97	13	1579.6	
22-Aug-2022	4.64	12	5.49	12	3.47	12	0.53	12	2.73	12	1.65	12	3.94	12	0.91	12	1575.3	
3-Sep-2022	4.90	12	5.72	12	3.72	12	0.58	12	2.80	12	1.76	12	4.07	12	0.49	12	1578.3	
8-Sep-2022	4.93	12	5.74	12	3.74	12	0.58	12	2.85	12	1.77	12	4.09	12	0.99	12	1580.6	
13-Sep-2022	4.77	12	5.76	12	3.79	12	0.58	12	2.88	12	1.74	12	4.09	12	0.98	12	1580.5	
19-Sep-2022	4.77	13	5.58	13	3.53	13	0.56	13	2.82	13	1.37	13	4.01	13	0.94	13	1575.7	
3-Oct-2022	5.03	13	5.81	13	3.97	13	0.60	13	2.74	13	1.80	13	4.13	13	1.00	13	1574.4	
8-Oct-2022	4.90	13	5.70	13	3.79	13	0.59	13	2.89	13	1.75	13	4.07	13	0.81	13	1581.8	
13-Oct-2022	4.91	13	5.71	13	3.77	13	0.60	13	2.86	13	1.75	13	4.08	13	0.97	13	1579.4	
19-Oct-2022	4.53	17	5.36	17	3.27	17	0.52	17	2.82	17	1.62	17	3.89	17	0.86	17	1572	
6-Nov-2022	5.02	13	5.80	13	4.10	13	0.60	13	3.00	13	1.79	13	4.13	13	1.01	13	1580.8	
12-Nov-2022	5.05	18	5.83	18	4.20	18	0.59	18	2.99	18	1.80	18	4.14	18	1.01	18	1581.2	
18-Nov-2022	4.11	12	4.98	12	2.69	12	0.47	12	2.73	12	1.49	12	3.72	12	0.76	12	1565.4	
24-Nov-2022	4.12	12	4.98	12	2.67	12	0.45	12	2.75	12	1.48	12	3.70	12	0.76	12	1565.5	
3-Dec-2022	4.09	11	4.96	11	2.67	11	0.56	11	2.74	11	1.48	11	3.70	11	0.76	11	1565.1	
8-Dec-2022	4.11	11	4.97	11	2.67	11	0.45	11	2.72	11	1.57	11	3.70	11	0.75	11	1565.1	
13-Dec-2022	4.15	16	5.00	16	2.67	16	0.44	16	2.74	16	1.48	16	3.71	16	0.72	16	1568.5	
19-Dec-2022	4.15	11	4.99	11	2.75	11	0.44	11	2.73	11	1.48	11	3.71	11	0.75	11	1570.2	
1-Jan-2023	4.22	10	6.00	10	2.91	10	0.45	10	2.77	10	3.74	10	3.74	10	0.76	10	1566.9	
9-Jan-2023	4.15	10	4.99	10	2.76	10	0.44	10	2.68	10	3.70	10	3.70	10	0.75	10	1565.1	
14-Jan-2023	4.14	10	4.99	10	2.84	10	0.53	10	2.63	10	3.69	10	3.69	10	0.75	10	1564.5	
21-Jan-2023	4.10	12	5.16	12	2.80	12	0.50	12	2.70	12	3.60	12	3.65	13	0.77	12	1568.1	
4-Feb-2023	4.18	13	5.03	13	2.90	13	0.46	13	2.60	13	1.49	13	3.74	13	0.76	13	1565.3	
11-Feb-2023	4.15	13	5.00	13	2.87	13	0.45	13	2.59	13	1.74	13	3.72	13	0.74	13	1567.7	
15-Feb-2023	4.28	8	4.97	8	2.75	8	0.45	8	2.56	8	1.45	8	3.70	8	0.73	8	1566.0	
22-Feb-2023	4.27	13	5.08	13	2.91	13	0.49	13	2.73	13	1.54	13	3.79	13	0.30	13	1568.1	
4-Mar-2023	4.22	13	5.07	13	2.96	13	0.47	13	2.68	13	1.50	13	3.78	13	0.77	13	1567.7	
10-Mar-2023	4.72	16	5.50	16	2.71	16	0.54	16	2.94	16	1.65	16	3.71	16	0.91	16	1576.9	
16-Mar-2023	4.28	11	5.12	11	3.03	11	0.51	11	2.77	11	1.53	11	3.81	11	0.79	11	1569.1	
21-Mar-2023	4.42	10	5.25	10	3.24	10	0.51	10	2.79	10	1.58	10	3.87	10	0.81	10	1573.1	
4-Apr-2023	4.38	8	5.21	8	3.22	8	0.51	8	2.78	8	1.58	8	3.86	8	0.80	8	1572.5	
10-Apr-2023	4.20	10	5.17	10	3.01	10	0.49	10	2.77	10	1.53	10	3.78	10	0.79	10	1572.2	
15-Apr-2023	4.10	8	4.96	8	2.83	8	0.45	8	2.71	8	1.43	8	3.72	8	0.74	8	1574.7	
21-Apr-2023	4.40	9	5.24	9	3.25	9	0.50	9	2.85	9	1.55	9	0.71	9	0.71	9	1571.6	

Annexure-III(a)

STAND PIPE PIEZOMETER AT D/S OF CFRD

Instrument ID		SPM1	SPM2	SPM3	SPM4	SPM5	SPM6	SPM7
Elevation		1589.66	1555.04	1537.93	1526.70	1528.94	1530.22	1546.17
Date	Reservoir level (meters)	Ground Water level (meters)						
2-May-2022	1574.8	1559.13	1533.86	1527.13	1521.87	1520.16	1522.1	1533.33
6-May-2022	1579.9	1558.79	1533..54	1528.72	1521.38	1520.28	1522.08	1533.77
10-May-2022	1576.3	1558.87	1533.23	1528.21	1521.07	1520.21	1521.9	1533.6
14-May-2022	1575.8	1558.84	1533.32	1528.57	1521.01	1520.42	1521.79	1533.7
19-May-2022	1577.5	1558.69	1534.02	1528.49	1521.33	1520.65	1521.59	1533.36
1-Jun-2022	1574.3	1558.86	1534.48	1530.54	1521.54	1520.56	1521.52	1533.63
8-Jun-2022	1576.5	1558.92	1534.47	1529.2	1521.46	1520.38	1521.92	1533.08
15-Jun-2022	1579.2	1558.99	1534.61	1530.12	1520.9	1520.39	1522.04	1533.65
20-Jun-2022	1577.9	1558.78	1535.86	1530.67	1522.6	1521.25	1522.71	1533.44
2-Jul-2022	1578.5	1558.85	1533.46	1530.53	1521.52	1520.47	1522	1533.25
6-Jul-2022	1574.2	1558.94	1534.69	1529.89	1521.3	1520.3	1521.87	1532.85
11-Jul-2022	1577.0	1559.05	1533.84	1529.39	1521.48	1520.39	1522.07	1534.3
15-Jul-2022	1577.4	1558.87	1533.92	1529.06	1521.3	1520.09	1522.12	1533.51
25-Jul-2022	1581.0	1558.83	1534.3	1529.21	1521.59	1520.59	1522.06	1533.41
3-Aug-2022	1578.3	1558.85	1534.62	1529.86	1521.57	1520.8	1521.92	1533.37
9-Aug-2022	1579.2	1558.72	1534.45	1530.33	1521.57	1520.78	1522.12	1533.32
16-Aug-2022	1579.6	1559.48	1533.92	1531.06	1521.51	1520.27	1522.0	1532.85
22-Aug-2022	1575.3	1558.94	1533.89	1529.87	1521.22	1520.32	1521.89	1532.76
3-Sep-2022	1578.3	1559.52	1534.28	1529.01	1521.11	1520.48	1522.92	1533.47
8-Sep-2022	1580.6	1558.94	1534.02	1530.23	1521.6	1520.66	1522.09	1533.79
13-Sep-2022	1580.5	1559.18	1534.18	1530.85	1521.53	1520.52	1522.02	1533.48
19-Sep-2022	1575.7	1558.95	1533.99	1530.85	1521.51	1520.42	1521.9	1533.34
3-Oct-2022	1574.4	1559.25	1533.96	1530.89	1521.38	1520.51	1521.66	1533.03
8-Oct-2022	1581.8	1558.76	1533.64	1531.7	1521.52	1520.69	1522.5	1533.71
13-Oct-2022	1579.4	1558.97	1533.41	1531.70	1520.10	1520.04	1522	1533.98
19-Oct-2022	1572	1558.82	1533.68	1531.43	1521.18	1520.11	1521.54	1532.43
6-Nov-2022	1580.8	1558.84	1533.35	1529.26	1521.14	1520.29	1521.92	1534.07
12-Nov-2022	1581.2	1559.22	1533.28	1527.75	1521.03	1519.64	1521.27	1532.97
18-Nov-2022	1565.4	1558.84	1533.69	1529.43	1521.12	1519.32	1521.39	1533.05
24-Nov-2022	1565.5	1559.04	1532.42	1527.78	1520.82	1519.63	1521.32	1532.32
3-Dec-2022	1565.1	1558.85	1532.42	1527.59	1520.95	1519.11	1521.52	1532.52
8-Dec-2022	1565.1	1559.03	1533.41	1528.41	1521.31	1520.35	1521.63	1533.27
13-Dec-2022	1568.5	1558.72	1533.07	1526.96	1521.46	1520.67	1521.73	1533.28
19-Dec-2022	1570.2	1559.19	1532.72	1527.38	1521.3	1520.22	1521.77	1533.73
1-Jan-2023	1565.8	1558.84	1532.84	1527.13	1521.28	1520.41	1521.02	1533.81
8-Jun-2023	1577	1559.04	1533.34	1529.39	1523.11	1521.37	1523.42	1534.76
17-Jun-2023	1577.1	1558.86	1534.43	1529.29	1521.52	1520.55	1523.06	1533.8
19-Jun-2023	1578.2	1558.68	1534.06	1529.34	1522.38	1520.53	1523.31	1533.22
23-Jun-2023	1578.9	1559.21	1534.94	1530.71	1521.4	1520.54	1522.6	1533.74
5-Jul-2023	1578.6	1559.28	1534.7	1528.8	1521.82	1520.82	1522.4	1533.4
10-Jul-2023	1578.2	1559.06	1534.01	1528.76	1521.6	1520.68	1522.19	1533.47
17-Jul-2023	1578.5	1559.08	1534.62	1528.84	1521.25	1521.14	1522.35	1533.79
24-Jul-2023	1578.3	1559.41	1534.25	1528.62	1521.14	1520.31	1522.19	1533.69
1-Aug-2023	1578.3	1558.8	1534.61	1529.11	1521.48	1520.81	1521.94	1533.59
7-Aug-2023	1578.4	1559.41	1533.81	1528.2	1520.9	1520.3	1522.06	1533.49
14-Aug-2023	1578.4	1559.28	1533.94	1528.13	1521.38	1520.17	1522.05	1532.27
21-Aug-2023	1578.2	1559.18	1533.97	1527.79	1520.94	1520.46	1521.86	1533.59
28-Aug-2023	1578.5	1559.18	1534.44	1528.81	1520.9	1521.38	1522.53	1533.69
2/9/2023(Before flushing)	1578.3	1559.18	1533.92	1528.03	1521.42	1520.32	1521.66	1533.02
3/9/2023(During flushing)	Freeflow	1559.18	1533.67	1528.96	1521.44	1520.39	1521.98	1532.39
4/9/2023(After flushing)	1579	1559.41	1533.72	1528.78	1521.6	1520.31	1521.75	1532.39
14-Sep-23	1578	1559.16	1533.62	1528.63	1521.25	1520.36	1521.87	1532.98
22-Sep-23	1578.7	1559.18	1533.56	1529.15	1521.6	1520.15	1521.76	1533.12
26-Sep-23	1578.9	1559.4	1533.74	1529.64	1521.1	1520.35	1522.12	1532.69

~~209~~

POWER INTAKE MPBX OBSERVATION

INSTRUMENT	MPBX					MPBX					MPBX				
Sign convention	Positive sign shows compression					Positive sign shows compression					Positive sign shows compression				
INSTALLATION	Horizontally inclined downwards					Horizontally inclined downwards					Horizontal				
LOCATION	Power Intake, N-14815.103, E-23206.096, EL/RD-1622.244					Power Intake, N-14837.865, E-23208.804, EL/RD-1610.128					Power Intake EL. 1592				Remarks
INST TAG	MPPWR01					MPPWR02					MPPWR04				
Anchor depth	15m	10m	5m			15m	10m	5m			15m	10m	5m		
Channel No.	Ch 70	Ch 71	Ch 72			Ch 58	Ch 59	Ch 60			Ch 42	Ch 43	Ch 44		
DATE	mm	mm	mm	°C	DATE	mm	mm	mm	°C	DATE	mm	mm	mm	°C	
19-May-2022	NIP	-7.108	-14.313	22	19-May-2022	-7.21	-0.94	-1.33	22	19-May-2022	2.61	-0.18	-0.23	22	
1-Jun-2022	NIP	-7.107	-15.119	24	1-Jun-2022	-7.22	-1.00	-1.35	24	1-Jun-2022	2.60	-0.20	0.21	24	
8-Jun-2022	NIP	-7.101	-15.151	23	8-Jun-2022	-7.20	-0.96	-1.43	23	8-Jun-2022	2.62	-0.17	0.24	23	
15-Jun-2022	NIP	-7.105	-15.154	26	15-Jun-2022	-7.20	-0.93	-1.32	26	15-Jun-2022	2.62	-0.17	0.27	26	
20-Jun-2022	NIP	-7.111	-15.357	18	20-Jun-2022	-7.20	-0.35	-1.34	18	20-Jun-2022	2.69	-0.15	0.25	18	
2-Jul-2022	NIP	-7.107	-14.171	23	2-Jul-2022	-7.21	-0.99	-1.35	23	2-Jul-2022	2.61	-0.18	0.22	23	
6-Jul-2022	-5.554	-7.116	-14.783	24	6-Jul-2022	-7.22	-1.03	-1.37	24	6-Jul-2022	2.61	-0.19	0.22	24	
11-Jul-2022	-5.536	-7.108	-13.91	27	11-Jul-2022	-7.19	-0.19	-1.32	27	11-Jul-2022	2.63	-0.17	0.23	27	
15-Jul-2022	NIP	-7.129	-15.15	23	15-Jul-2022	-7.21	-0.88	-1.34	23	15-Jul-2022	2.62	-0.18	0.22	23	
25-Jul-2022	NIP	-7.137	-14.37	25	25-Jul-2022	-7.70	-0.95	-1.35	25	25-Jul-2022	2.63	-0.17	0.23	25	
3-Aug-2022	NIP	-7.143	-15.179	21	3-Aug-2022	-7.19	-0.94	-1.33	21	3-Aug-2022	2.64	-0.60	0.23	21	
9-Aug-2022	NIP	-7.141	-15.166	26	9-Aug-2022	-7.19	-0.96	-1.32	26	9-Aug-2022	2.65	-0.16	0.23	26	
16-Aug-2022	NIP	-7.143	-15.180	16	16-Aug-2022	-7.19	-0.93	-1.33	16	16-Aug-2022	2.66	-0.16	0.23	16	
22-Aug-2022	NIP	-7.162	-15.185	22	22-Aug-2022	-7.20	-0.96	-1.34	22	22-Aug-2022	2.65	-0.16	0.22	22	
3-Sep-2022	NIP	-7.154	-13.148	17	3-Sep-2022	-7.17	-0.90	-1.30	17	3-Sep-2022	2.68	-0.14	0.24	17	
8-Sep-2022	NIP	-7.158	-15.178	17	8-Sep-2022	-7.17	-0.91	-1.29	17	8-Sep-2022	2.69	-0.13	0.25	17	
13-Sep-2022	NIP	-7.16	-15.157	21	13-Sep-2022	-7.17	-0.89	-1.30	21	13-Sep-2022	2.69	-0.13	0.25	21	
19-Sep-2022	NIP	-7.163	-15.177	18	19-Sep-2022	-7.18	-0.92	-1.31	18	19-Sep-2022	2.69	-0.14	-0.23	18	
3-Oct-2022	-5.529	-7.160	-15.167	19	3-Oct-2022	-7.16	-0.88	-1.28	19	3-Oct-2022	2.71	-0.12	0.25	19	
8-Oct-2022	-5.527	-7.158	-15.167	19	8-Oct-2022	-7.15	-0.87	-1.28	19	8-Oct-2022	2.74	-0.11	0.26	19	
13-Oct-2022	-5.529	-7.159	-15.162	19	13-Oct-2022	-7.16	-0.82	-1.29	19	13-Oct-2022	2.71	-0.13	0.24	19	
19-Oct-2022	NIP	-7.17	-14.772	18	19-Oct-2022	-7.16	-0.88	-1.30	18	19-Oct-2022	2.72	-0.1	0.26	18	
6-Nov-2022	NIP	-7.163	-15.168	24	6-Nov-2022	-7.15	-0.86	-1.27	24	6-Nov-2022	2.72	-0.08	0.27	24	
12-Nov-2022	-5.514	-7.157	-15.154	17	12-Nov-2022	-7.14	-0.85	-1.27	17	12-Nov-2022	2.75	-0.08	0.28	17	
18-Nov-2022	-5.523	-7.166	-15.167	13	18-Nov-2022	-7.14	-0.85	-1.28	13	18-Nov-2022	2.75	-0.07	0.28	13	
24-Nov-2022	-5.515	-7.165	-15.167	13	24-Nov-2022	-7.15	-0.07	-1.23	13	24-Nov-2022	2.78	-0.05	0.30	13	
3-Dec-2022	-5.520	-7.116	-15.164	14	3-Dec-2022	-7.14	-0.85	-1.28	14	3-Dec-2022	2.76	-0.06	0.28	14	
8-Dec-2022	-5.513	-7.162	-15.161	14	8-Dec-2022	-7.12	-0.83	-1.23	14	8-Dec-2022	2.77	-0.05	0.30	14	
13-Dec-2022	-5.513	-7.161	-15.161	13	13-Dec-2022	-7.12	-0.83	-1.23	13	13-Dec-2022	2.77	-0.06	0.3	13	
19-Dec-2022	-5.502	-7.16	-15.145	12	19-Dec-2022	-7.11	-0.8	-1.20	12	19-Dec-2022	2.78	-0.04	0.3	12	
1-Jan-2023	NIP	-7.154	-15.129	10	1-Jan-2023	-7.09	-0.79	-1.16	10	1-Jan-2023	2.28	0.00	0.34	10	
9-Jan-2023	NIP	-7.165	-15.143	10	9-Jan-2023	-7.10	-0.78	-1.18	10	9-Jan-2023	2.82	0.00	0.34	10	
14-Jan-2023	NIP	-7.155	-15.154	10	14-Jan-2023	-7.08	-0.76	-1.15	10	14-Jan-2023	2.81	0.00	0.34	10	
21-Jan-2023	NIP	-7.555	-15.150	11	21-Jan-2023	-7.10	-0.75	-1.16	11	21-Jan-2023	2.80	0.01	0.34	11	
4-Feb-2023	-5.52	-7.154	-15.162	11	4-Feb-2023	-7.11	-0.84	-1.23	11	4-Feb-2023	2.77	-0.05	0.3	11	
11-Feb-2023	NIP	-7.154	-15.154	13	11-Feb-2023	-7.10	-0.79	-1.21	13	11-Feb-2023	2.79	-0.02	0.23	13	
15-Feb-2023	NIP	-7.155	-15.155	13	15-Feb-2023	-7.10	-0.81	-1.22	13	15-Feb-2023	2.78	-0.03	0.31	13	
22-Feb-2023	-5.514	-7.155	-15.147	16	22-Feb-2023	-7.11	-0.82	-1.21	16	22-Feb-2023	2.78	-0.03	0.31	16	
4-Mar-2023	-5.524	-7.155	-14.176	13	4-Mar-2023	-7.12	-0.85	-1.25	13	4-Mar-2023	2.77	-0.05	0.30	13	
10-Mar-2023	NIP	-7.162	-15.172	15	10-Mar-2023	-7.12	-0.85	-1.25	15	10-Mar-2023	2.76	-0.05	0.29	15	
16-Mar-2023	-5.501	-7.143	-15.120	13	16-Mar-2023	-7.09	-0.81	-1.18	13	16-Mar-2023	2.79	-0.02	-0.32	13	
21-Mar-2023	-5.516	-7.154	-14.165	15	21-Mar-2023	-7.10	-0.81	-1.20	15	21-Mar-2023	2.79	-0.03	0.31	15	
4-Apr-2023	-5.528	-7.165	-15.188	16	4-Apr-2023	-7.12	-0.58	-1.23	16	4-Apr-2023	2.76	-0.05	0.41	16	
10-Apr-2023	-5.520	-7.162	-15.120	15	10-Apr-2023	-7.09	-0.79	-1.18	15	10-Apr-2023	2.77	-0.02	0.31	15	
15-Apr-2023	-5.527	-7.159	-15.134	17	15-Apr-2023	-7.13	-0.89	-1.24	17	15-Apr-2023	2.75	-0.06	0.28	17	
21-Apr-2023	-5.530	-7.154	-15.339	17	21-Apr-2023	-7.12	-0.86	-1.21	17	21-Apr-2023	2.75	-0.07	0.27	17	
4-May-2023	-5.520	-7.163	-15.173	15	4-May-2023	-7.11	-0.89	-1.18	15	4-May-2023	2.77	-0.05	0.29	15	
9-May-2023	-5.524	-7.155	-15.146	17	9-May-2023	-7.12	-0.87	-1.21	17	9-May-2023	2.75	-0.06	0.27	17	
17-May-2023	-5.521	-7.150	-15.170	17	17-May-2023	-7.10	-0.90	-1.20	17	17-May-2023	2.71	-0.07	0.29	17	
23-May-2023	NIP	-7.176	-15.188	19	23-May-2023	-7.15	-0.91	-1.26	19	23-May-2023	2.72	-0.08	0.24	19	
8-Jun-2023	NIP	-7.155	-14.158	16	8-Jun-2023	-7.16	-0.94	-1.24	16	8-Jun-2023	2.7	-0.10	0.22	16	
17-Jun-2023	NIP	-7.135	-10.646	14	17-Jun-2023	-7.12	-0.07	-1.17	14	17-Jun-2023	2.76	-0.05	0.27	14	
19-Jun-2023	NIP	-7.145	-15.149	16	19-Jun-2023	-7.14	-0.90	-0.19	16	19-Jun-2023	2.74	-0.07	0.25	16	
23-Jun-2023	NIP	-7.157	-15.194	16	23-Jun-2023	-7.15	-7.24	-1.21	16	23-Jun-2023	2.73	-0.06	0.44	16	
5-Jul-2023	NIP	-7.152	-13.962	23	5-Jul-2023	-7.13	-0.89	-0.44	23	5-Jul-2023	2.75	-0.02	0.25	23	
10-Jul-2023	NIP	-7.151	-8.439	22	10-Jul-2023	-7.14	-0.91	-1.20	22	10-Jul-2023	2.73	-0.02	0.25	22	
17-Jul-2023	NIP	-7.156	-15.201	15	17-Jul-2023	-7.14	-0.90	-1.22	15	17-Jul-2023	2.74	-0.01	0.24	15	
24-Jul-2023	NIP	-7.156	-15.202	21	24-Jul-2023	-7.16	-0.90	-1.21	21	24-Jul-2023	2.73	-0.01	0.24	21	
1-Aug-2023	NIP	-7.159	-15.805	19	1-Aug-2023	-7.18	-0.92	-1.20	19	1-Aug-2023	2.7	-0.03	0.2	19	
7-Aug-2023	NIP	-7.153	-14.803	20	7-Aug-2023	-7.14	-0.9	-1.21	20	7-Aug-2023	2.73	0	0.24	20	
14-Aug-2023	NIP	-7.143	-14.791	18	14-Aug-2023	-7.14	-0.9	-1.19	18	14-Aug-2023	2.75	-0.02	0.25	18	
21-Aug-2023	NIP	-7.144	-15.149	22	21-Aug-2023	-7.15	-0.9	-1.19	22	21-Aug-2023	2.74	-0.02	0.24	22	
28-Aug-2023	NIP	-7.139	-15.183	20	28-Aug-2023	-7.11	-0.85	-1.18	20	28-Aug-2023	2.77	-0.04	0.27	20	
04-Sep-23	NIP	-7.159	-15.207	24	04-Sep-23	-7.15	-0.92	-1.22	24	04-Sep-23	2.73	-0.09	0.22	24	
14-Sep-23	NIP	-7.147	-14.794	23	14-Sep-23	-7.22	-0.83	-1.2	23	14-Sep-23	2.73	0.01	0.22	23	
22-Sep-23	NIP	-7.149	-15.189	24	22-Sep-23	-7.28	-0.59	-1.22	24	22-Sep-23	2.79	0.02	0.23	24	
26-Sep-23	NIP	-7.157	-15.204	21	26-Sep-23	-7.13	-0.89	-1.22	21	26-Sep-23	2.75	0.03	0.24	21	

~~250~~

SURFACE SETTLEMENT POINT AT CFRD

Instrument ID	SP1	SP2
Location/ Elevation	U/S of Dam Axis on Face Slab	U/S of Dam Axis on Face Slab
Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on13 /2/2023 (m)	1586.038	1586.076
Difference in Surface Settlement(Initial Reading-Current Reading)	0.06	0.047
Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 20/2/2023 (m)	1586.039	1586.077
Difference in Surface Settlement(Initial Reading-Current Reading)	0.06	0.046
Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 27/2/2023 (m)	1586.041	1586.074
Difference in Surface Settlement(Initial Reading-Current Reading)	0.06	0.049
Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 6/3/2023 (m)	1586.045	1586.078
Difference in Surface Settlement(Initial Reading-Current Reading)	0.05	0.045

Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 13/3/2023 (m)	1586.042	1586.083
Difference in Surface Settlement(Initial Reading-Current Reading)	0.06	0.04
Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 20 /3/2023 (m)	1586.039	1586.081
Difference in Surface Settlement(Initial Reading-Current Reading)	0.06	0.042
Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 03/4/2023 (m)	1586.036	1586.083
Difference in Surface Settlement(Initial Reading-Current Reading)	0.06	0.04
Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 10/4/2023 (m)	1586.037	1586.085
Difference in Surface Settlement(Initial Reading-Current Reading)	0.06	0.038
Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 17/4/2023 (m)	1586.035	1586.086
Difference in Surface Settlement(Initial Reading-Current Reading)	0.06	0.037

Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 24/4/2023 (m)	1586.039	1586.086
Difference in Surface Settlement(Initial Reading-Current Reading)	0.06	0.037
Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 1/5/2023 (m)	1586.037	1586.082
Difference in Surface Settlement(Initial Reading-Current Reading)	0.06	0.041
Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 8/5/2023 (m)	1586.032	1586.079
Difference in Surface Settlement(Initial Reading-Current Reading)	0.07	0.044
Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 15/5/2023 (m)	1586.040	1586.081
Difference in Surface Settlement(Initial Reading-Current Reading)	0.06	0.042
Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 22/5/2023 (m)	1586.073	1586.076
Difference in Surface Settlement(Initial Reading-Current Reading)	0.03	0.047

Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 29/5/2023 (m)	1586.04	1586.079
Difference in Surface Settlement(Initial Reading-Current Reading)	0.06	0.044
Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 5/6/2023 (m)	1586.04	1586.079
Difference in Surface Settlement(Initial Reading-Current Reading)	0.06	0.044
Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 12/6/2023 (m)	1586.043	1586.086
Difference in Surface Settlement(Initial Reading-Current Reading)	0.06	0.037
Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 19/6/2023 (m)	1586.032	1586.078
Difference in Surface Settlement(Initial Reading-Current Reading)	0.07	0.045
Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 26/6/2023 (m)	1586.041	1586.075
Difference in Surface Settlement(Initial Reading-Current Reading)	0.06	0.048

Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 03/7/2023 (m)	1586.042	1586.081
Difference in Surface Settlement(Initial Reading-Current Reading)	0.06	0.042
Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 10/7/2023 (m)	1586.044	1586.091
Difference in Surface Settlement(Initial Reading-Current Reading)	0.05	0.032
Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 17/7/2023 (m)	1586.044	1586.081
Difference in Surface Settlement(Initial Reading-Current Reading)	0.05	0.042
Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 24/7/2023 (m)	1586.037	1586.087
Difference in Surface Settlement(Initial Reading-Current Reading)	0.06	0.036
Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 31/7/2023 (m)	1586.039	1586.081
Difference in Surface Settlement(Initial Reading-Current Reading)	0.06	0.042

~~225~~

Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 07/8/2023 (m)	1586.039	1586.083
Difference in Surface Settlement(Initial Reading-Current Reading)	0.06	0.04
Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 14/8/2023 (m)	1586.031	1586.086
Difference in Surface Settlement(Initial Reading-Current Reading)	0.07	0.037
Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 21/8/2023 (m)	1586.04	1586.08
Difference in Surface Settlement(Initial Reading-Current Reading)	0.06	0.043
Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 28/8/2023 (m)	1586.038	1586.076
Difference in Surface Settlement(Initial Reading-Current Reading)	0.06	0.047
Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 2/9/2023 (m) (After Flashing)	1586.041	1586.078
Difference in Surface Settlement(Initial Reading-Current Reading)	0.06	0.045

Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 4/9/2023 (m) (Before flushing)	1586.043	1586.084
Difference in Surface Settlement(Initial Reading-Current Reading)	0.06	0.039
Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 14/9/2023 (m)	1586.045	1586.086
Difference in Surface Settlement(Initial Reading-Current Reading)	0.05	0.037
Initial Ground Elevation of Surface Settlement Point on 3/9/16. (m)	1586.10	1586.123
Current Ground Elevation of Surface Settlement Point on 22/9/2023 (m)	1586.039	1586.079
Difference in Surface Settlement(Initial Reading-Current Reading)	0.06	0.044

SP3	SP4	SP5	SP6	SP7	SP8
U/S of Dam Axis on Face Slab	U/S of Dam Axis on Face Slab	U/S of Dam Axis on Face Slab	U/S of Dam Axis on Face Slab	Top of Parapet Wall	Top of Parapet Wall
1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.072	1586.034	1586.005	1586.107	1590.926	1591.227
0.033	0.001	0.004	0.021	0.088	0.044
1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.076	1586.038	1586.003	1586.104	1590.931	1591.229
0.029	-0.003	0.006	0.024	0.083	0.042
1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.074	1586.032	1586.006	1586.102	1590.928	1591.224
0.031	0.003	0.003	0.026	0.086	0.047
1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.075	1586.028	1586.005	1586.102	1590.92	1591.228
0.03	0.007	0.004	0.026	0.094	0.043

1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.079	1586.025	1586.003	1586.105	1590.928	1591.223
0.026	0.01	0.006	0.023	0.086	0.048
1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.072	1586.029	1586.007	1586.107	1590.925	1591.221
0.033	0.006	0.002	0.021	0.089	0.05
1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.075	1586.026	1586.009	1586.102	1590.921	1591.216
0.03	0.009	0	0.026	0.093	0.055
1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.078	1586.028	1586.004	1586.107	1590.925	1591.218
0.027	0.007	0.005	0.021	0.089	0.053
1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.074	1586.029	1586.006	1586.105	1590.926	1591.22
0.031	0.006	0.003	0.023	0.088	0.051

1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.079	1586.025	1586.003	1586.109	1590.927	1591.219
0.026	0.01	0.006	0.019	0.087	0.052
1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.07	1586.029	1586.004	1586.106	1590.923	1591.219
0.035	0.006	0.005	0.022	0.091	0.052
1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.078	1586.022	1586.004	1586.107	1590.924	1591.222
0.027	0.013	0.005	0.021	0.09	0.049
1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.076	1586.019	1586.006	1586.103	1590.921	1591.224
0.029	0.016	0.003	0.025	0.093	0.047
1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.078	1586.021	1586.002	1586.103	1590.918	1591.226
0.027	0.014	0.007	0.025	0.096	0.045

1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.078	1586.019	1586.006	1586.102	1590.919	1591.222
0.027	0.016	0.003	0.026	0.095	0.049
1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.078	1586.019	1586.015	1586.108	1590.915	1591.218
0.027	0.016	-0.006	0.02	0.099	0.053
1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.081	1586.021	1586.018	1586.112	1590.917	1591.222
0.024	0.014	-0.009	0.016	0.097	0.049
1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.086	1586.026	1586.009	1586.108	1590.921	1591.218
0.019	0.009	0	0.02	0.093	0.053
1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.078	1586.024	1586.016	1586.106	1590.929	1591.226
0.027	0.011	-0.007	0.022	0.085	0.045

1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.078	1586.02	1586.016	1586.100	1590.924	1591.226
0.027	0.015	-0.007	0.028	0.09	0.045
1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.08	1586.026	1586.011	1586.102	1590.918	1591.224
0.025	0.009	-0.002	0.026	0.096	0.047
1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.052	1586.024	1586.012	1586.104	1590.921	1591.219
0.053	0.011	-0.003	0.024	0.093	0.052
1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.076	1586.027	1586.011	1586.108	1590.925	1591.221
0.029	0.008	-0.002	0.02	0.089	0.05
1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.088	1586.027	1586.009	1586.101	1590.927	1591.217
0.017	0.008	0.0	0.027	0.087	0.054

1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.072	1586.030	1586.018	1586.103	1590.930	1591.224
0.033	0.005	-0.009	0.025	0.084	0.047
1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.069	1586.025	1586.021	1586.100	1590.925	1591.230
0.036	0.010	-0.012	0.028	0.089	0.041
1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.077	1586.018	1586.006	1586.108	1590.927	1591.228
0.028	0.017	0.003	0.020	0.087	0.043
1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.075	1586.019	1586.004	1586.106	1590.929	1591.226
0.03	0.016	0.005	0.022	0.085	0.045
1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.072	1586.015	1586.002	1586.104	1590.931	1591.223
0.033	0.020	0.007	0.024	0.083	0.048

1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.072	1586.017	1585.992	1586.101	1590.928	1591.223
0.033	0.018	0.017	0.027	0.086	0.048
1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.074	1586.021	1585.996	1586.091	1590.927	1591.221
0.031	0.014	0.013	0.037	0.087	0.050
1586.105	1586.035	1586.009	1586.128	1591.014	1591.271
1586.077	1586.025	1585.990	1586.086	1590.925	1591.216
0.028	0.010	0.019	0.042	0.089	0.055

SP9	SP10	SP11	SP12	SP13	SP13A
Top of Parapet Wall	Top of Parapet Wall	Top of Parapet Wall	Top of Parapet Wall	Top of Parapet Wall	
1591.485	1591.523	1591.368	1591.156	1591.015	
1591.449	1591.476	1591.362	1591.132	1591.062	
0.036	0.047	0.006	0.024	-0.047	
1591.485	1591.523	1591.368	1591.156	1591.015	
1591.451	1591.471	1591.368	1591.136	1591.063	
0.034	0.052	0	0.02	-0.048	
1591.485	1591.523	1591.368	1591.156	1591.015	
1591.448	1591.478	1591.365	1591.134	1591.06	
0.037	0.045	0.003	0.022	-0.045	
1591.485	1591.523	1591.368	1591.156	1591.015	
1591.442	1591.473	1591.362	1591.136	1591.052	
0.043	0.05	0.006	0.02	-0.037	

1591.485	1591.523	1591.368	1591.156	1591.015	
1591.447	1591.471	1591.359	1591.135	1591.058	
0.038	0.052	0.009	0.021	-0.043	
1591.485	1591.523	1591.368	1591.156	1591.015	
1591.445	1591.472	1591.357	1591.134	1591.057	
0.04	0.051	0.011	0.022	-0.042	
1591.485	1591.523	1591.368	1591.156	1591.015	
1591.443	1591.471	1591.352	1591.134	1591.059	
0.042	0.052	0.016	0.022	-0.044	
1591.485	1591.523	1591.368	1591.156	1591.015	
1591.444	1591.473	1591.356	1591.136	1591.066	
0.041	0.05	0.012	0.02	-0.051	
1591.485	1591.523	1591.368	1591.156	1591.015	
1591.442	1591.47	1591.360	1591.136	1591.054	
0.043	0.053	0.008	0.02	-0.039	

1591.485	1591.523	1591.368	1591.156	1591.015	
1591.448	1591.478	1591.358	1591.139	1591.058	
0.037	0.045	0.01	0.017	-0.043	
1591.485	1591.523	1591.368	1591.156	1591.015	
1591.445	1591.471	1591.358	1591.138	1591.06	
0.04	0.052	0.01	0.018	-0.045	
1591.485	1591.523	1591.368	1591.156	1591.015	
1591.45	1591.476	1591.359	1591.136	1591.054	
0.035	0.047	0.009	0.02	-0.039	
1591.485	1591.523	1591.368	1591.156	1591.015	
1591.453	1591.472	1591.362	1591.133	1591.053	
0.032	0.051	0.006	0.023	-0.038	
1591.485	1591.523	1591.368	1591.156	1591.015	
1591.456	1591.478	1591.365	1591.136	1591.055	
0.029	0.045	0.003	0.02	-0.04	

1591.485	1591.523	1591.368	1591.156	1591.015	
1591.452	1591.477	1591.362	1591.139	1591.058	
0.033	0.046	0.006	0.017	-0.043	
1591.485	1591.523	1591.368	1591.156	1591.015	
1591.458	1591.485	1591.358	1591.132	1591.068	
0.027	0.038	0.01	0.024	-0.053	
1591.485	1591.523	1591.368	1591.156	1591.015	
1591.462	1591.491	1591.362	1591.139	1591.063	
0.023	0.032	0.006	0.017	-0.048	
1591.485	1591.523	1591.368	1591.156	1591.015	
1591.458	1591.488	1591.358	1591.137	1591.065	
0.027	0.035	0.01	0.019	-0.05	
1591.485	1591.523	1591.368	1591.156	1591.015	
1591.447	1591.482	1591.352	1591.136	1591.062	
0.038	0.041	0.016	0.02	-0.047	

1591.485	1591.523	1591.368	1591.156	1591.015	
1591.45	1591.476	1591.359	1591.141	1591.062	
0.035	0.047	0.009	0.015	-0.047	
1591.485	1591.523	1591.368	1591.156	1591.015	
1591.446	1591.471	1591.351	1591.143	1591.056	
0.039	0.052	0.017	0.013	-0.041	
1591.485	1591.523	1591.368	1591.156	1591.015	
1591.448	1591.472	1591.354	1591.144	1591.061	
0.037	0.051	0.014	0.012	-0.046	
1591.485	1591.523	1591.368	1591.156	1591.015	
1591.452	1591.476	1591.356	1591.137	1591.057	
0.033	0.047	0.012	0.019	-0.042	
1591.485	1591.523	1591.368	1591.156	1591.015	
1591.453	1591.477	1591.362	1591.138	1591.057	
0.032	0.046	0.006	0.018	-0.042	

~~289~~

1591.485	1591.523	1591.368	1591.156	1591.015	
1591.452	1591.481	1591.361	1591.144	1591.065	
0.033	0.042	0.007	0.012	-0.05	
1591.485	1591.523	1591.368	1591.156	1591.015	
1591.449	1591.488	1591.365	1591.145	1591.063	
0.036	0.035	0.003	0.011	-0.048	
1591.485	1591.523	1591.368	1591.156	1591.015	
1591.451	1591.496	1591.356	1591.136	1591.052	
0.034	0.027	0.012	0.020	-0.037	
1591.485	1591.523	1591.368	1591.156	1591.015	
1591.450	1591.493	1591.353	1591.134	1591.051	
0.035	0.030	0.015	0.022	-0.036	
1591.485	1591.523	1591.368	1591.156	1591.015	
1591.451	1591.491	1591.355	1591.133	1591.049	
0.034	0.032	0.013	0.023	-0.034	

~~270~~

1591.485	1591.523	1591.368	1591.156	1591.015	
1591.452	1591.491	1591.358	1591.139	1591.052	
0.033	0.032	0.010	0.017	-0.037	
1591.485	1591.523	1591.368	1591.156	1591.015	
1591.452	1591.491	1591.365	1591.138	1591.054	
0.033	0.032	0.003	0.018	-0.039	
1591.485	1591.523	1591.368	1591.156	1591.015	
1591.450	1591.495	1591.36	1591.138	1591.054	
0.035	0.028	0.008	0.018	-0.039	

SP13B	SP14	SP15	SP16	SP17	SP18
	D/S of Dam Axis	D/S of Dam Axis	D/S of Dam Axis	D/S of Dam Axis	D/S of Dam Axis
	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.902	1560.529	1559.918	1561.824	1559.996
	-0.032	-0.011	-0.032	-0.026	-0.038
	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.899	1560.53	1559.916	1561.835	1559.994
	-0.029	-0.012	-0.03	-0.037	-0.036
	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.9	1560.528	1559.92	1561.83	1559.993
	-0.030	-0.01	-0.034	-0.032	-0.035
	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.903	1560.525	1559.924	1561.835	1559.997
	-0.033	-0.007	-0.038	-0.037	-0.039

	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.907	1560.521	1559.927	1561.837	1559.994
	-0.037	-0.003	-0.041	-0.039	-0.036
	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.903	1560.52	1559.926	1561.834	1559.998
	-0.033	-0.002	-0.04	-0.036	-0.04
	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.902	1560.521	1559.921	1560.835	1560.01
	-0.032	-0.003	-0.035	0.963	-0.052
	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.909	1560.522	1559.926	1561.831	1560.006
	-0.039	-0.004	-0.04	-0.033	-0.048
	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.906	1560.524	1559.928	1561.83	1560
	-0.036	-0.006	-0.042	-0.032	-0.042

~~213~~

	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.908	1560.525	1559.924	1561.837	1560.007
	-0.038	-0.007	-0.038	-0.039	-0.049
	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.906	1560.523	1559.925	1561.831	1560.004
	-0.036	-0.005	-0.039	-0.033	-0.046
	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.91	1560.527	1559.929	1561.839	1560.005
	-0.040	-0.009	-0.043	-0.041	-0.047
	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.905	1560.53	1559.924	1561.838	1560.008
	-0.035	-0.012	-0.038	-0.04	-0.05
	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.909	1560.532	1559.926	1561.836	1560.002
	-0.039	-0.014	-0.04	-0.038	-0.044

	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.911	1560.534	1559.93	1561.835	1560.004
	-0.041	-0.016	-0.044	-0.037	-0.046
	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.914	1560.538	1559.938	1561.841	1560.008
	-0.044	-0.02	-0.052	-0.043	-0.05
	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.917	1560.534	1559.941	1561.843	1560.002
	-0.047	-0.016	-0.055	-0.045	-0.044
	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.920	1560.530	1559.938	1561.840	1560.005
	-0.050	-0.012	-0.052	-0.042	-0.047
	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.911	1560.535	1559.935	1561.845	1560.009
	-0.041	-0.017	-0.049	-0.047	-0.051

	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.912	1560.526	1559.928	1561.836	1560.003
	-0.042	-0.008	-0.042	-0.038	-0.045
	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.907	1560.53	1559.926	1561.832	1560.008
	-0.037	-0.012	-0.04	-0.034	-0.05
	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.911	1560.527	1559.931	1561.831	1561.011
	-0.041	-0.009	-0.045	-0.033	-1.053
	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.907	1560.524	1559.929	1561.834	1560.007
	-0.037	-0.006	-0.043	-0.036	-0.049
	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.912	1560.526	1559.927	1561.835	1560.008
	-0.042	-0.008	-0.041	-0.037	-0.05

~~276~~

	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.910	1560.532	1559.930	1561.831	1560.005
	-0.040	-0.014	-0.044	-0.033	-0.047
	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.913	1560.540	1559.928	1561.836	1560.000
	-0.043	-0.022	-0.042	-0.038	-0.042
	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.910	1560.541	1559.926	1561.835	1560.004
	-0.040	-0.023	-0.040	-0.037	-0.046
	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.911	1560.540	1559.925	1561.832	1560.003
	-0.041	-0.022	-0.039	-0.034	-0.045
	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.910	1560.542	1559.922	1561.831	1560.002
	-0.040	-0.024	-0.036	-0.033	-0.044

	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.906	1560.540	1559.923	1561.829	1559.997
	-0.036	-0.022	-0.037	-0.031	-0.039
	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.909	1560.543	1559.925	1561.830	1560.002
	-0.039	-0.025	-0.039	-0.032	-0.044
	1559.870	1560.518	1559.886	1561.798	1559.958
	1559.910	1560.542	1559.931	1561.831	1560.005
	-0.040	-0.024	-0.045	-0.033	-0.047

~~218~~

SP19	SP20	SP21	SP22	SP23	Remarks
D/S of Dam Axis	D/S of Dam Axis	D/S of Dam Axis	D/S of Dam Axis	D/S of Dam Axis	
-	1540.494	1540.114	1540.386	1539.914	
	1540.53	1540.16	1540.458	1539.946	
	-0.036	-0.046	-0.072	-0.032	
-	1540.494	1540.114	1540.386	1539.914	
	1540.534	1540.158	1540.456	1539.948	
	-0.04	-0.044	-0.07	-0.034	
-	1540.494	1540.114	1540.386	1539.914	
	1540.538	1540.162	1540.455	1539.952	
	-0.044	-0.048	-0.069	-0.038	
-	1540.494	1540.114	1540.386	1539.914	
	1540.545	1540.164	1540.457	1539.957	
	-0.051	-0.05	-0.071	-0.043	

-	1540.494	1540.114	1540.386	1539.914	
	1540.537	1540.167	1540.461	1539.958	
	-0.043	-0.053	-0.075	-0.044	
-	1540.494	1540.114	1540.386	1539.914	
	1540.542	1540.168	1540.46	1539.959	
	-0.048	-0.054	-0.074	-0.045	
-	1540.494	1540.114	1540.386	1539.914	
	1540.543	1540.161	1540.462	1539.962	
	-0.049	-0.047	-0.076	-0.048	
-	1540.494	1540.114	1540.386	1539.914	
	1540.546	1540.163	1540.465	1539.958	
	-0.052	-0.049	-0.079	-0.044	
-	1540.494	1540.114	1540.386	1539.914	
	1540.546	1540.163	1540.462	1539.957	
	-0.052	-0.049	-0.076	-0.043	

~~20~~

-	1540.494	1540.114	1540.386	1539.914	
	1540.547	1540.167	1540.457	1539.961	
	-0.053	-0.053	-0.071	-0.047	
-	1540.494	1540.114	1540.386	1539.914	
	1540.544	1540.164	1540.463	1539.958	
	-0.05	-0.05	-0.077	-0.044	
-	1540.494	1540.114	1540.386	1539.914	
	1540.548	1540.165	1540.456	1539.956	
	-0.054	-0.051	-0.07	-0.042	
-	1540.494	1540.114	1540.386	1539.914	
	1540.551	1540.171	1540.452	1539.953	
	-0.057	-0.057	-0.066	-0.039	
-	1540.494	1540.114	1540.386	1539.914	
	1540.556	1540.175	1540.456	1539.954	
	-0.062	-0.061	-0.07	-0.04	

-	1540.494	1540.114	1540.386	1539.914	
	1540.551	1540.172	1540.456	1539.958	
	-0.057	-0.058	-0.07	-0.044	
-	1540.494	1540.114	1540.386	1539.914	
	1540.546	1540.167	1540.452	1539.963	
	-0.052	-0.053	-0.066	-0.049	
-	1540.494	1540.114	1540.386	1539.914	
	1540.549	1540.172	1540.448	1539.960	
	-0.055	-0.058	-0.062	-0.046	
-	1540.494	1540.114	1540.386	1539.914	
	1540.552	1540.17	1540.446	1539.962	
	-0.058	-0.056	-0.06	-0.048	
-	1540.494	1540.114	1540.386	1539.914	
	1540.555	1540.173	1540.461	1539.964	
	-0.061	-0.059	-0.075	-0.05	

-	1540.494	1540.114	1540.386	1539.914	
	1540.545	1540.164	1540.451	1539.96	
	-0.051	-0.05	-0.065	-0.046	
-	1540.494	1540.114	1540.386	1539.914	
	1540.54	1540.164	1540.453	1539.962	
	-0.046	-0.05	-0.067	-0.048	
-	1540.494	1540.114	1540.386	1539.914	
	1540.538	1540.164	1540.456	1539.964	
	-0.044	-0.05	-0.07	-0.05	
-	1540.494	1540.114	1540.386	1539.914	
	1540.547	1540.169	1540.459	1539.955	
	-0.053	-0.055	-0.073	-0.041	
-	1540.494	1540.114	1540.386	1539.914	
	1540.544	1540.168	1540.458	1539.959	
	-0.05	-0.054	-0.072	-0.045	

-	1540.494	1540.114	1540.386	1539.914	
	1540.547	1540.166	1540.458	1539.960	
	-0.053	-0.052	-0.072	-0.046	
-	1540.494	1540.114	1540.386	1539.914	
	1540.544	1540.168	1540.453	1539.958	
	-0.05	-0.054	-0.067	-0.044	
-	1540.494	1540.114	1540.386	1539.914	
	1540.541	1540.163	1540.461	1539.956	
	-0.047	-0.049	-0.075	-0.042	
-	1540.494	1540.114	1540.386	1539.914	
	1540.54	1540.162	1540.463	1539.954	
	-0.046	-0.048	-0.077	-0.040	
-	1540.494	1540.114	1540.386	1539.914	
	1540.542	1540.161	1540.462	1539.951	
	-0.048	-0.047	-0.076	-0.037	

-	1540.494	1540.114	1540.386	1539.914	
	1540.544	1540.163	1540.459	1539.954	
	-0.05	-0.049	-0.073	-0.040	
-	1540.494	1540.114	1540.386	1539.914	
	1540.545	1540.166	1540.458	1539.957	
	-0.051	-0.052	-0.072	-0.043	
-	1540.494	1540.114	1540.386	1539.914	
	1540.541	1540.169	1540.461	1539.953	
	-0.047	-0.055	-0.075	-0.039	

~~285~~

Instrument ID		ST1
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022
	Elevation	1566.645
20-Mar-23	Easting	23448.468
	Northing	14859.251
	Elevation	1566.68
Difference in Elevation between Initial & Last reading (m)		-0.035
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022
	Elevation	1566.645
3-Apr-23	Easting	23448.462
	Northing	14859.258
	Elevation	1566.685
Difference in Elevation between Initial & Last reading (m)		-0.04
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022
	Elevation	1566.645
10-Apr-23	Easting	23448.471
	Northing	14859.262
	Elevation	1566.688
Difference in Elevation between Initial & Last reading (m)		-0.043
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022
	Elevation	1566.645
17-Apr-23	Easting	23448.466
	Northing	14859.254
	Elevation	1566.682
Difference in Elevation between Initial & Last reading (m)		-0.037
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022
	Elevation	1566.645
24-Apr-23	Easting	23448.467
	Northing	14859.261
	Elevation	1566.686
Difference in Elevation between Initial & Last reading (m)		-0.041
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022
	Elevation	1566.645
01-May-23	Easting	23448.466
	Northing	14859.258
	Elevation	1566.688
Difference in Elevation between Initial & Last reading (m)		-0.043
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022

	Elevation	1566.645
08-May-23	Easting	23448.471
	Northing	14859.258
	Elevation	1566.683
Difference in Elevation between Initial & Last reading (m)		-0.038
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022
	Elevation	1566.645
15-May-23	Easting	23448.475
	Northing	14859261
	Elevation	1566.682
Difference in Elevation between Initial & Last reading (m)		-0.037
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022
	Elevation	1566.645
22-May-23	Easting	23448.463
	Northing	14859.265
	Elevation	1566.683
Difference in Elevation between Initial & Last reading (m)		-0.038
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022
	Elevation	1566.645
29-May-23	Easting	23448.468
	Northing	14859.253
	Elevation	1566.68
Difference in Elevation between Initial & Last reading (m)		-0.035
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022
	Elevation	1566.645
05-Jun-23	Easting	23448.472
	Northing	14859.267
	Elevation	1566.687
Difference in Elevation between Initial & Last reading (m)		-0.042
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022
	Elevation	1566.645
12-Jun-23	Easting	23448.463
	Northing	14859.278
	Elevation	1566.682
Difference in Elevation between Initial & Last reading (m)		-0.037
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022
	Elevation	1566.645
19-Jun-23	Easting	23448.472
	Northing	14859.285
	Elevation	1566.680
Difference in Elevation between Initial & Last reading (m)		-0.035
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022

	Elevation	1566.645
23-Jun-23	Easting	23448.479
	Northing	14859.29
	Elevation	1566.683
Difference in Elevation between Initial & Last reading (m)		-0.038
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022
	Elevation	1566.645
03-Jul-23	Easting	23448.475
	Northing	14859.28
	Elevation	1566.679
Difference in Elevation between Initial & Last reading (m)		-0.034
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022
	Elevation	1566.645
10-Jul-23	Easting	23448.482
	Northing	14859.269
	Elevation	1566.683
Difference in Elevation between Initial & Last reading (m)		-0.038
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022
	Elevation	1566.645
17-Jul-23	Easting	23448.473
	Northing	14859.264
	Elevation	1566.685
Difference in Elevation between Initial & Last reading (m)		-0.04
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022
	Elevation	1566.645
24-Jul-23	Easting	23448.477
	Northing	14859.265
	Elevation	1566.68
Difference in Elevation between Initial & Last reading (m)		-0.035
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022
	Elevation	1566.645
31-Jul-23	Easting	23448.485
	Northing	14859.261
	Elevation	1566.678
Difference in Elevation between Initial & Last reading (m)		-0.033
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022
	Elevation	1566.645
07-Aug-23	Easting	23448.469
	Northing	14859.255
	Elevation	1566.678
Difference in Elevation between Initial & Last reading (m)		-0.033
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022
	Elevation	1566.645

14-Aug-23	Easting	23448.461
	Northing	14859.256
	Elevation	1566.679
Difference in Elevation between Initial & Last reading (m)		-0.034
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022
	Elevation	1566.645
21-Aug-23	Easting	23448.471
	Northing	14859.256
	Elevation	1566.68
Difference in Elevation between Initial & Last reading (m)		-0.035
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022
	Elevation	1566.645
28-Aug-23	Easting	23448.472
	Northing	14859.251
	Elevation	1566.681
Difference in Elevation between Initial & Last reading (m)		-0.036
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022
	Elevation	1566.645
2/9/2023 (Before flushing)	Easting	23448.467
	Northing	14859.255
	Elevation	1566.676
Difference in Elevation between Initial & Last reading (m)		-0.031
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022
	Elevation	1566.645
4/9/2023 (After flushing)	Easting	23448.467
	Northing	14859.255
	Elevation	1566.677
Difference in Elevation between Initial & Last reading (m)		-0.032
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022
	Elevation	1566.645
14-Sep-23	Easting	23448.465
	Northing	14859.254
	Elevation	1566.678
Difference in Elevation between Initial & Last reading (m)		-0.033
22/12/2016 (Initial)	Easting	23448.536
	Northing	14859.022
	Elevation	1566.645
22-Sep-23	Easting	23448.471
	Northing	14859.255
	Elevation	1566.679
Difference in Elevation between Initial & Last reading (m)		-0.034

SURVEY TARGET AT CHUTE SPILLWAY

ST2	ST3	ST4	ST5	ST6
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061
1566.542	1560.58	1560.199	1554.434	1555.332
23473.996	23463.201	23486.961	23476.134	23497.639
14864.769	14825.421	14835.041	14795.402	14810.303
1566.582	1560.617	1560.239	1554.467	1555.375
-0.04	-0.04	-0.04	-0.033	-0.043
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061
1566.542	1560.58	1560.199	1554.434	1555.332
23473.981	23463.198	23486.962	23476.127	23497.636
14864.785	14825.428	14835.052	14795.416	14810.315
1566.584	1560.613	1560.238	1554.461	1555.376
-0.042	-0.03	-0.039	-0.027	-0.044
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061
1566.542	1560.58	1560.199	1554.434	1555.332
23473.974	23463.196	23486.969	23476.131	23497.639
14864.781	14825.426	14835.058	14795.418	14810.318
1566.587	1560.616	1560.233	1554.465	1555.372
-0.045	-0.04	-0.034	-0.031	-0.04
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061
1566.542	1560.58	1560.199	1554.434	1555.332
23473.98	23463.198	23486.965	23476.135	23476.639
14864.772	14825.425	14835.046	14795.401	14810.309
1566.586	1560.617	1560.234	1554.462	1555.372
-0.044	-0.04	-0.035	-0.028	-0.04
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061
1566.542	1560.58	1560.199	1554.434	1555.332
23473.985	23463.200	23486.964	23476.13	23497.635
14864.774	14825.427	14835.048	14795.404	14810.312
1566.584	1560.615	1560.236	1554.465	1555.374
-0.042	-0.04	-0.037	-0.031	-0.042
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061
1566.542	1560.58	1560.199	1554.434	1555.332
23473.981	23463.199	23486.967	23476.132	23497.64
14864.778	14825.429	14835.054	14795.412	14810.315
1566.584	1560.616	1560.234	1554.464	1555.373
-0.042	-0.04	-0.035	-0.03	-0.041
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061

~~290~~

1566.542	1560.58	1560.199	1554.434	1555.332
23473.987	23463.188	23486.952	23476.121	23497.628
14864.778	14825.429	14835.054	14795.412	14810.315
1566.582	1560.615	1560.238	1554.467	1555.374
-0.04	-0.04	-0.039	-0.033	-0.042
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061
1566.542	1560.58	1560.199	1554.434	1555.332
23473.981	23463.183	23486.958	23476.128	23497.631
14864.776	14825.431	14835.058	14795.415	14810.318
1566.58	1560.618	1560.236	1554.465	1555.374
-0.038	-0.04	-0.037	-0.031	-0.042
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061
1566.542	1560.58	1560.199	1554.434	1555.332
23473.978	23463.175	23486.948	23476.114	23476.621
14864.781	14825.436	14835.051	14795.41	14810.318
1566.582	1560.622	1560.238	1554.461	1555.376
-0.04	-0.04	-0.039	-0.027	-0.044
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061
1566.542	1560.58	1560.199	1554.434	1555.332
23473.986	23463.18	23486.945	23476.106	23497.621
14864.771	14825.423	14835.048	14795.407	14810.304
1566.58	1560.615	1560.239	1554.466	1555.374
-0.038	-0.04	-0.04	-0.032	-0.042
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061
1566.542	1560.58	1560.199	1554.434	1555.332
23473.973	23463.201	23486.933	23476.087	23497.627
14864.776	14825.431	14835.067	14795.421	14810.31
1566.585	1560.622	1560.238	1554.463	1555.374
-0.043	-0.04	-0.039	-0.029	-0.042
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061
1566.542	1560.58	1560.199	1554.434	1555.332
23473.983	23463.201	23486.933	23476.087	23497.627
14864.763	14825.431	14835.067	14795.421	14810.31
1566.58	1560.622	1560.238	1554.463	1555.374
-0.038	-0.04	-0.039	-0.029	-0.042
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061
1566.542	1560.58	1560.199	1554.434	1555.332
23473.976	23463.209	23486.96	23476.084	23497.633
14864.767	14825.436	14835.072	14795.428	14810.312
1566.578	1560.620	1560.240	1554.466	1555.372
-0.036	-0.04	-0.041	-0.032	-0.04
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061

~~201~~

1566.542	1560.58	1560.199	1554.434	1555.332
23473.981	23463.200	23486.962	23476.12	23497.642
14864.771	14825.445	14835.059	14795.438	14810.321
1566.581	1560.623	1560.245	1554.464	1555.375
-0.039	-0.04	-0.046	-0.03	-0.043
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061
1566.542	1560.58	1560.199	1554.434	1555.332
23473.992	23463.197	23486.955	23476.125	23497.636
14864.776	14825.441	14835.053	14795.43	14810.316
1566.581	1560.617	1560.239	1554.466	1555.377
-0.039	-0.04	-0.04	-0.032	-0.045
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061
1566.542	1560.58	1560.199	1554.434	1555.332
23473.99	23463.191	23486.961	23476.128	23497.632
14864.772	14825.431	14835.056	14795.416	14810.321
1566.583	1560.61	1560.243	1554.461	1555.38
-0.041	-0.03	-0.044	-0.027	-0.048
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061
1566.542	1560.58	1560.199	1554.434	1555.332
23473.989	23463.184	23486.964	23476.135	23497.631
14864.778	14825.436	14835.059	14795.418	14810.325
1566.581	1560.612	1560.241	1554.455	1555.382
-0.039	-0.03	-0.042	-0.021	-0.05
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061
1566.542	1560.58	1560.199	1554.434	1555.332
23473.98	23463.186	23486.959	23476.141	23497.639
14864.782	14825.428	14835.053	14795.419	14810.322
1566.579	1560.616	1560.235	1554.463	1555.377
-0.037	-0.04	-0.036	-0.029	-0.045
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061
1566.542	1560.58	1560.199	1554.434	1555.332
23473.982	23463.189	23486.958	23476.126	23497.631
14864.779	14825.426	14835.057	14795.418	14810.317
1566.581	1560.614	1560.238	1554.463	1555.378
-0.039	-0.03	-0.039	-0.029	-0.046
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061
1566.542	1560.58	1560.199	1554.434	1555.332
23473.986	23463.188	23486.994	13476.118	23497.622
14864.773	14825.486	14835.048	14795.41	14810.312
1566.579	1560.615	1560.237	1554.464	1555.371
-0.037	-0.04	-0.038	-0.03	-0.039
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061
1566.542	1560.58	1560.199	1554.434	1555.332

23473.98	23463.169	23486.929	23476.085	23497.601
14864.765	14825.423	14835.039	14795.401	14810.302
1566.578	1560.616	1560.236	1554.469	1555.371
-0.036	-0.04	-0.037	-0.035	-0.039
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061
1566.542	1560.58	1560.199	1554.434	1555.332
23473.987	23463.186	23486.947	23474.12	23497.62
14864.772	14825.426	14835.048	14795.441	14810.311
1566.58	1560.615	1560.237	1554.464	1555.372
-0.038	-0.04	-0.038	-0.03	-0.04
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061
1566.542	1560.58	1560.199	1554.434	1555.332
23473.985	23463.183	23486.945	23474.121	23497.623
14864.773	14825.424	14835.043	14795.44	14810.312
1566.582	1560.613	1560.234	1554.461	1555.37
-0.04	-0.03	-0.035	-0.027	-0.038
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061
1566.542	1560.58	1560.199	1554.434	1555.332
23473.986	23463.180	23486.945	23474.107	23497.615
14864.771	14825.424	14835.048	14795.405	14810.309
1566.579	1560.614	1560.235	1554.467	1555.365
-0.037	-0.03	-0.036	-0.033	-0.033
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061
1566.542	1560.58	1560.199	1554.434	1555.332
23473.986	23463.178	23468.944	23474.106	23497.618
14864.771	14825.425	14836.05	14795.406	14810.31
1566.58	1560.614	1560.237	1554.467	1555.34
-0.038	-0.03	-0.038	-0.033	-0.008
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061
1566.542	1560.58	1560.199	1554.434	1555.332
23473.985	23463.176	23486.944	23474.104	23497.616
14863.77	14825.424	14835.048	14795.406	14810.307
1566.578	1560.614	1560.237	1554.465	1555.366
-0.036	-0.03	-0.038	-0.031	-0.034
23474.067	23463.228	23487.013	23476.132	23497.681
14864.536	14825.182	14834.806	14795.156	14810.061
1566.542	1560.58	1560.199	1554.434	1555.332
23473.981	23463.177	23468.949	23474.109	23497.619
14864.773	14825.426	14835.051	14795.409	14810.308
1566.581	1560.616	1560.239	1554.464	1555.369
-0.039	-0.04	-0.04	-0.03	-0.037

~~253~~

ST7	ST8	ST9	ST10	Interpretation/ Remarks
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	
1547.944	1548.252	1542.028	1541.693	
23490.864	23513.311	23505.976	23529.785	
14762.474	14775.098	14730.018	14739.482	
1547.977	1548.288	1542.051	1541.734	
-0.033	-0.036	-0.023	-0.041	
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	
1547.944	1548.252	1542.028	1541.693	
23490.87	23513.335	23505.968	23529.78	
14762.461	14775.096	14730.022	14739.482	
1547.976	1548.283	1542.048	1541.73	
-0.032	-0.031	-0.02	-0.037	
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	
1547.944	1548.252	1542.028	1541.693	
23490.871	23513.332	23505.952	23529.781	
14762.466	14775.092	14730.021	14739.484	
1547.975	1548.285	1542.056	1541.736	
-0.031	-0.033	-0.028	-0.043	
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	
1547.944	1548.252	1542.028	1541.693	
23490.87	3513.315	23505.97	23529.78	
14762.47	14775.092	14730.016	14739.484	
1547.976	1548.284	1542.056	1541.732	
-0.032	-0.032	-0.028	-0.039	
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	
1547.944	1548.252	1542.028	1541.693	
23490.865	23513.32	23505.972	23529.781	
14762.472	14775.094	14730.018	14739.48	
1547.978	1548.287	1542.052	1541.734	
-0.034	-0.035	-0.024	-0.041	
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	
1547.944	1548.252	1542.028	1541.693	
23490.868	23513.326	23505.968	23529.784	
14762.468	14775.095	14730.02	14739.481	
1547.977	1548.285	1542.053	1541.735	
-0.033	-0.033	-0.025	-0.042	
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	

1547.944	1548.252	1542.028	1541.693	
23490.878	23513.314	23505.961	23529.767	
14762.468	14775.095	14775.02	14739.481	
1547.974	1548.289	1542.057	1541.736	
-0.03	-0.037	-0.029	-0.043	
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	
1547.944	1548.252	1542.028	1541.693	
23490.871	23513.321	23505.965	23529.761	
14762.472	14775.091	14730.004	14739.488	
1547.975	1548.287	1542.06	1541.732	
-0.031	-0.035	-0.032	-0.039	
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	
1547.944	1548.252	1542.028	1541.693	
23490.867	23513.321	23505.948	23529.758	
14762.475	14775.092	14729.98	14739.486	
1547.978	1548.294	1542.063	1541.73	
-0.034	-0.042	-0.035	-0.037	
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	
1547.944	1548.252	1542.028	1541.693	
23490.86	23513.303	23505.945	23529.76	
14762.479	14775.082	14729.997	14739.478	
1547.975	1548.294	1542.06	1541.733	
-0.031	-0.042	-0.032	-0.04	
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	
1547.944	1548.252	1542.028	1541.693	
23490.872	23513.311	23505.945	23529.768	
14762.492	14775.093	14729.997	14739.478	
1547.982	1548.292	1542.065	1541.733	
-0.038	-0.04	-0.037	-0.04	
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	
1547.944	1548.252	1542.028	1541.693	
23490.872	23513.311	23505.945	23529.768	
14762.492	14775.093	14729.997	14739.478	
1547.982	1548.292	1542.065	1541.733	
-0.038	-0.04	-0.037	-0.04	
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	
1547.944	1548.252	1542.028	1541.693	
23490.865	23513.319	23505.953	23529.773	
14762.488	14775.087	14729.983	14739.483	
1547.985	1548.290	1542.054	1541.736	
-0.041	-0.038	-0.026	-0.043	
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	

~~205~~

1547.944	1548.252	1542.028	1541.693	
23490.859	23513.324	23505.958	23529.778	
14762.495	14775.081	14729.988	14739.488	
1547.99	1548.289	1542.055	1541.731	
-0.046	-0.037	-0.027	-0.038	
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	
1547.944	1548.252	1542.028	1541.693	
23490.862	23513.322	23505.961	23529.783	
14762.487	14775.086	14730.005	14739.478	
1547.978	1548.291	1542.059	1541.732	
-0.034	-0.039	-0.031	-0.039	
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	
1547.944	1548.252	1542.028	1541.693	
23490.869	23513.328	23505.970	23529.781	
14762.49	14775.089	14730.015	14739.478	
1547.976	1548.286	1542.062	1541.734	
-0.032	-0.034	-0.034	-0.041	
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	
1547.944	1548.252	1542.028	1541.693	
23490.871	23513.331	23505.975	23529.776	
14762.479	14775.091	14730.018	14739.473	
1547.979	1548.289	1542.064	1541.736	
-0.035	-0.037	-0.036	-0.043	
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	
1547.944	1548.252	1542.028	1541.693	
23490.877	23513.328	23505.969	23529.769	
14762.471	14775.099	14730.008	14739.48	
1547.978	1548.288	1542.058	1541.736	
-0.034	-0.036	-0.03	-0.043	
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	
1547.944	1548.252	1542.028	1541.693	
23490.876	23513.319	23505.966	23529.769	
14762.463	14775.099	14730.022	14739.483	
1547.971	1548.291	1542.061	1541.741	
-0.027	-0.039	-0.033	-0.048	
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	
1547.944	1548.252	1542.028	1541.693	
23490.874	23513.302	23505.957	23529.782	
14762.486	14775.095	14729.996	14739.476	
1547.973	1548.289	1542.051	1541.735	
-0.029	-0.037	-0.023	-0.042	
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	
1547.944	1548.252	1542.028	1541.693	

~~296~~

23490.863	23513.300	23505.97	23529.773	
14762.475	14775.092	14729.979	14739.482	
1547.971	1548.290	1542.051	1541.735	
-0.027	-0.038	-0.023	-0.042	
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	
1547.944	1548.252	1542.028	1541.693	
23490.873	23513.304	23505.958	23529.787	
14762.485	14775.095	14729.988	14739.47	
1547.972	1548.289	1542.043	1541.732	
-0.028	-0.037	-0.015	-0.039	
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	
1547.944	1548.252	1542.028	1541.693	
23490.87	23513.301	23505.957	23529.786	
14762.483	14775.092	14729.984	14739.473	
1547.971	1548.287	1542.042	1541.73	
-0.027	-0.035	-0.014	-0.037	
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	
1547.944	1548.252	1542.028	1541.693	
23490.867	23513.298	23505.945	23529.782	
14762.481	14775.091	14729.983	14739.473	
1547.976	1548.289	1542.046	1541.732	
-0.032	-0.037	-0.018	-0.039	
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	
1547.944	1548.252	1542.028	1541.693	
23490.86	23513.296	23505.937	23529.781	
14762.481	14775.093	14729.987	14739.47	
1547.967	1548.285	1542.044	1541.734	
-0.023	-0.033	-0.016	-0.041	
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	
1547.944	1548.252	1542.028	1541.693	
23490.857	23513.262	23505.938	23529.78	
14762.479	14775.087	14729.982	14739.475	
1547.969	1548.288	1542.044	1541.732	
-0.025	-0.036	-0.016	-0.039	
23490.858	23513.354	23505.910	23529.834	
14762.219	14774.840	14729.719	14739.345	
1547.944	1548.252	1542.028	1541.693	
23490.853	23513.297	23505.942	23529.782	
14762.478	14775.087	14729.988	14739.473	
1547.972	1548.290	1542.046	1541.736	
-0.028	-0.038	-0.018	-0.043	

TEESTA URJA LIMITED

(A Government of Sikkim Enterprise)

TEESTA-III H.E. PROJECT (6 x 200 MW)

(SIKKIM)

EMERGENCY PREPAREDNESS AND DISASTER MANAGEMENT PLAN

NOVEMBER–2016

वाप्कोस लिमिटेड
WAPCOS LIMITED

WAPCOS LIMITED,
76-C, Institutional Area, Gurgaon-122015
(Haryana)
Tel: (+91-124) 2399421 (16 lines)
Fax :(+91-124) 2397392
E-mail: mail@wapcos.gov.in

TABLE OF CONTENTS

1. INTRODUCTION 4
2. PROJECT DESCRIPTION 4
3. DISASTER MANAGEMENT - INTRODUCTION 5
4. HAZARD SPECIFIC DISASTERS 6
5. DISASTER EMERGENCY LEVEL DETERMINATION 6
5.1 Emergency level-1 6
5.2 Emergency level-2 7
5.3 Emergency Level-3 8
5.4 Events and Associated Emergency Levels: 9
6. EMERGENCY RESPONSE PLAN 10
7. NOTIFICATION FLOW CHART 13
8. EMERGENCY SERVICE CONTACTS 16
9. ROLE AND RESPOSIBILITIES 17
9.1 Teesta Urja Ltd 18
9.2 Local Emergency Manager/ Nodal officer 18
9.3 District Development Management Authority (DDMA) 19
9.4 Sikkim State Disaster Management Authority 19
9.5 National Executive Council (NEC) 20
9.6 Down Stream and Upstream Projects 20
9.7 Project Security 20
10. EMERGENCY PREPAREDNESS PLAN 20
10.1 Planning for emergency 21
10.2 Inputs for preparation of Emergency Plan 21
10.3 Priority of Spillway Gate Operation 23
10.4 Flood Warning 24
10.5 Availability of Equipment, material and Manpower 24
11. DISASTER MITIGATION PLAN 24
11.1 Disaster due to Earthquake 24
11.2 Disaster due to unprecedented Flood due to cloud burst 25
11.3 Disaster due to Dam Break 26
11.4 Disaster due to Land slides 28
11.5 Disaster due to Fire 28
11.6 Classes of Fire 30
11.7 Types of Fire Extinguishers 30
11.8 Fire Fighting Strategies 32
11.9 How to Use Fire Extinguisher 33
11.10 Precautions While Fighting a Fire 33
11.11 How to help in case of a Fire 33
11.12 Disaster due to Gate Operation failure 34

11.13 Disaster due to Abnormal reading in Instrument 34
11.14 Terrorist/ Bomb threat 34
12. PREVENTIVE AND CORRECTIVE ACTIONS 35
13. INSPECTION AND MAINTENANCE 37
13.1 Routine Inspections 38
13.2 Annual Inspection 39
13.3 Periodic Inspection (5-Yearly) 39
13.4 Performa for Periodical Inspection of dam and appurtenant Structures 40
13.5 Periodic Maintenance 49
14. REVIEW AND UPDATION 50
14.1 Review 50
14.2 Revision 50
14.3 Disaster Management Plan (DMP) training and exercise 51
15. NOTIFICATION AND COMMUNICATION 51
15.1 Notification Emergency Level-1 52
15.2 Notification Emergency Level-2 52
15.3 Notification Emergency Level-3 52
15.4 Notification Responsibility 53
15.5 Control Room and Communication System 54
15.6 Downstream Warning 54
15.7 Management after receding of flood water 55
Annexure-1 57
Annexure-2 58
Annexure-3 59
Annexure-4 60
Annexure-5 61
Annexure-6 62
Annexure-7 63

1. INTRODUCTION

Teesta-III Hydro Electric Project is a run-of-the-river scheme with diurnal storage to generate 1200 MW power by utilizing the discharge of River Teesta between EL.1585.0 m and EL.768.0 m. The Project is developed by Teesta Urja Limited (TUL). This scheme is not a storage scheme for flood moderation. The project envisages diversion of Teesta River water up to 175cumec for power generation by constructing a diversion dam on the river at about 400m downstream of the confluence of Lachen Chu and Lachung Chu. The diverted water would be carried to the powerhouse through 7.5m diameter and 13.816 km long head race tunnel followed by two steel lined pressure shafts. The powerhouse is also located underground and would be equipped with 6 units of 200MW each vertical Pelton type turbines. The turbines would run under a rated net head of 780.33 m. The water released from the turbines is carried through a tail race tunnel to join back the Teesta River at a point slightly upstream of the confluence with Talungchu.

Teesta-III Hydro Electric Project is located in the State of Sikkim and falls in High Seismic zone in Himalayan region. The power stations located in Himalayan region are prone to heavy rainfall, especially during monsoon and the occurrence of flood, landslides at different location is common. Further since there is no other means of transport except roads in Himalayan states where power stations are located. The poor accessibility to these power stations increases the vulnerability during disaster. Thus, the Disaster Management Plan assumes great significance for Hydropower Sector. This manual provides exclusively basic guidelines for the Disaster Management Plan during occurrence of Earthquake, Floods, Landslides and Fire etc. The document also provides guidance for the **Emergency action plan utilized for unusual and emergency conditions** to avoid loss of human life and properties.

2. PROJECT DESCRIPTION

The main components of the Teesta-III Hydro Electric Project are:

- Concrete Faced Rock-fill Dam,
- Spillways to surpass 7000 m^3/s comprises Chute Spillway, 2 Nos. of Tunnel Spillway and 1 No. of Flushing / Spillway Tunnel,
- One Nos. of Power Intake and 2 Nos. of De-silting Chamber,
- Horse-shoe shaped HRT on right bank,
- Surge Shaft with restricted orifice,
- Two Pressure Shafts,
- Underground Powerhouse housing 6 Units each 200 MW generating equipment's using 175 m^3/s of discharge and 780.33 m head,
- D-Shaped tail race tunnels.

The main dam comprises of a compacted rock fill section with a concrete face slab on the upstream slope and a concrete toe slab. Plastic diaphragm wall is provided on the upstream toe of dam going into bedrock, to act as a foundation seepage barrier. The top of dam has been kept at 1590.0m, which gives a free board of 5m above the FRL. The total length of dam at its top will be 298.0m, from RD 0.0m on the left bank to RD 298.0m on the right bank. The rock-fill dam will be of 170.0m length is

placed between the right abutment and the spillway. The spillway crest length is 32m. The Dam (CFRD) of 60.0 m high is resting over RBM in its entire length with upstream deep cut off wall.

On successful completion, the Project would provide **1200 MW peaking power and 5228 MU of design energy.** The detailed salient features of the Project are given in **Annexure-1.**

3. DISASTER MANAGEMENT - INTRODUCTION

A disaster is an event of natural or manmade causes that leads to sudden disruption of normalcy within society, causing damage to life and property to such an extent that normal social and economic mechanisms available are inadequate to restore normalcy. Flash floods, snow avalanche, road blockade due to land slides are very common occurrence in the Himalayan region where Teests-III HE Project is located. This area is highly earthquake prone and it is placed in zone IV of Earth quake Damage Risk zone. There is need for pro-active approach in facing these disasters. A well-made **Disaster Management Plan (DMP)** can help in preparedness, prevention and integrating disaster plan to developmental plan. A well prepared plan envisages the adequate responsibility and role to achieve goal of minimum losses to both life and property. A well prepared plan also helps in handling the hazards in such a way that it does not turn into disasters. The objective of DMP shall be "**to minimize the adverse effects of a hazard through effective precautionary actions, rehabilitation and recovery to ensure the timely, appropriate and effective organization and delivery of relief and assistance following a disaster**".

The Ministry of Law And Justice, Government of India has brought out a **"Disaster Management Act - 2005, India"** for guidance and making necessary awareness to public and the same is attached as **Annexure-2.** The above act defines the **"Disaster", "Disaster Management/ Mitigation"** and **"Preparedness"** etc. as under:

- **"Disaster"** means a catastrophe, mishap, calamity or grave occurrence in any area arising from **natural** or **man-made** causes or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of property or damage to, or degradation of environment and in of such a nature or magnitude as to be beyond coping capacity of the community of the affected areas.
  - The "**Natural Disaster"** is one that emerges by natural environment. The Disasters caused by earthquakes, floods, cyclones, landslides etc. are considered as **Natural Disasters**.
  - The **"Manmade Disaster"** is the direct creation/ activity of human being with direct/ indirect knowledge of the risk/ resultant catastrophe or due to serious human/ technical failure and hazards are created to generate the outcome. Those caused by chemical, industrial, transport related accidents and security related threats including terrorism are classified as **"Manmade Disaster"**.
- **"Disaster Management"** means a continuous and integrated process of Planning, organising, coordinating and implementing measures which are necessary for prevention of danger/ threat, reduction of risk of disaster and preparedness to deal with such disaster.
- **"Mitigation"** means measures aimed at reducing the risk, impact or effect of a disaster or threatening disaster situation.

- **"Preparedness"** means the state of readiness to deal with threating disaster and the effect thereof.

The following are the major objectives of Disaster management Plan:

- To prevent loss of human lives and property due to any disaster.
- Preparedness, prevention and Mitigation of Disaster.
- Training and awareness creation.
- To make the society able to act very fast to manage the loss caused by disaster.

The objectives can be achieved by taking various pre-disaster preparedness like establishing pre-disaster warning system, dissemination of information, training, rehearsal etc. and well thought out response plan, rescue plan during the disaster , linking disaster management plan with National/ District civil administration disaster management plan for long term preparation, preparing and following standard operation procedure etc.

The Disaster mitigation plan, role and responsibility of various agencies, emergency preparedness plan etc. have been detailed in this report in succeeding paragraphs.

4. HAZARD SPECIFIC DISASTERS

The following are the natural and manmade disasters which may cause substantial loss of life or human suffering, damage and destruction of property in Teesta-III H. E. Project:

1. Disaster due to Earthquakes
2. Disaster due to unprecedented Flood due to cloud burst
3. Disaster due to Land slides
4. Disaster due to Fire
5. Disaster due to Gate Operation failure
6. Disaster due to Abnormal reading in Instrument
7. Terrorist/ Bomb threat

The following disasters/ events can lead to emergency situations:

- Non-emergency incident/ unusual event/ slowly developing situation
- Potential dam failure situation (rapidly developing)
- Dam failure is imminent or in progress

5. DISASTER EMERGENCY LEVEL DETERMINATION

After an unusual or emergency event is detected and verified, Teesta-III Project authorities are responsible for classifying the event into one of the following three emergency levels:

5.1 Emergency level-1

[Non-emergency incident; unusual event; slowly developing situation]

This situation is not normal but has not yet threatened the operation or structural integrity of the dam, but possibly could if it continues to develop. Teesta-III Project Engineering Department (Design) should be contacted to investigate the situation and recommend actions to be taken. The condition of the dam should be closely monitored, especially during storm events, to detect any development of a potential or imminent dam failure situation. The Local Emergency Manager should be informed if it is determined that the conditions may possibly develop into a worse condition that may require emergency actions.

Event	Situation	Emergency Level
Seepage/ Sinkholes	New seepage areas in or near the dam and in galleries and new sinkhole in reservoir area or on dam	1
Dam cracking	New cracks in the dam greater than 1/4-inch wide without seepage	1
	Visual movement/slippage of the dam slopes	1
Earthquake	Measurable earthquake felt or reported on or within 80 kilometers of the dam	1
Sabotage/ vandalism	Damage to dam or appurtenances with no impacts to the functioning of the dam	1
	Modification to the dam or appurtenances that could adversely impact the functioning of the dam	1
High Water Inflow	Increase in water inflow due to small cloudburst/ flash floods in upstream or sudden water release from upstream projects	1
Fire	Major fires in control room causing loss of control over reservoir/spillway operations	1
Instruments	Instrumentation readings beyond predetermined values	1

5.2 Emergency level-2

[Potential dam failure situation, rapidly developing]

This situation may eventually lead to dam failure and flash flooding downstream, but there is not an immediate threat of dam failure. The Local Emergency Manager should be notified of this emergency situation and placed on alert. The Teesta-III Project authorities should closely monitor the condition of the dam and periodically report the status of the situation to the Local Emergency Manager. As time permits, remedial actions should be taken to delay, moderate, or prevent failure of the dam. If the dam condition worsens and failure becomes imminent, the Local Emergency Manager must be notified immediately of the change in the emergency level to evacuate the people at risk downstream.

Event	Situation	Emergency Level
Spillway flow	Spillway flowing with active gully erosion	2
	Spillway flow that could result in flooding of people downstream	2
Dam overtopping	Overtopping flow not eroding the dam slope; reservoir level expected to lower	2
Seepage and Sinkholes	New seepage areas with cloudy discharge or increasing flow rate and Rapidly enlarging sinkhole	2
Dam cracking	Cracks in the dam with seepage	2

Earthquake	Earthquake resulting in visible damage to the dam or appurtenances	2
Sabotage/ vandalism	Damage to dam or appurtenances that has resulted in seepage flow	2
High Water Inflow	High water inflow due to major cloudburst/ flash floods in upstream or sudden water release from upstream projects	2
Landslides	Landslides in upstream area which results in water surge and high waves	2
Security threat	Verified bomb threat that, if carried out, could result in damage to the dam	2

Teesta-III Project Engineering Design Department should be contacted to evaluate the situation and recommend remedial actions to prevent failure of the dam. Teesta-III Project authorities should initiate remedial repairs with the local resources that may be available.

This emergency level is also applicable when flow through the spillways has, or is expected to, result in flooding of downstream areas where people near the channel could be endangered. Emergency services should be on alert to initiate evacuations or road closures if the flooding increases.

5.3 Emergency Level-3

[Dam failure is imminent or in progress]

This is an extremely urgent situation when a dam failure is occurring or obviously is about to occur and cannot be prevented. Flash flooding will occur downstream of the dam. This situation is also applicable when flow through the spillway is causing downstream flooding of people and roads. The Local Emergency Manager should be contacted immediately so emergency services can begin evacuations of all at-risk people and close roads as needed.

Event	Situation	Emergency Level
Spillway flow	Spillway flowing with an advancing head cut that is threatening the control section	3
	Spillway flow that is flooding people downstream	3
Dam overtopping	Overtopping flow not eroding the dam slope; reservoir level expected to rise	3
	Overtopping flow eroding the dam slope	3
Seepage	Rapid flow rate increase with cloudy discharge from existing seepage area(s)	3
Dam movement	Sudden or rapidly progressing slides of the dam slopes	3
Earthquake	Earthquake resulting in uncontrolled release of water from the dam	3

Sabotage/ vandalism	Damage to dam or appurtenances that has resulted in uncontrolled water release	3
Security threat	Detonated bomb that has resulted in damage to the dam or appurtenances	3
Cloud burst	High water inflow due to cloudburst near dam/ flash floods near dam	3

5.4 Events and Associated Emergency Levels:

After an unusual or emergency event is detected, Teesta Urja Ltd. shall contact the **Project Engineering Design Department** to evaluate the situation and recommend remedial actions to prevent failure of the dam. Teesta Urja Ltd. authorities should initiate remedial repairs with the local resources. Some of the events and associated emergency levels are tabulated below:

Event	Emergency Level-2 Situation (Potential dam failure situation; rapidly developing)	Emergency Level-3 Situation (Dam failure is imminent or in progress)
Spillway flow	Significant erosion or head cutting of the spillway is occurring but the rate does not appear to threaten an imminent breach of the spillway crest that would result in an uncontrolled release of the reservoir.	Significant erosion or head cutting of the spillway is occurring at a rapid rate and a breach of the control section appears to be imminent.
Dam over topping	The reservoir level has reached the top of the dam and is projected to continue to lower. Flow is occurring over the dam, but it is not eroding the dam slope and the reservoir is expected to continue to lower.	**1.** Flow is occurring over the dam causing damage to the dam slope. **2.** The reservoir level has exceeded the top of the dam and is expected to continue to rise.
Seepage	**1.** Cloudy seepage or soil deposits are observed at seepage exit points or from internal drain outlet pipes. **2.** New or increased areas of wet or muddy soils are present on the downstream slope, abutment, and/or foundation of the dam, and there is an easily detectable and unusual increase in volume of downstream seepage. **3.** Significant new or enlarging sinkhole(s) near the dam. **4.** Reservoir level is falling without apparent cause. **5.** The following known dam defects are or soon will be inundated by a rise in the reservoir: **a.** Sinkhole(s) located on the upstream slope, crest, abutment, and/or foundation of the dam; or **b.** Transverse cracks extending through the dam, abutments, or foundation.	**1.** Rapidly increasing cloudy seepage or soil deposits at seepage exit points to the extent that failure appears imminent or is in progress. **2.** Rapid increase in volume of downstream seepage to the extent that failure appears imminent or is in progress. **3.** Water flowing out of holes in the downstream slope, abutment, and/or foundation of the dam to the extent that failure appears imminent or is in progress. **4.** Whirlpools or other evidence exists indicating that the

		reservoir is draining rapidly through the dam or foundation. 5. Rapidly enlarging sinkhole(s) are forming on the dam or abutments to the extent that failure appears imminent or is in progress. 6. Rapidly increasing flow through crack(s) eroding materials to the extent that failure appears imminent or is in progress.
Dam movement	1. Settlement of the crest, slopes, abutments and/or foundation of the dam that may eventually result in breaching of the dam. 2. Significant increase in length, width, or offset of cracks in the crest, slopes, abutments, and/or foundation of the dam that may eventually result in breaching of the dam.	1. Sudden or rapidly progressing slides, settlement, or cracking of the dam crest, slopes, abutments, and/or foundation, and breaching of the dam appears imminent or is in progress.

6. EMERGENCY RESPONSE PLAN

The periodical inspection of the dam and other appurtenant structures shall be carried out as per **Para No.-13 "Inspection and Maintenance"** of this report by an experienced engineer. For further details for carrying out the inspection of various components of project refer **Annexure-3 {CWC's "Guidelines for Safety Inspection of Dam"}.** In case any problem/abnormality is noticed in any project components/ structures, Teesta Urja Ltd. should immediately contact engineering department for Technical consultation. After determining the emergency level at site the remedial measures shall be carried out as suggested/ recommended by the engineering department and simultaneously take appropriate action as mentioned below:

1. **Emergency Level-1**

   a. The Dam and other appurtenant structures should be inspected periodically at regular intervals and record the observations. At a minimum, inspect the full length of the upstream slope, crest, downstream toe, and downstream slope. Also check the reservoir area, abutments, and downstream channel for signs of changing conditions. If increased seepage, erosion, cracking, or settlement is observed, immediately report the observed conditions to Engineering Department as per **Para No.-7 "Notification Flow Chart"** for guidance in determining the appropriate event level for the newly developed condition and to recommend remedial measures.

   b. Record all information, observations, and actions taken on the *Unusual or Emergency Event* as mentioned in following **Para No.-13.4**. Note the time of changing conditions. Document the situation with photographs and video if possible.

2. **Emergency Level-2**

Teesta-III project authorities should contact the Local Emergency Manager as per **Para No.-7 "Notification Flow Chart"** to inform that the Disaster Management Plan has been activated and, if current conditions get worse, the emergency level may increase and the emergency situation may require evacuation. Preparations should be made for possible road closures and evacuations.

The Project Authorities should report the situation to the Engineering Department and request investigation of the situation and recommend corrective actions.

Provide updates to the Local Emergency Manager to assist them in making timely decisions concerning the need for warnings, road closures, and evacuations.

If time permits, project authorities should inspect the dam. At a minimum, inspect the full length of the upstream slope, crest, downstream toe, and downstream slope. Also check the reservoir area, abutments, and downstream channel for signs of changing conditions. If piping, increased seepage, erosion, cracking, or settlement are observed, immediately report the observed conditions to the Local Emergency Manager and Engineering Department.

Record all contacts that were made on the *Contact Checklist*. Record all information, observations, and actions taken. Note the time of changing conditions. Document the situation with photographs and video, if possible.

If time permits, the following emergency remedial actions should be considered for Emergency Level 2 conditions and close monitoring of the dam must be maintained to confirm the success of remedial action at the dam:

- **Dam overtopping**
  - Remove the debris, if any.
  - Place sandbags along the low areas of the top of the dam to reduce the likelihood of overtopping and to safely direct more water through the spillway.
  - Cover the weak areas of the top of the dam, downstream and upstream slope with riprap, sandbags, plastic sheets, or other materials to provide erosion-resistant protection.
- **Seepage and sinkholes**
  - Open the Spillway gates to lower the reservoir level as rapidly as possible to a level that stops or decreases the seepage to a non-erosive velocity. Continue lowering the water level until the seepage stops.
  - If the entrance to the seepage origination point is observed in the reservoir (possible whirlpool) and is accessible, attempt to reduce the flow by plugging the entrance with readily available materials, such as bentonite, soil or rock fill, or plastic sheeting.
  - Cover the seepage exit area(s) with several feet of sand/ gravel to hold fine-grained dam or foundation materials in place. Alternatively, construct sand bag or other types of ring dikes around seepage exit areas to retain a pool of

water, providing backpressure and reducing the erosive nature of the seepage.

- Prevent vehicles and equipment from driving between the seepage exit points and the dam to avoid potential loss from the collapse of an underground void.

➢ **Dam movement**

- Open the Spillway gates and lower the reservoir to a safe level at a rate commensurate with the urgency and severity of the condition of the slide or slump.
- Repair settlement of the crest by placing sandbags or earth and rock fill materials in the damaged area to restore freeboard.
- Stabilize slides on the downstream slope by placing a soil or rock fill buttress against the toe area of the slide.

➢ **Earthquake**

- Immediately conduct a general overall visual inspection of the dam.
- Perform field survey to determine if there has been any settlement and movement of the dam, spillway and Intakes. Record observations.
- Drain reservoir if required.

➢ **High water inflow**

- Emergency level to be determined on the basis of expected water inflow and readiness to be ensured as per the determined emergency level to spill the extra water through spillway gates.
- Reservoir operation and maintenance manual should be referred to calculate the spillage requirements.
- Before releasing the discharge through spillways and before increasing the outflows through Spillway, advance warnings shall be given through loudspeakers/ hooters so as to warn the people working in Project area as well downstream.

➢ **Terrorist/ bomb threat**

- Immediately call the bomb disposal squad of project security / Local Police.

3. **Emergency Level-3**

a. Contact immediately the Local Emergency Manager and others shown on the "**Notification Flow Chart**". The contact details of various emergency services are tabulated in **Para No.-8 "Emergency Service Contacts".**

b. The Local Emergency Manager shall make efforts to carry out warnings, close roads, and evacuate people at risk downstream from the dam.

c. The Local Emergency Manager shall alert the general public and immediately evacuate at-risk people and close roads as necessary.

d. Maintain continuous communication and provide the Local Emergency Manager with updates of the situation to assist him in making timely decisions concerning warnings and evacuations.

e. Record all contacts that were made. Also record all information, observations, and actions taken on the Unusual or Emergency Event. Note the time of changing conditions. Document the situation with photographs and video, if possible.

f. Advise people monitoring the dam to follow safe procedures. Everyone should stay away from any of the failing structures or slopes and out of the potential breach inundation areas.

g. Medical relief and availability of ambulances shall be ensured to meet any emergency.

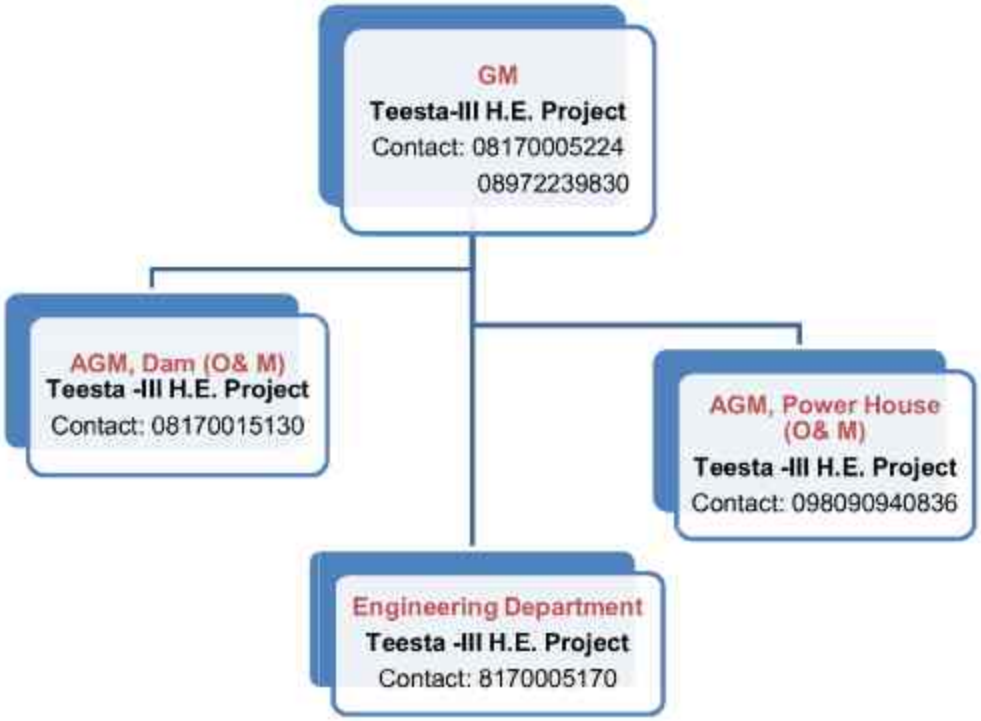
7. NOTIFICATION FLOW CHART

The Notification Flow Chart showing officers of various organisations responsible during the various levels of emergency such as Emergency Level-1; Emergency Level-2 and Emergency Level-3 are as below:

Notification Flow Chart

Emergency Level-1

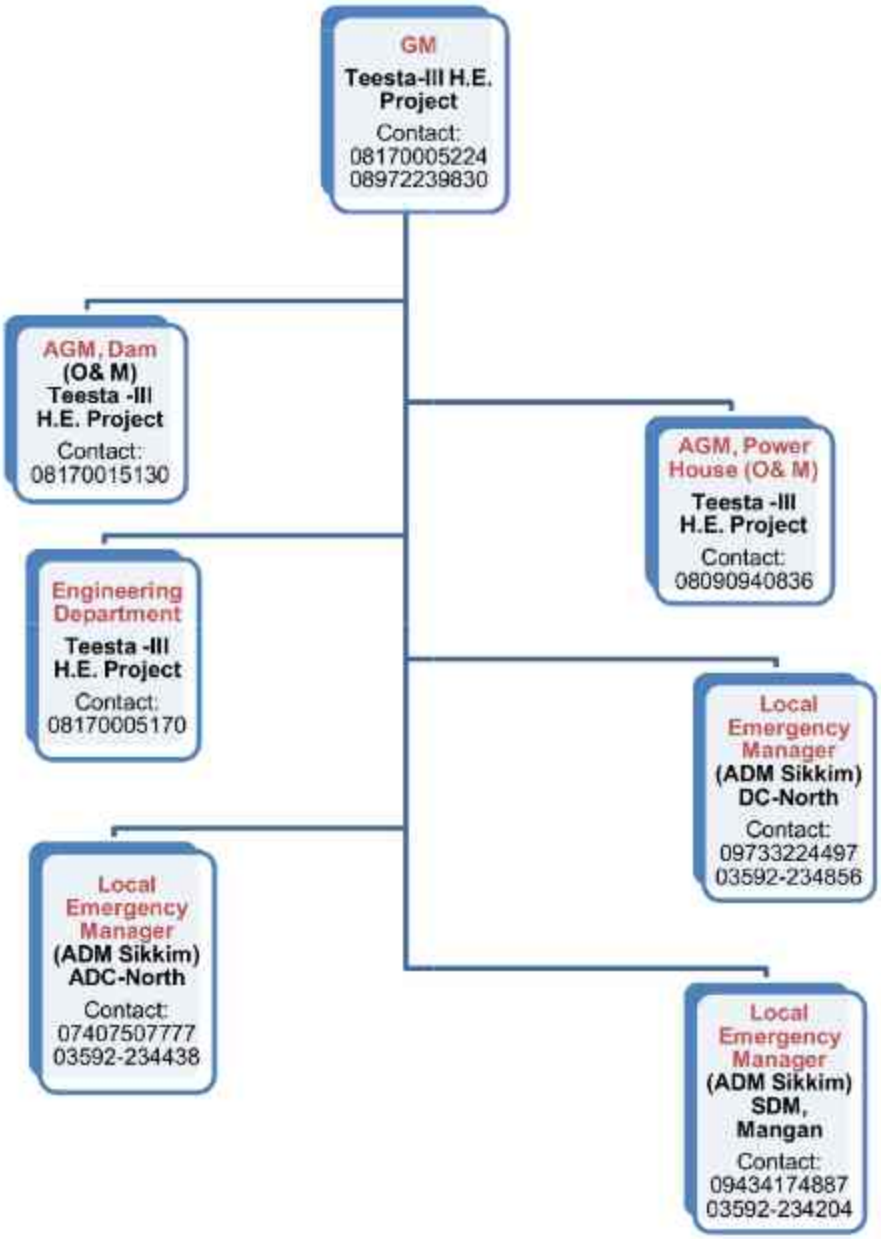
[Non-emergency incident; unusual event; slowly developing situation]



Notification Flow Chart

Emergency Level-2

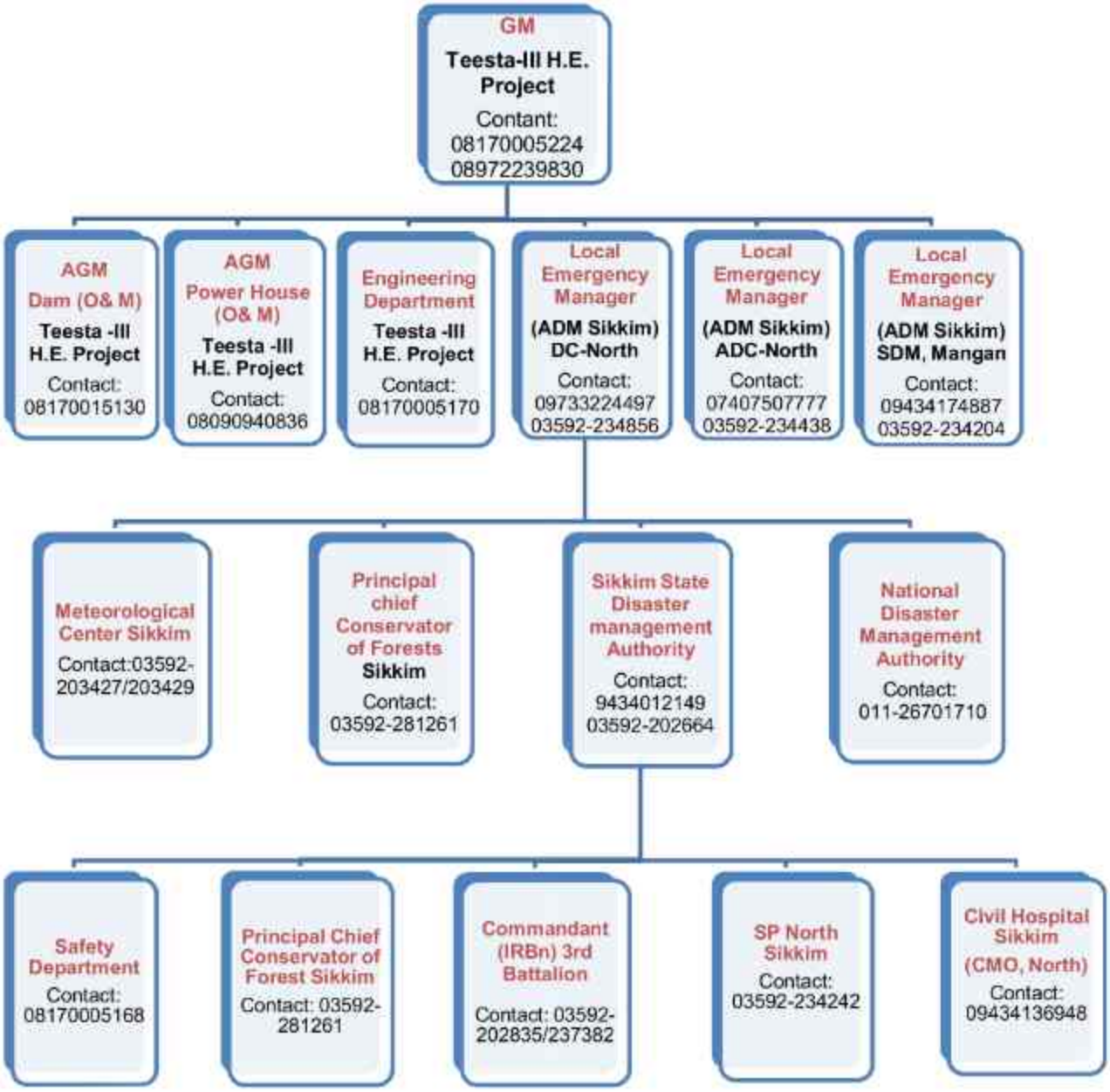
[Potential dam failure situation, rapidly developing]



Notification Flow Chart

Emergency Level-3

[Dam failure is imminent or in progress]



8. EMERGENCY SERVICE CONTACTS

The various emergency service contact details are tabulated below:

S.N.	Agency/Organization	Principal Contact Number	Office Telephone Number	Alternate Telephone Number(s)/ Fax/ Email	Address
1	GM, Teesta-III HEP	8170005224		8972239830 / subhendu.s@teestaurja.com	Teesta Urja Ltd, Dam site Chungthang
2	AGM, Power House (O&M) – Teesta-III HEP	8090940836		bdkumar1967@gmail.com	Teesta Urja Ltd Power house Chungthang
3	AGM, Dam (O&M) – Teesta-III HEP	8170015130		kksinghnpcc@yahoo.co.in	Teesta Urja Ltd Dam site Chungthang
4	Teesta-III HEP Engineering Department / FES	8170005170		verendra.p@teestaurja.com	Teesta Urja Ltd Dam site Chungthang
5	Commandant (IRBn) 3rd Battalion Teesta-III HEP		03592-202835/ 237382	Tel no. 03592-205220, email: coirb3@sikkimpolice.nic.in	State Police Headquarters, NH10, Gangtok-737101
6	Safety Deptt ,Teesta-III HEP	8170005168		bhim.s.v@teesataurja.com	Teesta Urja Ltd Power house Chungthang
7	Fire Station, Teesta-III HEP	-do-			-do-
8	Teesta-III HEP Hospital (if any)	8170005172		pema.t@teestaurja.com	Teesta Urja Ltd Dam site Chungthang
9	Local Emergency Manager (ADM, Sikkim) DC- North	9733224497	.03592-234856	Fax. No- 03592-234234, email id: dc_northsikkim@gmail.com	District Administrative Centre - North, Mangan, Sikkim
10	Local Emergency Manager (ADM Sikkim) ADC-North	7407507777	03592-234438	Tel no.03592-234229, email id: admnorthsikkim@gmail.com	District Administrative Centre - North, Mangan, Sikkim
11	Local Emergency Manager (ADM Sikkim) SDM, Mangan	9434174887	03592-234204	Tel no.03592-234205, email id: sdomangan@gmail.com	District Administrative Centre - North, Mangan, Sikkim
12	Sikkim State Disaster Management Authority	9434012149	03592-202664	Fax. No- 03592-201075, email id: sikkimsdma@gmail.com	Land Revenue and Disaster Management Department, Manan Bhawan, Development Area, Gangtok, Sikkim
13	National Disaster Management Authority		011-26701710	Fax No- 011-26701716, email id: secretary@ndma.gov.in	NDMA Bhawan, A-1, Safdarjung Enclave,New Delhi - 110029
14	PRO (Sikkim) (DIO North)	9635821099			District Administrative Centre - North, Mangan, Sikkim, IPR Deptt.
15	Chief Engineer, Sikkim Energy & Power Department.				
16	Head of the Project Teesta-III HEP	9810026621	03592-234022, 03592-234166	email id: tulmangan@teestaurja.com	C-75, Power Colony Mangan North Sikkim
17	SDM, Sikkim (Chungthang)	9733301780			SDO, Chungthang, North Sikkim-737120
18	Superintending Engineer (SE) North Sikkim Power Department	9434117734			Power Colony, Mangan, North Sikkim-737116
19	Meteorological Centre Sikkim (Indian Meteorological Department)		03592-203427/ 203429	email id: itsraha@gmail.com (Director IMD Sikkim) Fax 03592-203427/203429	Meteorological Center Gangtok, Rajbhawan Area, Baluwakhani, Baluwakhani Road, Sungava, Gangtok, Sikkim- 737103
20	Principal Chief Conservator of Forests Sikkim			Fax No-03592-281778, email id: sik@envis.nic.in	Wildlife Management Department Government of Sikkim, Forest Secretariat, Deorali - 737102,Gangtok, East Sikkim

S.N.	Agency/Organization		Principal Contact Number	Office Telephone Number	Alternate Telephone Number(s)/ Fax/ Email	Address
21	SP North Sikkim			03592-234242	Tel no- 03592-234285, email id: spnorth@sikkimpolice.nic.in	District Administrative Centre - North, Mangan, Sikkim
22	Sikkim Police Station (Mangan)				ocmangan@ sikkimpolice.nic.in	
23	Bomb Diffuse Squad/ Police Control Room Sikkim					
24	Civil Hospital Sikkim (CMO, North)			9434136948		District Hospital-North, Mangan, Sikkim
25	Electronic Media	National TV				
		India TV				
		Zee TV				
		Aaj Tak				
26	Print Media	Times of India				
		Hindustan Times				
		Nav-Bharat Times				
		Sikkim Express				
		Samay Dainik				
		The Voice of Sikkim				
		Hamro Prajashakti				
		Sikkim Herald				

9. ROLE AND RESPOSIBILITIES

Teesta Urja Ltd., (A Government of Sikkim Enterprise) is the owner of the Teesta-III H. E. Project. The company is fully responsible for the maintenance of Dam and appurtenant structures. They are also responsible for development and maintenance of the Disaster Management Plan (**DMP**) and for activating the notification procedures of the plan. Under the national policy, Local State (state of Sikkim) and Central Officials/ Organizations are responsible for providing relief in the event of calamities / disasters, warning and evacuation within the potential affected areas.

The responsibility of Teesta Urja Ltd. is to take most effective measures in ensuring health and integrity of the dam, appurtenant structures and the reservoir rim. Also in providing timely information to concerned State and Central Government Agencies about the flood forecasts from its network and the flood water being released from the spillways. Also in the event of any Dam incident, it will take immediate measures to rectify the damage for preventing it to become a disaster while keeping the State and Central Government Authorities duly informed. The responsibility for issuing warnings to citizens and their shifting and providing relief measures rests mainly with the District Administration.

The list of telephone / fax numbers, mobile numbers and other details of all the concerning officials of Teesta Urja Ltd, Central Government, State Government, District Administration, CWC and Irrigation Departments, who shall be informed in case of any emergency as per the Emergency Service Contacts mentioned in the preceding **Para No.-8** above.

This section of DMP specifies person(s) responsible for declaring an emergency under various circumstances, and for initiating emergency actions.

9.1 Teesta Urja Ltd

- Determine and identify the condition(s) or triggering event(s) that initiate or requires emergency actions, and specify the actions to be taken and by whom.
- Teesta Urja Ltd will form teams comprising of personnel from various departments for effective emergency management. Roles and responsibilities of the teams must be clearly defined.
- Respond to the observed/ reported conditions/ incidents/ unusual events to detect whether an potential emergency exists.
- As soon as an emergency event is detected, immediately determine the emergency level **as per the preceding Para No.-5.**
  - Level 1: Non-emergency incident; Unusual event; Slowly developing situation
  - Level 2: Potential dam failure situation; Rapidly developing
  - Level 3: Urgent; Dam failure is imminent or in progress
- Describe who is responsible for taking specific actions at the dam after the emergency notification procedures have been implemented. Also provide instructions for the operation of the project during the anticipated emergency.
- Describe who is responsible for communicating emergency messages with the internal stakeholders and external stakeholders (Local Emergency Manager, Sikkim State Disaster Management Authority and National Disaster Management Authority etc.)
- Ensure immediate notification to the personnel in the order shown on the notification flow chart for the appropriate emergency level.
- Provide updates of the situation to the Local Emergency Manager to assist them in making timely and accurate decisions regarding warnings and evacuations.
- Provide leadership to assure the DMP is reviewed and updated annually and copies of the revised DMP are distributed to all who received copies of the original DMP.
- Facilitate exercise of the DMP as necessary to ensure the effectiveness of the DMP and emergency response.

9.2 Local Emergency Manager/ Nodal officer

- DM/ ADM of District (Sikkim) will act as the Local Emergency Manager/ Nodal officer for Teesta-III H. E. Project.
- Serve as the primary contact person responsible for coordination of all emergency actions.
- Maintain communication with media.
- When a Level-2 situation occurs:
  - Prepare emergency management personnel for possible evacuations that may be needed if a Level 3 situation occurs. Also alert public as appropriate.
- When a Level 3 situation occurs:
  - Initiate warnings and order evacuation of people at risk downstream of the dam.

- Carry out the evacuation of people and close roads within the evacuation area.
- Alert the general public for the emergency with the help of public addressing systems like sirens, loudspeaker etc.
- Air lifting facility may be used for rescue of affected person in emergency situation.

- Decide when to terminate the emergency.
- Participate in annual review and update of the DMP.

9.3 District Development Management Authority (DDMA)

The DDMA acts as the planning, coordinating and implementing body for disaster management at the district level as per the guidelines of the National Disaster Management Authority **(NDMA) and** State Disaster Management Authority **(SDMA).**

The Disaster Management Plan prepared for Teesta-III H. E. Project takes into consideration only the actions that are required to be taken by Teesta Urja Ltd. on account of emergencies arising out of operation of Teesta-III H. E. Project. These actions basically relate to proper maintenance of Teesta-III H.E. Project and of timely warning to District Administration in the event of impending disaster. Further actions in the event of disaster are to be taken by the District Administration for which they are required to prepare District Disaster management Plans for each District.

These District Disaster management Plans would cater to situations not only arising out of operation of Teesta-III H. E. Project but also from natural disasters. Thus for example, the region is prone to earthquakes, a large earthquake occurring at Teesta-III H. E. Project may not affect the dam at all and therefore no action would be required based on Disaster Management Plan prepared for Teesta-III H.E. Project, but this earthquake can cause considerable damage otherwise for which the District Administration is required to have a contingency plan. So is the case with floods. Contingency plans have to be prepared for other minor disasters likely that are due to forest fires, cloud bursts, cyclones etc. Thus the Disaster Management Plan prepared for Teesta-III H. E. Project would get merged/ separated into the District Disaster management Plans prepared by the District Administration.

The District Disaster management Plans would *inter-alia* includes the following and would be annexed with this document by District Administration:

1. Flood Plain Zoning. It regulates the land use in the flood plains in order to restrict the damage by floods. It also aims at determining the locations and the extent of areas likely to be effected by floods of different magnitudes.
2. Flood warning system and Communication Plans.
3. Resource mobilization planning.
4. Rescue Relief.
5. Pre-disaster preparedness. This is a well-documented emergency plan for effective preparedness to face the disaster and to avoid last minute arrangements in panic conditions.
6. Disaster Preparedness.

9.4 Sikkim State Disaster Management Authority

Respond to specific requests from the Local Emergency Manager to help minimize the impacts of an emergency event. As envisaged in the National Policy on Disaster Management it is the primary

responsibility of the State Governments/ State Disaster Management Authority **(SDMA)** to monitor and assess any developing situation and keep the National Disaster Management Authority **(NDMA)** and National Executive Council **(NEC)** apprised of the same. They will also be responsible to constantly evaluate their own capabilities to handle that situation and project the anticipated requirements for the Central resources well in time. Inter-state assistance and cooperation will be encouraged. The State will also be responsible for developing their-own response potential progressively and complete the process at the earliest. This will comprise training and equipping of State response forces, community preparedness, training and creation of response caches at the District level. District level preparations will provide the cutting edge to all response activities. Local authorities, PRIs and ULBs will play a significant role in the entire process, particularly in response and rescue operations, relief and rehabilitation, awareness generation and disaster preparedness, restoration of livelihood options and coordination with NGOs and civil society.

9.5 National Executive Council (NEC)

The NEC will coordinate response in the event of any threatening disaster situation or disaster. While disaster specific guidelines will be formulated by NDMA, NEC may give directions to the concerned ministries/ Departments of the Government of India, the State Governments and the State Authorities regarding measures to be taken by them in response to any specific threatening disaster situation or disaster.

9.6 Down Stream and Upstream Projects

- Provide timely information regarding sudden water release from the projects located at the upstream of Teesta-III, landslides/ floods occurred in the vicinity of the project which may cause an emergency.
- Respond to any other specific requests from Upstream and Downstream projects to help and minimize the impacts of an emergency event.

9.7 Project Security

- Project security will prevent any incident of sabotage/ vandalism/ bomb threat and shall have a bomb squad.
- Provide timely and reliable information on any security threat.
- Respond to specific requests from Local Emergency Manager to help minimize the impacts of an emergency event.
- Advise Local Emergency Manager when conditions are safe to terminate the emergency.

10. EMERGENCY PREPAREDNESS PLAN

A situation of emergency arises in case of an impending disaster. The disaster itself may be natural or man-made. While natural disasters run through a definite known cycle of events and follow certain norms of localized scale, man-made disaster neither have known cycle of events nor are they necessarily spatially and temporarily restricted. In other words, natural disaster barring earthquake, may be considered to be structured events while man- made disasters are unstructured.

Floods are one of the natural events, which often spell disaster. The disaster due to the existence of a dam may be natural or man-made disaster. The disaster would be considered natural if the quantum of outflow from the dam is equal to the inflow flood. If, however, due to the existence of dam the

outflow exceeds the inflow, the disaster can be logically classified as man-made. In the event of dam break also, it will then be purely man-made.

10.1 Planning for emergency

The emergency preparedness plan should, however, be applicable for both natural and man-made disaster. The man-made disaster arising out of an outflow in excess of the inflow can be taken care of by developing operation rules with built-in factor of safety and adequate and efficient warning system. Our greater concern is to evaluate the disaster, consequent to dam break.

Disaster preparedness can minimize loss of life and property by proper planning in advance so that measures are available to counteract the disaster. Visualizing challenges in advance to equip and to meet it effectively is the hallmark of rational human being. Such planning would call for correct assessment of the following items:

- Evaluation of the disaster - advance knowledge of the likely occurrence of floods.
- To identify the likely effects on property and human beings with a view to assess the damage potential of the disaster.
- Vulnerability analysis and hazard area mapping to identify the most common area prone to such type of disaster.
- Review of organization and machinery for proper upkeep and maintenance of flood control works like dams, embankments, etc.
- Review of the provision of anti-disaster shelter - adequacy of medical aid facility, transportation, food, etc.
- Review of existing method of flood and cyclone warning system with a view to rectify the missing links and gaps and modernizing the system in accordance with the latest state-of-art, if necessary.

10.2 Inputs for preparation of Emergency Plan

Planning of emergency preparedness plan would get facilitated if the "flood plain zoning bill" has been enacted and is given effect for the basin under consideration. Such an approach would minimize the effect of the disaster at a later stage. Flood-plain zoning measures aim at demarcating zones or areas likely to be affected by floods of different magnitudes or frequencies and probability levels, and specify the types of permissible developments in these zones, so that whenever floods actually occur, the damage can be minimized, if not avoided. Unfortunately, while all generally endorse this approach in principle, scant attention is given to it in actual practice, leading to increased flood damages. The Central Water Commission **(CWC)** has continuously impressed upon the states the need to take follow-up action to implement the flood plain zoning approach.

Release of large amount of water due to combination of flood coupled with dam break, disaster preparedness shall be done for the dam. The Inundation map is the first input for planning an effective emergency preparedness plan. The following guidelines are suggested:

- Assess the safe carrying capacity of the downstream channel and the safe levels.
- Assess the inundation area for
    - 25 years flood;

- 50 years flood
- For routed design flood
- For PMF + dam break

The inundation map may be prepared for 25 years flood, 50 years flood and routed PMF in the order in which they are indicated above. The Dam break studies shall be carried out to evaluate inundation area due to dam break floods. The inundation map for floods coupled with dam break shall be prepared subsequently after conducting studies on dam break and collecting additional data, etc.

The population and property situated within the area prone to inundation and damage must be surveyed to identify the emergency potential. Based on this survey, the index maps and detailed maps of likely inundation area due to dam break floods are to be prepared. The index maps and detailed maps of the dam break inundation area should ordinarily be prepared and handled as secret documents. These maps should also indicate location of safe high ground which can be used for evacuation and shelter purposes.

In respect of cities or towns and the villages falling in the likely inundation area of dam break floods, the detailed contour maps of the entire area showing contours at 0.5 m intervals should be prepared. The hypothetical dam break flood line, the 25 years return period outflow and the maximum spillway design discharge flood line (wherever relevant), the various populated sectors, streets and roads, public buildings, important installations and all prominent places must be marked on these plans. The detailed maps should be prepared on the available town planning or city survey or land record plans or village maps.

The volume of the inflow must be predicted before releases can be determined. Although forecasting of the runoff from reports of rainfall and river stage / discharges provides a sound basis for operation/ regulation of reservoir.

Therefore, an adequate flood forecasting system with proper communications such as wireless, walky-talky etc. needs to be established for reservoirs and such system is likely to provide enough advance information of incoming flood volumes useful for reservoir regulation/ operation. An adequate plan for collection and analysis of hydrological data should be developed and adopted in order to ensure efficient operation of reservoirs, particularly during the monsoon period. A suitable network of rainfall and river gauging stations should be established. This would provide sufficient basic data to evolve a reliable programme of flood forecasting for use in the reservoir operation.

The instrumentation for the purpose should include hydrological sensors with capability of in-situ recording and compatibility with telemetry network for the operation of reservoirs. The number and distribution of ordinary and self-recording rain gauge station should be decided based on the storm characteristics and topography of the region and the requirements of flood forecasting. An adequate number of river gauging stations should be set at key locations to provide satisfactory information on current river stages/ flows upstream and the total inflow to the reservoir.

Manual and/ or automatic reservoir gauges should be installed for obtaining current reservoir levels. Reservoir levels should be recorded at regular intervals, say every 12 hourly. However, during flood times the reservoir water level/ gauges should be observed hourly.

A close co-operation should be maintained with the nearest office of the Indian Meteorological Department **(IMD)** to obtain the data on current weather situation and its expected development. It would be necessary to have a separate meteorological unit which will collect the necessary data and interpret them to the engineer-in-charge of operations.

The mode and frequency of communication of basic data recorded by reporting stations should be decided based on the requirements of such data at the given time. The data transmission media such as telephones, telemetry, VHF wireless, general purpose communication satellites etc, should be used for communication of data. All these types of transmission media may be used either singularly or in combination.

The hydro-meteorological data collected during storm periods should be analysed by suitably trained personnel. Use of computer at the analysing centre may be useful in providing accurate information on prevailing and anticipated flood stage/ flows at all the locations of interest. Forecast of inflow into the reservoir and the regulation plans during storm period should be developed usually every six hours or as required using the advancements in techniques. Based on the results of this analysis, the operations should be determined by the engineer-in-charge of the reservoir system operation taking into consideration the operation schedule.

In order to facilitate and to keep up-to-date information for the operation of reservoirs, a proper record of all the data pertaining to reservoir operation should be maintained. A suitable computerized data base management system is essential for storage and retrieval of data/information. Data received from the data collection network should be stored in the data base.

10.3 Priority of Spillway Gate Operation

It has been desired by the **statutory authority (CEA)** while according concurrence of Teesta-III project that **"The Reservoir water level during the monsoon period shall be maintained at MDDL (Minimum Drawdown level) El. 1565.0m".** Therefore during the monsoon period the water level in the reservoir shall be maintained at El. 1565.0m (MDDL) which is a statuary requirement. There are four spillways provided for regulation/ management of flood water in the reservoir based on the water availability and its requirement. The spillways should be operated in the priority as listed/ detailed below in Table:

S.N.	Priority	Facility to be operated
1	**Priority No.-1**	Chute Spillway
2	**Priority No.-2**	Left Bank Diversion Tunnel Spillway No.-1
3	**Priority No.-3**	Left Bank Diversion Tunnel Spillway No.-2
4	**Priority No.-4**	Flushing cum Spillway Tunnel

The Volume of outflow shall be computed from the above mentioned spillway's Rating Curves depending upon the time required for reservoir evacuation; volume of water to be released from the reservoir; reservoir levels; volume of river inflow and accordingly the spillway gates shall be regulated. The reservoir regulation shall be done as per **"Reservoir Operation and Maintenance Manual".**

10.4 Flood Warning

Whenever the water is released from the reservoir through any of the spillways/ outlets for management of Flood/ high discharges to the downstream of diversion dam the following precautions shall be taken:

a) The Local civil administration authorities may be informed in advance before releasing the water from the reservoir.
b) The Sirens may be blown to alert/ inform the downstream population so that the people can take action in advance for their safety.
c) The Power House control room shall be informed in advance.
d) The downstream project under construction/ under operation should be informed.

The sirens/ hooters may be installed at every Km between dam and power house. A fool proof flood warning system may be installed in the river reach between dam and power house. At close interval, along the river reach, sign boards /warning signs may be displayed about the HFL and danger associated with sudden release of water from the dam. The Public awareness programs shall be conducted every year about the precautions to be taken during release of high flood from the reservoir.

10.5 Availability of Equipment, material and Manpower

The location of readily available Equipment's, Tool and Plants, Materials, Manpower/ labour and Engineering Expertise, which can be required needs to be identified and properly planned. In case of any emergency, when required, these shall be readily available without any loss of time during emergency.

All emergency preparedness plans shall be reviewed every year depending upon its operation.

11. DISASTER MITIGATION PLAN

The mitigation plan for each of the above hazard specific disaster is detailed below to avoid losses/ damage to life and property:

11.1 Disaster due to Earthquake

The proposed Teesta-III HE project site lies in seismic zone IV as per the seismic zoning map of India as incorporated in Indian Standard Criteria for Earthquake Resistant Design of Structures **IS:1893-(Part I) 2002 : General Provisions and Buildings.** It is usually presumed that in design of normal structures adequate safety would be attained if structures are designed as per codal recommendations.

The seismic site specific studies for Teesta-III H E Project were carried out by IIT, Roorkee. The Maximum Considered Earthquake **(MCE)** has been evaluated on the basis of above studies using deterministic approach and the same is recommended for consideration in the design of structures and accordingly the Dam and other appurtenant structures of Teesta-III project have been designed.

After the earthquake event the visual inspection of Dam and other appurtenant structures shall be carried out and instrumentation readings shall also be taken and the same shall be intimated to the designer. If the instrumentation readings indicate magnitude of earthquake more than Design Basic Earthquake **(DBE)**, the information shall be immediately passed to Power House, state civil authorities etc. **If there appears to be any possibility any substantial damage or failure of dam**

or any appurtenant structures due to earthquake immediate information shall be passed on to Civil Authorities, warning Stations, projects authorities of project located in the downstream. The people living near Highest Flood Level **(HFL)** mark shall be asked to be ready for evacuation. Necessary action to shift the project staff to safer places shall be taken by the project authorities.

11.2 Disaster due to unprecedented Flood due to cloud burst

Teesta-III HE Project being a run-of-the-river scheme does not afford the flood protection if power plant is operated at FRL. The Power plant shall be operated at MDDL during the monsoon to minimize the risk of overtopping of the dam in the event of natural calamities such as Cloud Burst and Flash Flood.

The **Cloud burst** is an extreme weather event in which very heavy rainfall occurs over a high localized area in a very short time span. Generally the cloudbursts in India occur during monsoon season over mountainous regions. Though, cloudbursts usually do not last for more than few minutes but they are capable of flooding the entire area. Rainfall from a cloudburst is usually equal to or greater than 100 mm per hour. Cloud bursts are generally associated with thunderstorms.

The **Flash Flood** is a flood that raises the stream/ reservoir water level quite rapidly without any advance warning. Usually this occurs due to heavy intense rainfall in a part of the catchment area of the stream.

The flood moderation is one of the important functions of a reservoir. The flood moderation aims to moderate the flood flows by temporarily retaining the flood water and making controlled releases within the safe carrying capacity of the downstream channel in order to minimise flood damages. Therefore, one of the essential features of reservoir operation for flood moderation is that storage between MDDL and FRL shall act as temporary flood storage during the passage of floods and thereby reduce flooding at the affected downstream reach of the river. Further, when flood storage space is being occupied, maximum possible releases by opening both spillways gates shall be allowed in order that this space can be vacated before the onset of the flood.

Generally, in order to safeguard the permanent structures of the project against exceptional floods, elaborate flood warning system has to be installed to safeguard the project components and for the safety of men and machinery employed at the project sites having telecommunication, wireless and satellite based data communication system.

To deal with flash flood of large magnitudes, it is absolutely necessary that accurate and timely warning of heavy inflows into the reservoir is transmitted to control room so that sufficient time is available for proper assessment of flood and depleting the reservoir in anticipation of heavy inflows and timely operation of spillways gates. Based on this, the requirement of depleting the reservoir level by operating the spillway gates shall be decided as per the guidelines mentioned in **"Reservoir Operation and Maintenance Manual". The power plant must be operated at MDDL during monsoon.**

During the floods, the river carries a lot of silt, boulders, gravel and trash etc. and the same may settle or float in the reservoir water. If the silt content shows a rising trend beyond the permissible limit, the power Plant shall be shut down and Power Intake gates shall be closed. The reservoir shall be regulated as detailed/ described in **"Reservoir Operation and Maintenance manual".**

11.3 Disaster due to Dam Break

In the eventuality of dam break/ failure, the disaster would be catastrophic. Therefore, it is the responsibility of the Project authorities involved with the safety of the dams, to plan preventive measures so that in the eventuality of dam failure, the losses can be minimized to the extent possible. One of the preventive measures in avoiding dam failure disaster is by issuing flood warning of the imminent flood to the public residing in the areas likely to be affected, as early as possible if there is a possibility of dam failure. However, it is quite difficult to conduct analysis and determine the warning time of the dam break flood at the time of disaster. Therefore, pre-determination of the warning time assuming various hypothetical dam break situations is an essential part of dam safety measures.

The failure of **Concrete Faced Rock-fill Dam (CFRD)**, as envisaged in the Teesta-III hydroelectric project, is a very-very remote possibility as the dam has been designed as per the international/ Indian technical standards and built with adequate quality control. Moreover, compared to other types of dams, maximum possibility of failure of rock fill dam in worst case situations is limited to breach of dam than complete breaking of dam.

The dam break analysis of Teesta-III H. E. Project has been carried out for the worst condition in which it has been assumed that whole dam gets washed away. A breach with bottom width of 50 m at an elevation 1530.00m has been considered. The maximum discharge in the event of dam break shall be **62635 cumecs**, about 0.6 hours after the break. The assumed condition that the entire dam gets washed away instantaneously is only hypothetical.

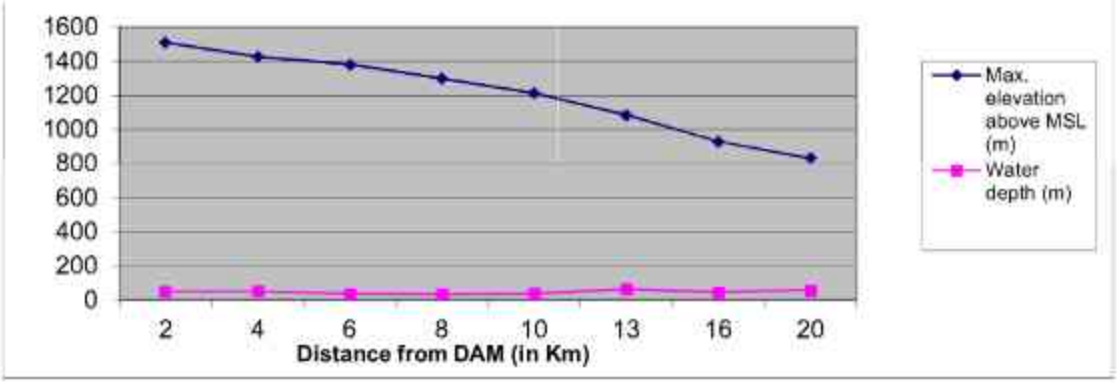
The water depth and water spread at various distances downstream of the dam in the event of dam break are outlined in Table below. The variation of flood water level with distance is given in **Figure-1.**

Water depth and spread downstream of dam in the event of dam break

Distance from dam (km)	Max. elevation above MSL (m)	River bed level (m)	Water depth (m)	Water spread width (m)
2.0	1507.4	1458	49.47	194
4.0	1425.13	1275	50.00	143
6.0	1379.70	1345	34.70	207
8.0	1297.71	1265	32.71	128
10.00	1211.55	1175	36.11	171
13.00	1082.91	1020	62.91	129
16.00	927.20	885	42.20	200
20.00	830.39	775	55.39	228

The inundation map depicts the downstream areas vulnerable to inundation by the flood generated in the event of dam break. The selected dam break flood for this purpose corresponds to the extreme conditions that yield maximum possible flow stages at the downstream location i.e. a worst case scenario which corresponds to maximum breach width, minimum time of failure and maximum Manning's roughness coefficient. The peak stages are then converted to flood levels/ elevation. These elevations are marked on the topographic sheets depicting areas likely to be flooded.

Figure-1 Variation of Flood Level with distance



The map so prepared serves as a guide for deciding the vulnerable areas where Emergency Action Plan (EAP) is to be executed. The Inundation Maps have been prepared considering the distances from the Dam and corresponding flood level at these places as tabulated above. The under mentioned drawings showing the inundated area upto 20.00Km downstream of dam and approach roads to different project components are appended as **Annexure-4** for reference:

- General Lay out Plan **(Drawing No. T-3-WAP-GA-005)**
- General Lay out Plan showing Inundation map **(Drawing No. T-3-WAP-GA-006)**
- Inundation plan near the Dam area **(Drawing No. T-3-WAP-GA-007)**
- Inundation plan near the Power House area **(Drawing No. T-3-WAP-GA-008)**
- Plan showing the Approach Road to Dam complex **(Drawing No. T-3-WAP-GA-009)**
- Plan showing the Approach Road to P.H. complex **(Drawing No. T-3-WAP-GA-010)**

The above maps/ drawings shall be verified and updated from time to time depending upon the actual site condition for carrying out the Emergency Action Plan efficiently.

The dam safety programme as indicated above includes the formation of an Emergency Action Plan for the dam. An emergency is defined as a condition of serious nature which develops unexpectedly and endangers downstream property and human life and requires immediate attention. The project authorities shall classify the event as per the preceding Para-5 "Disaster Emergency Level Determination" above and remedial / safety measures shall be carried out as mentioned in the preceding Para-6 "Emergency Response Plan" above. The objective is to provide timely warning to nearby residents and alert key personnel responsible for taking action in case of emergency.

Once the likelihood of an emergency situation is suspected, action has to be initiated to prevent a failure. The point at which each situation reaches an emergency status shall be specified and at that stage the vigilance and surveillance shall be upgraded both in respect of time and level. At this stage a thorough inspection of the dam should be carried out to locate any visible sign(s) of distress. The Engineers responsible for preventive action should identify sources of equipment needed for repair, materials, labour and expertise for use during an emergency. The amount and type of material required for emergency repairs should be determined for each dam, depending upon its characteristics, design, construction history and past behavior. It is desirable to stockpile suitable construction materials at an appropriate site. The anticipated need of equipment should be

evaluated and if these are not available at the dam site, the exact location and availability of these equipment should be determined and specified. The sources/agencies must have necessary instructions for assistance during emergency. Due to the inherent uncertainties about their effectiveness, preventive actions should usually be carried out simultaneously with appropriate notification on alert situation or a warning situation.

11.4 Disaster due to Land slides

The landslides are simply defined as the mass movement of rock mass, debris or earth down a slope whereby falling, sliding and flowing under the influence of gravity dislodges earth material. They often take place in conjunction with heavy rainfall, earthquakes and floods etc. At times the prolonged rainfall may cause blockade of the rain water stream flow or river flow for quite some time. The formation of river flow blockade can cause havoc to the settlements in the downstream on its bursting. In the hilly terrain the landslides have been a major and widely spread natural disaster the often strike life and property and occupy a position of major concern. The Himalayas mountain belt comprise of tectonically unstable younger geological formations subjected to severe seismic activity. The slides in the Himalayas region are huge and massive and in most cases the overburden along with the underlying lithology is displaced during sliding particularly due to the seismic factor.

The disaster due the landslide can also be manmade due to various reasons such as failure of natural hill slopes due to various construction activities in the project area like construction of access roads, muck dumping sites, quarry sites, colonies, offices etc.

The landslides can also be caused by poor ground conditions, geomorphic phenomena such as ground uplift and erosion, natural physical forces and quite often due to heavy spells of rainfall coupled with obstructed drainage. The landslides may cause road blockade and this may cause obstruction in the movement of manpower and machine and will hinder different urgent activities required for running and management of the project work.

In order to prevent the landslides suitable vegetation/ plantation and proper drainage arrangement shall be provided in the project area. The retaining walls/ breast walls/ toe wall shall be constructed to prevent the hill slope failures. In case the landslides has caused road blockade the same should be removed immediately.

11.5 Disaster due to Fire

As long as fire is under our control, it serves a lot of useful purposes for us, but once it goes out of our control it can create a lot of destruction. However, despite the presence of fire safety measures, the occurrence of accidents is many times inevitable. The fire is used for many useful purposes. Therefore, people keep sources of fire in/ around their houses/ workplace. These sources could sometimes result in "undesired" fire. Thus, the occurrence of fire related accidents is often inevitable in spite of all the safety precautions. For this reason, an insurance policy should always be taken. The most common causes of fire are:

a. Electrical
b. Pantry Area
c. Smoking

a. **Electrical:** Incidents of Fire mainly caused due to overloading, short circuit etc. it is seen that many times people start making modifications to the electric sockets in order to plug in additional electric appliances/ apparatus etc. This result in the total amount of current drawn from all the sockets together exceeds the rated capacity of the internal wiring and may cause fire. Therefore, it is advisable not to make too many changes to the electrical circuit at work-place. While making any alterations it should be kept in view that the total amount of current drawn is within the capacity of the wires used. As time progresses the insulation among wires might break down. This might cause some wires to come in contact with each other and thus cause short circuit. This short-circuit can cause a very high current flow through the wires and thus causing fires. Therefore, periodic inspection of wiring shall be carried out and preventive measures shall be taken whenever needed. Install MCBs (Miniature Circuit Breakers) so that any short-circuit would result in immediate disconnection of the current flow.

b. **Pantry Area:** Leakage of cooking gas accompanied by a spark around the leakage would cause fire. These are typically very dangerous. The sources of sparks could be anything such as burning item, turning on/ off of electrical gadgets/ switches etc. The leakage itself can be in the gas cylinder or in pipeline carrying the gas or regulator or joints etc. Some simple precautions to be taken for this include:
   - Regular inspection of gas pipes and its timely replacement.
   - No sparks/ turning on/ off of electrical gadgets/ switches in case there is any trace of LPG smell.
   - Just like electrical points turn off gases at multiple points when not in use.

   While cooking sometimes the cooking medium could get overheated and may cause fire. Therefore, the cooking oil shall not be left unattended when it is being heated. Also do not keep bottles of oil etc. in contact with very hot object like hot utensils etc.

c. **Smoking:** Smoking in or around combustible materials could cause fire due to hot ashes falling from the cigarette. Some simple precautions to be taken include:
   - Don't smoke in or around bed, sofa etc.
   - When you throw away the cigarette etc. always stub it out.
   - Always try to dispose-off the cigarette-ash at proper places.

   Incidents of fires are usually not evenly distributed. There are higher numbers of fires during:

d. **Summer season:** Due to higher ambient temperature and tree leaves etc. being dry catch fire easily. This is the time, when many forest-fires start.

e. **Some specific festive events:** Due to use/ availability of fire-crackers and lights etc. during festivals. Fire based lights could pose a direct fire-risk while electricity based lighting could cause the risk due to overloading.

Hence, it is important to be more careful during these periods. This will not only increase the chances of incidents higher but also overload the local Fire fighting department. This

might have an impact on their ability to respond swiftly on call in case there is a need as they could be busy fighting fire elsewhere.

11.6 Classes of Fire

It is important to know about the classes of fires because fire-extinguishers are classified and marked based on the type of fire on which they would be effective. The use of wrong fire extinguishers could be ineffective and may be fatal also in some cases. The following are the classes of fire-extinguishers:

- **Class-A:** These are fires that involve some solid material like, cloths, paper, junk-heap, wood etc.
- **Class-B:** These are fires that involve liquid materials like: petrol, gasoline, diesel, oil etc.
- **Class-C:** These are fires that involve electrical elements
- **Class-D:** These are fires are those involve metals

11.7 Types of Fire Extinguishers

The following are the types of fire-extinguishers normally available in market:

a. Water Based
b. Foam Based
c. CO_2 Based
d. CFC Based
e. Dry Chemical Based

a. Water Based:

These are most effective on **Class-A** fires. On **Class-B** fires, these are mostly ineffective. This is because, oil/ petrol/ gasoline etc. being lighter than water continues to float over water and thus, it continues to burn. In some cases use of water based extinguishers on **Class-B** fires could turn out to be injurious also. That is because the water thrown over burning fuel the force due to water-stream could cause burning petrol to be sputtered and this hot fuel could cause injury in case it falls on somebody.

On **Class-C** fires, these should never be used. Use of water based extinguishers on **Class-C** fires would surely be fatal. That is because water is a good conductor of electricity and the electric current flows through the water-jet directly into the hands of the person who is holding the water-hose resulting in immediate electrocution.

In case of the water based fire extinguishers the water comes in contact of burning materials and because of the high temperature water vaporizes. While vaporizing it extracts the latent heat from the burning element thereby reducing the temperature. Besides, vaporization it also expands. Usually, the expansion is in the order of 100 times (by volume). The need for higher volume of steam (vaporized water) displaces oxygen from the immediate vicinity of the burning material, thus, cutting off the oxygen supply. Also, water being non-combustible material also tries to form a coating between the atmosphere (which is supplying the oxygen) and the combustible material.

Thus, it tries to reduce temperature, as well as displace oxygen thus it extinguish the fire.

b. Foam Based

These are used mostly on **Class-B** fires. It can also be used on **Class-A** fires. These should never be used on **Class-C** fires. The main constituent of foam being water – it can easily prove to be fatal on a **Class-C** fire. Foam being lighter engulfs the burning liquid. By covering the burning liquid it cuts off the supply of oxygen to the burning material. Besides, the vaporization of water also helps in reduction of temperature due to extraction of latent heat. The basic principle is thus similar to Water Based Extinguisher. The only difference is foam stays above burning oil thus trying to engulf the fire and something that water could not do.

c. CO_2 Based

These are mostly used on **Class-C** fires. It can also be used on **Class-A** and **Class-B** fires. These kinds of extinguishers might also be used to extinguish fires in computers and costly electronic equipment where usage of water could cause damage to the equipment. The biggest advantage of these kinds of fire extinguishers is that it does not leave any residue smell or mess.

However, usage of these kinds of extinguishers in confined space could result in poisoning. Because, under lack of oxygen carbon-di-oxide could react as a fuel and the resulting gas produced could be carbon-monoxide and which is highly poisonous.

During the operation of these extinguishers a stream of dry-ice (trade name for solidified carbon-di-oxide) is directed towards fire. Dry ice being very cold helps to reduce the temperature. Being heavy the carbon-di-oxide gas settles on the burning equipment thus blowing away the oxygen – thereby cutting out the availability of oxygen to fire.

Sometimes, the printed circuit boards (PCBs) of this electrical equipment could develop a crack, because the burning material which was hot is suddenly subjected to a very cold temperature (of dry ice). However, having a few cracks on a few boards might be a better choice than using water/foam, which will cause total short-circuit within the electrical circuit.

Carbon-di-oxide based extinguishers have an additional advantage. Being primarily gaseous in nature, the extinguishing agent can easily percolate inside machinery through fine slots (usually provided for ventilation/ heat dissipation) on the outer casing of the equipment. So, it can be much more effective in fires which are inside the casing of electronic equipment.

d. CFC Based

These are mostly used on **Class-C** fires. **CFC or Chlorofluorocarbons** is one of the most dangerous air pollutants. It can also be used on **Class-A** and **Class-B** fires. The main difference between CO_2 based extinguisher and CFC based extinguishers is that instead of carbon-di-oxide it uses some gases namely CFCs. These extinguishers also do not leave any residue, smell or mass. However, these are highly damaging to the environment (because of the tendency of CFCs to deplete the ozone layer). Many variants of CFCs are already banned. Some newer and cleaner variants are already under consideration. These extinguishers are very costly, both in terms of money as well as impact on environment, and hence, should be used only on very costly, specialty equipment.

The working of this equipment is very simple. They simply displace the oxygen at the burning site and these being highly sluggish gases would not take part in any chemical reaction (including the process of burning) nor would let the burning material take part in the burning process and thereby extinguishing the fire.

These kinds of extinguishers can also be used on metallic fires (**Class-D**). Other extinguishers mentioned earlier could have mixed results on **Class-D** fire depending on which metal is burning.

e. Dry Chemical Based

These are most commonly used type of fire extinguishers. It can be used on **Class-A**, **B** and **C** fire. Hence, it is popularly also called as **ABC** type extinguisher. Its impact on **Class-D** fire could be varied depending on the type of metal being burnt. It works in the following way:

It stores dry yellowish chemical powder (mono-ammonium phosphate) under pressure of nitrogen gas or, any other inert gas. When turned on the dry powder is sprayed with pressure onto the burning material along with the inert gas. Nitrogen displaces oxygen. The powder itself sits on the burning material and thus removing contact between burning materials. The powder is a non-conductor of electricity – hence, it is equally effective on **Class-C** fire.

11.8 Fire Fighting Strategies

The constituents of a fire and various kinds of fire-extinguishers have been detailed above in the preceding paragraphs. If any fire occurs, depending on the circumstances, it has to be decided what method/ strategy has to be adopted to extinguish the fire. Accordingly, appropriate type of fire extinguisher has to be used.

As an example some different fire-situations and the corresponding strategies are explained below:

- ***Fire in human cloths:*** In case some person' s clothing catches a fire, simply wrap the person in blankets or any other thick piece of clothing layer and roll the person on the ground. The fire gets extinguished due to lack of oxygen supply.
- ***Let the fire die:*** Sometimes, just isolate the burning material from other combustible material. The fire would simply die down, once it has burnt the entire burning material as it finds nothing else to burn.
- ***Fire in pantry area:*** Simply cover the utensil which contains the burning oil etc. Lack of oxygen supply will simply extinguish the fire. Meanwhile turn off the stove. This will help bring down the temperature.
- ***Class-C Fire:*** Use of incorrect extinguishing agent (water or foam based) on a **Class-C** fire would simply be fatal. Thus, do not ever pour/direct water jet/stream on a **Class-C** fire (or, even where electrical involvement is suspected). It will be fatal. Hence, first thing to do would be to convert it into a **Class-A** fire. This can be done by turning off the electric supply. However, if you are suspecting gas-leak also, don't flip the switch. If in case the water is to be used as a last resort than throw mugful of water from a safe distance, such that the last drop of water has left the mug, before the first drop of water touches the electrical line. This way, the continuity of the water stream is broken, and, electricity cannot reach your body. This method is to be used only in case no other alternative is advisable.

- ***LPG Cylinder related fire:*** First and foremost is to keep the cylinder standing upright. An upright cylinder, with a fire at its mouth is not necessarily that dangerous. Cylinder on fire in a rolled-down position/ upward-down is an explosive. Stay away from it. The regulators of the LPG cylinders are not designed to handle rolled-down cylinder. The fire can enter the cylinder causing the pressure in its neck area and thus causing an explosion. In order to put out a fire at the mouth of a cylinder, pour approximately 60 litres of water in one go at the base of the fire. In very high probability, the fire would be extinguished.

11.9 How to Use Fire Extinguisher

Most extinguishers are based on PASS System. The abbreviation of word **"PASS",** to remember the operational steps involved are detailed below:

- **"P"**- Pull the Pin on the extinguisher. This pin is kept to prevent accidental discharge while carrying/transporting the extinguishers.
- **"A"**- Aim the nozzle of the extinguisher at the base of the fire. Its very important that the discharge from the extinguisher is directed towards the base of the fire. Most people make the mistake of directing the extinguishing agent on the fire itself. That's ineffective. The extinguishing agent should be directed at the base of the fire – where the burning material is located. That is the point, where the fire-triangle is established, which needs to be broken.
- **"S"**- Squeeze the trigger, so that the extinguishing agent starts flowing out of the cylinder, and, onto the burning material – at the base of the fire.
- **"S"**- Swipe the nozzle sideways to coat the entire burning material, with the extinguishing agent.

11.10 Precautions While Fighting a Fire

The following precautions shall be taken while fighting a fire:

- **Always stay upwind:** It protects from heat, smoke etc. It allows going closer to fire - thus, being able to better direct your extinguishing agent. It protects you from inhalation of poisonous gases, which might be given out during the fire.
- **Keep under observation:** Even when the fire is extinguished, blazing particles can easily revive fire, thus keep the fire place under guard.
- **Fire extinguishing agent:** Pour extinguishing agent in adequate quantity rather than small quantities. Doing it in instalments does not help. One discharge of 60 liters of water is not the same as two discharges of 30 liters each. If you have to pour 4 buckets of water, have the 4 buckets ready, and pour the water of all the four buckets in one go. Instead, if you pour two buckets of water, refill them, and, pour again.

11.11 How to help in case of a Fire

The following are the ways to help and to assist in fire-incident to extinguish fire:

1. Direct help in fighting the fire, if you are able, and are knowledgeable in fire-fighting.
2. Provide background logistics support
3. Inform the local fire station
4. Help in crowd-control, and keeping the curious onlookers at fire place.

5. Help in directing fire engines and rescue vehicles (particularly in the internal lanes/ sub-lanes etc.
6. Clearing the way for fire-fighting crew.
7. Do not panic and decide strategy.

Do not put yourself and others at risk. Do not question the established chain of command. There are multiple ways of fighting a fire. This is not the time to argue and convince each other on the best method.

11.12 Disaster due to Gate Operation failure

In normal condition one gate of chute spillway has been considered inoperative. However, if more than one gate is not operative the matter shall be reported to the Teesta Urja Ltd. Engineering department for further advice. Also all Hydro-mechanical and electrical equipment should be maintained properly and inspected at regular intervals to avoid any mishap in case of emergency. The working of all the spillway gates should be specially checked before the onset of monsoon every year to ensure that the gates are in proper working condition.

11.13 Disaster due to Abnormal reading in Instrument

The Instrumentation in Dam and other appurtenant structures is done to monitor the structural behaviour of the various structures. The following are the objectives of monitoring of various structures by instrumentation:

- **Safety Evaluation**
- **Early Warning of ingoing distress in the structure**

The primary and the most important purpose of monitoring is to provide necessary information about the health/ performance of the structures and also enlighten about adverse condition or distress taking place in the structure. Therefore regular observations of instruments installed in critical areas provide early warning of malfunctioning or any ingoing development of distress that may endanger the safety of the dam and other appurtenant structures, thereby ensuring timely remedial action/ measures.

All the instruments installed in Dam and other appurtenant structures shall be monitored. A record of the above instruments readings shall be maintained. If any abnormal change in the reading of these instruments is noticed immediately action shall be taken to know the reason of this change in reading. The detailed analysis of the abnormal readings of the instruments shall be carried out and if required the remedial measures shall be undertaken to rectify the problem in the structure till the instrument function satisfactorily. In case of any distress in any structure of the project the same shall be immediately notified to Local Emergency Manager and others shown in the notification Flow Chart.

The location of the various instruments provided in Diversion Dam and other appurtenant structures and Instrumentation drawings are placed as **Annexure-5.**

11.14 Terrorist/ Bomb threat

In case of any Terrorist/ Bomb threat immediately call the bomb disposal squad of the Project Security/ Local Police. Also contact the Local Emergency Manager and others shown in the notification Flow Chart and take other precautionary measures to avert catastrophe.

12. PREVENTIVE AND CORRECTIVE ACTIONS

The main dam of Teesta-III H.E. Project, namely CFRD, comprises of a compacted rock fill section with a concrete face slab on the upstream slope and a concrete toe slab and is classified as Embankment Dam. In case of embankment dams, it is perhaps always possible to take suitable preventive actions to avoid catastrophic situation of breaching of dam provided a constant vigil is made through regular inspections and analysis of instrumentation data. Immediate implementation of these remedial actions may delay, moderate, or prevent the failure of the dam. Several of the listed adverse or unusual conditions may be apparent at the dam at the same time, requiring implementation of several modes of remedial actions. A brief resume is provided here for the preventive actions to be taken by Teesta Urja Limited (Dam Department) for various developing situations.

12.1 Arrangements to Avoid Overtopping of the Dam Due to Extreme Floods

Possibility of this situation developing in the case of Teesta-III H.E. Project is extremely rare because a very conservative estimate of design flood has been made and very flexible flood releasing arrangements have been planned. Overtopping of the dam due to extreme floods occurs only in the event of either when the design flood gets exceeded or when at the time of high floods, due to some defects, some gates of the spillway get stuck up. Inflow design flood estimated for Teesta-III H.E. Project is 7000cumecs and has a return period of 1 in 10,000 years. There are four outlets/ Spillways in Teesta-III H.E. Project for regulation/ lowering the reservoir water level as mentioned below:

- Left Bank spillway tunnel-1
- Left Bank spillway tunnel-2
- Left Bank Flushing cum spillway tunnel
- Chute Spillway (Left bank)

It has been desired by the **statutory authority (CEA)** while according concurrence of Teesta-III project that **"The Reservoir water level during the monsoon period shall be maintained at MDDL (Minimum Drawdown level) El. 1565.0m".**

There are four spillways provided for regulation/ management of flood water in the reservoir based on the water availability and its requirement. The spillways should be operated in the priority as listed/ detailed below in Table:

S.N.	Priority	Facility to be operated
1	**Priority No.-1**	Chute Spillway
2	**Priority No.-2**	Left Bank Diversion Tunnel Spillway No.-1
3	**Priority No.-3**	Left Bank Diversion Tunnel Spillway No.-2
4	**Priority No.-4**	Flushing cum Spillway Tunnel

The Volume of outflow shall be computed from the above mentioned spillways Rating Curves depending upon the time required for reservoir evacuation; volume of water to be released from the reservoir; reservoir levels; volume of river inflow and accordingly the spillway gates shall be regulated.

It is necessary that all spillway gates and mechanical equipment for operating the gates be thoroughly inspected by the Hydro-Mechanical Department before the start of Monsoon season every year. Inspection report shall be submitted to Head - (O & M), Teesta Urja Ltd. for planning and execution of remedial measures on priority.

12.2 Arrangements to Avoid Overtopping due to Huge Land Slides in the Reservoir

Landslides usually occur during rainy season either during heavy rainfall or immediately after it. Therefore, it is possible that the reservoir is nearly full when a slide situation begins to develop. As soon as a developing slide zone is noticed, it should be thoroughly examined by a team of Officers nominated by Teesta Urja Ltd. to estimate the likely volume of the slide material. If the assessment indicates that sliding can lead to overtopping of the Dam, a notice for alert situation should be given and the reservoir suitably lowered.

12.3 Appearance of Boils in Downstream of Dam:

If the boils are localized, these should be immediately loaded with an inverted filter. If the boil comes under control, no further action is necessary. However, sometimes it would happen that while the existing boils come under control, new boil would begin to form. If this happens, the situation should be brought to the notice of the Teesta Urja Ltd. (Engineering Department), who would be responsible for suggesting detailed measures, which may be in terms of loading berm, constructing relief wells or carrying out additional grouting.

12.4 Boggy Conditions in Downstream of the Dam:

General boggy conditions or high piezometric heads downstream of the dam indicate large seepage through the foundations and call for immediate action. The situation shall be brought to the notice of the Head (O&M) & Teesta Urja Ltd., who would be responsible for suggesting detailed measures. Generally one of the following solutions can be adopted:

- Installation of a row of relief wells downstream of the dam.
- Providing properly designed loading berm.
- Carrying out additional grouting through the foundations. If it is not possible to successfully carry out grouting against large seepage pressures, lowering of the reservoir may be required.

12.5 Visible Cracks on the Surface:

Formation of visible cracks on the surface is likely but they should be investigated thoroughly to determine their cause. These should be dug up to find out how they are propagating in the interior. If these are shallow and are not caused by any serious defect, these should be filled back with appropriate compacted material. In case they are deep caused by differential movements or hydraulic fracturing, these may require to be sealed through alluvial grouting

12.6 Increased Amount of Seepage:

Increase in seepage, if it is not connected with rise in reservoir water level, could be due to three causes:

- Rain water which has penetrated the d/s shell of dam during a heavy downpour is getting gradually released. In such a situation, seepage would return to normal after two to three days. No action is required.

- Increased seepage through the foundations or the fill due to internal cracking. The first thing in this case is to determine whether the increased seepage is from fill or the foundations. This will require interpretation of instrumentation data, especially of piezometric cells and seepage measurement weirs. Also water quality tests may be carried out which will help determine whether the water mixing is taking place from dam foundations/ filter soil materials of the dam body. If the increased seepage is found to be from foundations but is not noticed by piezometric rise or excessive leaching of foundation material, no action may be needed unless loss of water is economically very costly as compared to additional grouting that would be required to be carried out.

  If the increased seepage is through the fill, then it should be examined whether the out flowing water is muddy or clear. Exit of clear water indicates no emergency, but investigations should be carried out for reasons of excess seepage. If the seepage water is muddy, it is a cause for concern as it indicates both internal cracking as well as failure of the filter to arrest erosion of the core. If the seepage of muddy water continuously goes on increasing, a message for alert situation should be given to District Administration and reservoir lowered till the seepage decreases. After locating the cracked/ internally eroded zone, alluvial grouting should be carried out. Whether increase in seepage not related to reservoir level is noticed, it should be brought to the notice of Teesta-III Project authorities and actions shall be taken to rectify the problem.

12.7 Formation of Chimneys /Sinkholes or Vortices near the Upstream Slope:

These indicate internal erosion of core due to its cracking and failure of filters to prevent its erosion. A notice for warning alert situation should be given and reservoir lowered. Treatment would comprise of alluvial grouting of the affected zone. Normally such a situation would take considerable time before it appears at the surface and can be timely detected through analysis of seepage discharge and instrumentation data.

12.8 Equipment and Facilities for Meeting out Emergency Requirements:

A set of construction equipment and storage of construction material shall be kept ready by the project, for meeting out emergency requirements and maintenance of the dam. The equipment and stock of construction materials shall be kept on both the banks. Diesel generating sets for meeting emergency power requirements shall also be maintained.

As borrow areas, especially for shell and filter material will submerge on dam impounding, therefore, some other borrow areas have to be identified for extracting material for any emergency use.

13. INSPECTION AND MAINTENANCE

The Periodical Inspection of dam and appurtenant structures is necessary especially before and after monsoon season to ascertain/examine their condition and functioning. The main purposes of carrying out periodic inspection are:

- To ensure the adequacy of the structures to serve the purpose for which they were designed,
- To verify the conditions of the structures and monitor their behaviour,
- To investigate conditions that might cause distress to the structures, and

- To study the extent of deterioration based on which maintenance and repairs can be planned.

Adequate inspection shall be carried out by competent personnel to investigate the performance of the dam and appurtenant structures. All inspection observations shall be compared with the design assumptions and prediction, previous results, results of model studies and tests and limiting values, where specified. Any conditions that might adversely affect the safety of structures shall be closely observed. These shall include conditions such as excessive settlement, deflection, seepage, uplift pore-pressure, deterioration of masonry/ concrete. Periodical inspection of reservoir area including reservoir rim shall also be undertaken.

An effective inspection program is essential for identifying problems and providing safe performance of a dam. A proper inspection program should involve the following three types of inspections:

- Routine Inspections
- Annual Inspections
- 5-yearly Periodic Inspections

13.1 Routine Inspections

Routine inspections are typically performed on a frequent basis (e.g. Fortnightly/ Monthly). The frequency of routine inspections is tied to the need for operation and monitoring at the facility. Important monitoring data recorded during a routine inspection would include: reservoir level, seepage flow, toe drain flow, piezometer levels and other project-specific information. A brief, visual inspection of the major project features is performed to observe any obvious changes which may threaten dam safety such as structure's subsidence/ settlement, sinkholes, abnormality in instrumentation readings/ observation etc.

1. Record Reservoir Level
2. Determine Reservoir Inflow
3. Check and Record Outlet Flow
4. Make Required Changes in Gates and Valves
5. Visually Examine Condition of:
    - Dam Crest,
    - Upstream and Downstream dam Faces,
    - Spillway and Stilling Basin
    - Outlet Works Energy Dissipater
    - All Drainage Systems
    - Security and Safety Devices
6. Check and Record Piezometer Readings
7. Check and Record Toe Drain Flow
8. Check Spillway Channel For Debris
9. Check Foundation Seepage Area
10. Check Log Boom
11. Check Oil Reservoir Level in Hydraulic System

12. Check Exposed Electrical Wiring
13. Record Pertinent Information in Operating Log

13.2 Annual Inspection

An annual inspection is a more detailed inspection during which all features and equipment at the facility are evaluated. Typical inspection items would include: the condition of the dam crest, upstream, and downstream slopes, condition of the spillway and outlet works, observation and measurement of all seepage, and any other important, project-specific items. During the annual inspection, all valves, control works and other mechanisms should be test-operated to ensure they are in proper working order. Monitoring information over the past year should be reviewed for development of any adverse conditions such as increased seepage or higher piezometer levels. All information from the annual inspection should be recorded on an inspection. This type of inspection shall include following:

1. Perform Detailed Inspection of Dam and appurtenant structures
2. Test Operate All Gates and Valves
3. Drain and Inspect Interior of Outlet
4. Drain and Inspect Spillway Stilling Basin and Outlet Energy Dissipater
5. Test Operate all Backup Operating Equipment
6. Survey surface Settlement points/ Monuments/ points on Dam Crest
7. Check Corrosion Protection on all Exposed Metal work
8. Review and Update Emergency Action Plan

13.3 Periodic Inspection (5-Yearly)

It is recommended that Periodic Inspections be performed every 5 years. These inspections should be performed by professional engineering specialists and familiar with the design and construction of dams and possess thorough knowledge about assessment of structural safety. This type of inspection includes:

- A visual inspection of all project elements,
- Detailed Engineering Analyses of project components under extreme flood and earthquake loadings,
- A review of project operation and maintenance procedures,
- A comprehensive report of findings.

Inspection reports on the condition of the structures shall be prepared and submitted to the Engineer-in-Charge deputed for operation and maintenance. The special inspection/ Periodic Inspection of all the works (including the dam, the reservoir and the appurtenant works), shall be done by a committee of experts at least once in 5 years in accordance with the criteria for inspections laid down as per the **CWC's "Report on Dam Safety Procedures" and "Guidelines for safety inspection of dams"** placed as **Annexures-6** and **Annexure-3** respectively. The committee shall go through the record of observations concerning the behaviour of structures, the inspection reports on the condition of the structure and other relevant data and submit a report suggesting ways and means for improvements required, if any, about the safety and serviceability of the structures.

Even a well-constructed dam may face problems and difficulties if it is not properly maintained. It is generally noticed/ observed that the maintenance budget hardly covers the establishment charges leaving very little funds for carrying out actual maintenance. Therefore sufficient budget provisions for maintenance of Dam and other appurtenant structure shall on the basis of the present cost of the structure instead of the original cost.

Inspection reports shall be periodically reviewed by the Engineer-in-Charge and necessary maintenance and repair instructions issued expeditiously. Maintenance required shall be completed before the monsoon, as far as possible.

All routine and extraordinary work/ repair necessary to upkeep the facilities in good and reliable working order to fulfil the intended designed project purposes. The following conditions are critical and require immediate repair or maintenance under the direction of Engineer-in-charge of operation and maintenance.

- Abutment erosion due to rains causing slope stability which are endangering the stability of the dam.
- Piping or internal erosion as evidenced by increasingly cloudy seepage or other symptoms.
- Spillway blockage or restriction.
- Excessive or rapidly increasing seepage appearing anywhere near the dam/ Power House and appurtenant structures.
- Repair defective gates and valves to ensure smooth operation and prevent leakage

13.4 Performa for Periodical Inspection of dam and appurtenant Structures

The basic data on dam and other appurtenant structures of the project shall be compiled as per **CWC's "Standardized Data Book Format, Sample Checklist and Proforma for Periodical inspection of Dams"** placed at **Annexures-7.**

However, the inspections shall be carried out at a frequency weekly/ monthly/ as per requirement. The sample format showing various activities/ check list for guidance is shown below:

Downstream drainage

Sl. No.	Check List	Observations and Remarks
a)	Are there any standing pools of water in the downstream area of the dam? If so, give their locations and extend.	
b)	Are there any boils observed in the vicinity of the downstream toe of the dam?	
c)	Is the downstream area sufficiently clear and free draining?	
d)	Are all the exposed drains working satisfactorily	

1. **Surface drainage of downstream slope**

Sl. No.	Check List	Observations and Remarks

a)	Is the condition of the downstream slope drainage arrangements satisfactory?	
b)	Are all the drains properly maintained and free of vegetation growth and debris?	
c)	Does the slope have a tendency to develop severe rain cuts at any location?	
d)	Enumerate any other defects noticed in the surface drainage of downstream slope.	

2. **Seepage measurements**

Sl. No.	Check List	Observations and Remarks
a)	Is the general condition of concrete lining normal?	
b)	Are there any cracks? or deformations in the lining.	
c)	Is the quantity of seepage being daily or periodically measured with respect to water level in reservoir and recorded?	
d)	Does it show any abnormal rise or fall? If so, does it have any relation to a certain reservoir level elevation?	
e)	Does the seepage flow show a turbid colour at any stage? Was such a phenomenon observed at any stage at any location in the past?	
f)	What is the measured rate of seepage flow with date and reservoir level?	
i.	On the day of present inspection	
ii.	Maximum since last month	
iii.	Minimum since last month	
g)	Is the portion upstream and downstream of measuring points of seepage easily accessible with proper steps and path and free vegetation growth?	
h)	Are the measuring points properly located, constructed and maintained so as to give accurate and reliable measurements of seepage?	
i)	Is the method of taking seepage measurements satisfactory?	
j)	What is the design seepage discharge? State your observation on comparison.	

3. **CFRD Section/ crest**

Sl. No.	Check List	Observations and Remarks
a)	Is the crest profile at proper elevation? 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).	
b)	Is the surface of the crest free from undulations and local depressions/ settlement or heaving?	
c)	Does it develop any visible cracks in transverse or	

	longitudinal directions? If so, attach a map showing their locations and extent. Depth and width of cracks must be ascertained by taking open trenches extending below the bottom of cracks.	
d)	What is the condition of the edges of crest? Have they got eroded and cut up resulting in reduced effective width?	
e)	Is the crest free from local slips throughout its length on either sides?	
f)	Do the guard stones and parapet wall provided at the edges of the crest appear in proper profile and plumb?	

4. **Earth dam section – upstream and downstream slopes**

Sl. No.	Check List	Observations and Remarks
a)	Do the upstream and downstream slopes show any sign of bulging or concavity/ any signs of movement or settlement? If so, indicate their locations and extent.	
b)	Does the section of the dam and both the slopes appear structurally sound and stable?	
c)	Are any longitudinal or transverse cracks noticed in any part of the slopes?	
d)	Were 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 conditions of upstream pitching, downstream pitching / turfing and the rock toe.	
e)	Is there any profuse growth of bushes or weeds over any portion of the dam? If so, indicate the locations.	
f)	Do the upstream or downstream slopes show existence of crab holes or holes made by rodents or burrowing animals or anthills? If so, indicate the locations.	
g)	Are there any wet or slushy patches and 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 your findings.	
h)	Are all the rain cuts and erosion channels properly treated and made good? Please indicate location of recurring damages, if any.	

5. **Junction earth work with masonry / Concrete dam sections and outlets**

Sl. No.	Check List	Observations and Remarks
a)	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 color of the	

	leakage? Does it turn turbid at any time? Ascertain from enquiries and record the findings.	
b)	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.	
c)	Is there any tendency for surface erosion at the junctions?	
d)	Check the conditions of the crest and slopes, especially in the zones adjacent concrete structures. Detect the deformations, settlements, cracks or other distress conditions caused by external erosion due to wind, rain, etc. Set up permanent observation system for the same at the places of occurrence. Seepage at junctions between earth dam and masonry concrete retaining wall or corch type junctions with concrete dam is a possible source of trouble and should be carefully watched.	

6. **Spillway**

Sr. No.	Check List	Observations and Remarks
a	**Approach Channel**	
	Is there any Debris fallen in Approach Channel or on its slopes	
	Are the slopes in Approach Channel stable.	
b	**Crest**	
c	Is the Surface condition normal.	
	Is the General condition of concrete normal.	
	Is there any Signs of Movement	
	Is there any signs of Settlement	
	Are there any visible Cracks	
	Spillway Piers	
	Is the Surface condition normal.	
	Is the General condition of concrete normal.	
	Is there any Signs of Movement	
	Is there any signs of Settlement	
	Are there any visible Cracks	
	Is there any visible opening of Joints	
d	**Bridge**	
	Is the Surface condition normal?	
	Is the General condition of concrete normal?	
	Is the Structural condition of slab and beams normal	
	Is the condition of Bridge bearings normal	
e	**Chute Walls**	
	Is the Surface condition normal?	
	Is the General condition of concrete normal?	

Sr. No.	Check List	Observations and Remarks
	Is there any Signs of Movement	
	Is there any signs of Settlement	
	Are there any visible Cracks	
	Is there any visible opening of Joints	
	Is there any sign of Erosion	
	Are the outside drains clean?	
	Is there any tendency for the water to undercut the foundation of walls	
f	**Chute Floor**	
	Is the Surface condition normal?	
	Is the General condition of concrete normal?	
	Is there any Signs of Movement	
	Is there any signs of Settlement	
	Are there any visible Cracks	
	Is there any visible opening of Joints	
	Is there any Debris fallen in the Chute floor	
	Is there any sign of Erosion	
g	**Flip Bucket Walls**	
	Is the Surface condition normal.	
	Is the General condition of concrete normal.	
	Is there any Signs of Movement	
	Is there any signs of Settlement	
	Are there any visible Cracks	
	Is there any visible opening of Joints	
	Are the outside drains clean.	
	Is there any sign of Erosion	
h	**Flip Bucket Floor**	
	Is the Surface condition normal.	
	Is the General condition of concrete normal.	
	Is there any Signs of Movement	
	Is there any signs of Settlement	
	Are there any visible Cracks	
	Is there any visible opening of Joints	
	Is there any Debris fallen in the Chute floor	
	Is there any sign of Erosion	
	Is the Surface condition normal.	
	Is the General condition of concrete normal.	
i	**Plunge Pool area**	
	Cladding concrete	
	Side slopes	

7. **Spillway gates**

Sl. No.	Check List	Observations and Remarks
a.	Is the condition of the steel surfaces and the surface paint deteriorated?	
b.	Are any connecting bolts of rubber seals loosened or	

	damaged? If so, indicate the details of defects.	
c.	What is the general condition of rubber seals? Do any of the rubber seals show signs of weathering, hardening, cracking or tearing and damage?	
d.	Are the rubber seals of side and bottom touching uniformly all along the sealing surface?	
e.	Do the rollers (wherever applicable) touch the track plates uniformly? Are the rollers well lubricated?	
f.	Are the electrical meters, gear systems, limit switches, brakes, bush bearing, etc., of hoist mechanism well lubricated?	
g.	Is the operation of the above, smooth and satisfactory? If not, list out individual results and observations.	
h.	Are the embedded 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 observations, if any, regarding such defects.	
i.		
I.	Gate leaf and stiffeners	
II.	End arms	
III.	Trunnion girders	
IV.	Stop logs	
V.	Lifting beams	
VI.	Gantry cranes	
VII.	Bridge structures	
VIII.	Tracks	
j.	Are the trunnion bearings of radial gates properly lubricated?	
k.	Is there any damage or weathering caused to the seal plates? If so, indicate the nature of damage noticed	
l.	Is the full length of wire rope of the hoist in sound condition and free from broken strands in Gantry crane?	
m.	Is the electrical wiring in sound condition?	
n.	Is the alternative power system for gate operation working properly? Give details of generating sets and standby units and the time required to operate all gates on the alternative power system, on the basis of actual trial operation. Check for diesel stock for operation of generator, battery charger available. Battery in spare.	
o.	Is the operation, which is a standby in case of electrical hoists, tried and found satisfactory? Please take test trial and ascertain.	

p.	Are all the nuts of connecting bolts and anchorages properly tightened? In case of trunnion girder anchorages tightening torque which is generally specified should be adhered to. (Note: After inspection of the various items, it is necessary to draw up a list of actions needed to be taken and pursue matters with the concerned agency.)	
q.	Are the hydraulic hoists working satisfactorily?	
r.	Are the trunnion hub and the brackets well maintained?	
s.	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.	
t.	Are any of the mechanical or structural components and fastening or seals subjected to excessive wear? If so, please give details. Is there any tendency for recurring damage to any particular components? If so, please give details.	
u.	Is sufficient stock of spare which need frequent replacement maintained at the site?	
v.	Is the staff posted at the site, maintenance and operation of gates, hoists, equipments and electrical installation well experienced, fully trained and conversant with the job requirements and responsibilities?	
w.	What is the exercising frequency? When the gates were last exercised?	
x.	Performance during inspection.	
y.	Changes over switches for main power supply to generator supply are provided.	

8. **Instruments installed and observations**

Sl. No.	Check List	Observations and Remarks
a)	Are all the instruments installed properly accessible? Are all the location properly, lighted ventilated and adequately protected from possibilities of damage.	
b)	Are all the instruments in proper working order? Ascertain the cases of instruments going out of order and indicate.	
c)	Are the observations of all the instruments are being taken regularly?	

9. **Power Intake**

Sl. No.	Check List	Observations and Remarks
a)	Is there any structural damage to the intake walls such as leakage noticed through walls?	

b)	Is there any leakage observed through the conduit, concrete or masonry?	
c)	Is there any damage noticed to the conduit concrete, breast wall and gate slots?	
d)		
	Take operating trials of the following as provided and record the observations and defects noticed, if any.	
I.	Service - gate	
II.	Stop-log - gate/s	
e)	Are the trash racks (wherever provided cleaned before monsoon?	
f)	Are there vibration and noise noticed in operation of intake gates at any time? If so, are any periodical observations taken to ascertain their severity?	
g)	Is there any structural damage to the decanting chamber? If so, give the details of nature and extent of the damage.	

10. **Power Intake gates**

Sl. No.	Check List	Observations and Remarks
a)	Is the surface of gates and the paint deteriorated?	
b)	Are the connecting bolts of rubber seals loosened or damaged	
c)	Do the rubber seals show signs of weathering & damage and need replacement?	
d)	Are the rubber seals of sides and bottom touching the bearing surface uniformly?	
e)	Do all the rollers touch the track plates?	
f)	Are the rollers well lubricated?	
g)	Is the operation of intake gates smooth?	
h)	Are the stem rods for lifting the gates straight?	
i)	Are the actual operation of lifting and lowering of the gates and hoist mechanisms smooth and satisfactory?	
j)	Are all the gears and hoist mechanisms well lubricated?	
k)	Is the storing arrangement for stop logs in satisfactory condition?	
l)	Are the seal plates in sound condition? If not, ascertain the type of damage and indicate.	
m)	Is the full length of wire rope (wherever applicable) of the hoist in serviceable condition and free from any broken strands?	
n)	Are all the nuts of connecting bolts and anchorage properly tightened?	
o)	Are all the lifting beams in proper order and sound condition?	

	If not, ascertain the nature and extent of damage and indicate.	
p)	Do any of the mechanical or structural parts of the gates, fasteners or hoists show signs of excessive wear? If so, please give details.	
q)	Is there any tendency for recurring damage to any particular component of components? If so, give details.	
r)	Is sufficient stock of spare which needs frequent replacement maintained at the site?	
s)	Whether hand cracks are kept under lock and key and not attached on hoist mechanism when operated by electrical energy?	
t)	Whether warning sign indicating "Danger, Do not switch on" is hung during maintenance?	
u)	Whether there is a "standby" power supply?	
v)		
I.	Is the diesel generator in the working condition	
II.	Frequency of exercise	
III.	Is it developing full voltage?	
IV.	Is the wiring intact and is the changeover switch in working condition?	
V.	Are the spares available at site?	

11. **Emergency preparedness**

Sl. No.	Check List	Observations and Remarks
a)	Are the project officers well conversant with the Emergency Action Plan, reporting procedures, warning procedures?	
b)	When the Emergency Action Plan was last reviewed?	
c)	Are the communication directories updated?	
d)	Are the concerned authorities informed about the system of emergency reporting procedures and warning?	
e)	Are the inundation maps updated?	
f)	Are available safety spots on the downstream of the dam identified and made known to the concerned authorities?	
g)	Is the communication system working satisfactorily?	
h)	Are adequate warning devices and facilities provided at the dam?	
i)	Is the downstream warning system operational?	
j)	Are proper arrangements made for security of the dam and preventing cases of unauthorized trespass, vandalism and sabotage to the dam works?	
k)	Is downstream warning system operational on alternative power supply?	

12. **Access roads**

Sl. No.	Check List	Observations and Remarks
a)	Is there a properly constructed and well maintained all-weather access road to the dam site?	
b)	What is the type of pavement of the access road and its condition?	
	Are there properly constructed and well maintained access roads arrangements to the following components for inspection, maintenance and repairs?	
I.	Top of dam	
II.	Spillway	
III.	Gates and hoisting arrangement	
IV.	Bridge structure	
V.	Junction and abutments	
VI.	Toe of earth dam	
c)	What is the general condition of all the structures on various access roads? Are all the structures on the access roads adequately safe, for allowing passage of plant machinery for emergent repairs?	

13. **Communication facilities**

Sl. No.	Check List	Observations and Remarks
a.	**Are following facilities working properly at dam site?**	
I.	Wireless	
II.	Telephone	

13.5 Periodic Maintenance

The following items noted during Inspections or Periodic Inspections should be repaired and maintained properly. The maintenance should be completed as soon as possible after identification:

- Remove bushes and trees from the embankment and abutments near the dam.
- Fill rodent burrows with slurry of soil, cement and water.
- Maintain fences to provide site security and to exclude livestock from the embankments. Repair damaged embankment surfaces.
- Perform regular inspections of the embankments and abutments to identify potential maintenance items.
- Repair erosion gullies.
- Test gates and valves semi-annually
- Repair defective gates and valves to ensure smooth operation and prevent leakage
- Repair deteriorated concrete or metal components.
- Lubricate gates and valves annually or as recommended by the manufacturer.
- Inspect and repair erosion protection.

- Inspect and maintain instrumentation and gauging equipment and verify calibration of water measurement equipment.
- Remove debris from dam area, emergency spillway approach and exit channel.
- Remove debris from embankment face and from areas around the intake structures.
- Clean and remove debris from seepage weirs and small drainage ditches.
- Erosion, slope failure or other conditions which are endangering the integrity of the dam and other appurtenant structures.
- Piping or internal erosion as evidenced by increasingly muddy seepage or other symptoms.
- Spillway blockage or restriction.

14. REVIEW AND UPDATION

Disaster Management Plan is a "Living Document". This requires updates with time and it should be reviewed at least annually. Reviews should include participation of the local emergency manager. All updates should be made promptly. Additionally, emergency incidents at dams and/or dam failures are not common events. Therefore, training and exercises are necessary to maintain emergency response readiness, timeliness, and effectiveness.

The DMP therefore requires periodic maintenance to remain current and as useful and effective as possible. The three steps in Maintenance as below:

14.1 Review

The DMP minimum annual review should include the following:

- All the contacts on the three emergency notification charts in the DMP shall be verified so that the phone numbers and persons in the specified positions are updated/ current.
- The Local Emergency Manager to verify whether the responsibilities as described in the DMP are understood properly.
- Verify that the phone numbers, addresses, and services in emergency service contacts are current.
- Review people and structures at risk information for changes in development within the dam failure flood inundation area downstream of the dam.

14.2 Revision

The DMP will be revised if any of the contacts, responsibilities, services or service providers, or people at risk information has changed. Teesta Urja Ltd. is responsible for updating the DMP documents. The DMP document held by Teesta Urja Ltd. is the master document. For purpose of updating for changes in telephone numbers and personnel, review shall be made every year before onset of monsoon (i.e in the month of May/ June). If after the review, no revision is required a statement shall be issued by Head O & M Dept., Teesta Urja Ltd., that review was made and no revision of the plan was necessary and same shall be made available to each recipient of the original plan. Whenever a revision is made, the revised DMP shall be made available to every recipient of the DMP. When revisions occur, Teesta Urja Ltd. should provide the revised pages and a revised Revision Summary Page to all the DMP document holders. The document holders are responsible for

revising out dated copy of the respective document(s) whenever revisions are received. Out dated pages shall be immediately discarded to avoid any confusion with the revisions.

14.3 Disaster Management Plan (DMP) training and exercise

Periodic training and exercises are necessary to help ensure that all Teesta Urja Ltd. personnel are thoroughly familiar with the emergency action plan and their individual roles and responsibilities. The DMP exercising can include:

- Orientations
- Phone Drills
- Functional Exercises

As a minimum, Teesta Urja Ltd. should conduct an orientation and a phone drill yearly. The orientation can be a simple meeting where those individuals and entities with a stake in the DMP come together to review the roles and responsibilities described in the DMP. Orientations are especially useful for bringing new staff and/or leadership within any of the various organizations up to speed with regard to the components of the DMP.

Phone drills represent the next level of complexity with regard to DMP exercises. Phone drills is part of the DMP review process to confirm contact information in the notification flow charts.

A comprehensive DMP exercise program should include provisions for table top and functional exercises. The program should be considered a normal part of the O&M program for the structure with the various exercises planned and executed as the owner would perform O&M on the physical components of the dam itself.

Key personnel from local emergency management agencies should be invited to participate in any orientation and exercises provided by Teesta Urja Ltd.

Following any emergency, a critique shall be conducted by an officer nominated by Head, Teesta-III HEP involving all participants. This would discuss and evaluate the events prior to, during and following the emergency, significant actions taken by each participant and what improvements would be practicable for future emergencies, and all deficiencies found in procedures, materials, equipment, manpower, leadership and funding. A report on the critique shall be prepared by Operation and Maintenance, Teesta-III HEP & results of this critique shall be used for revising the emergency action plan for Teesta-III.

15. NOTIFICATION AND COMMUNICATION

After the emergency level has been determined, person on the **"Notification flowcharts"** as per **Para-6 above,** the appropriate emergency level shall be notified immediately. The initiator of any notification shall be In-charge of the Control Room located at Dam/ Power House of Teesta-III Project. For emergency situations like release of water through spillways that can inundate downstream areas. In-charge Control Room is responsible for issuing proper notification both to Corporate Officials as well as to District Administration / Concerned Authorities. In case of slowly developing situations, he would only inform to Project Head and in-charge of operation and maintenance of Teesta Urja Ltd. Who would in consultation with design department, then direct further operations of rectification or notification when necessary? Notification responsibility and the officials to whom the notices are to be issued are given in Notification Flowcharts of the Disaster

Management Plan. This does not include list of officials which are to be further notified by the District Magistrates.

This type of notification is mainly used for disseminating an important piece of information and is not intended to convey whether or not an emergent situation can arise. For example notification that dam attained Full Reservoir Level is a pre-alert notification. This notification may include slowly developing dam site emergencies which can either be rectified or would at least take 15 days before they become real emergencies.

15.1 Notification Emergency Level-1

(Non-emergency incident; unusual event; slowly developing situation)

Teesta Urja Ltd. should contact the engineering department, describe the situation, and request technical assistance on the next steps that should be taken.

An alert notification is used to provide notice that although failure or flooding is not imminent, a more serious situation could occur unless conditions improve. Local officials and residents in affected areas would be alerted that an unsafe situation could be developing. Examples could be a full reservoir with forecasts for heavy storms in the catchment which could lead to release of water through spillways that can submerge downstream areas or a dam that is leaking excessively but is not yet a hazardous situation.

15.2 Notification Emergency Level-2

(Potential dam failure situation; rapidly developing)

Teesta Urja Ltd. should contact Local Emergency Manager and Engineering Department, describe the situation, and request technical assistance on the next steps that should be taken. The following message (English format followed by Hindi format and Local Language) may be used to help describe the emergency situation to the Local Emergency Manager:

"We have an Emergency condition at Teesta-III H. E. Project. We have activated the Emergency Action Plan for this dam and are currently under Emergency Level 2. We are implementing predetermined actions to respond to a rapidly developing Situation that could result in dam failure.

Refer the Inundation/Google Earth maps in your copy of the Emergency Action Plan. We will advise you as soon as the situation is resolved or if the situation gets worse. I can be contacted at the following number _____. If you cannot reach me, please call the following alternative number_____."

A warning notification is used to indicate that flooding is imminent as a result of high run off. Such a notification implies that an order for evacuation of delineated inundation areas is required to be issued by District Administration.

15.3 Notification Emergency Level-3

(Urgent; dam failure is imminent or in progress)

The Local Emergency Manager should be contacted immediately and the potentially flooded area must be evacuated (see Appendix A-2 *Inundation/Google Earth maps*). The following actions should be taken:

1. The following message (English format followed by Hindi format and Local Language) may be used to help describe the emergency situation to the Local Emergency Manager:

"This is an Emergency. The Teesta-III CFRD (DAM) is failing. The downstream area must be evacuated immediately.

Repeat, Teesta-III CFRD (DAM) is failing. Evacuate the area along low-lying portions of River Teesta. We have activated the emergency action plan for this dam and are currently under Emergency Level 3. Refer the Inundation/Google Earth maps in your copy of the Emergency Action Plan. I can be contacted at the following number _____. If you cannot reach me, please call the following alternative number_____."

2. Do whatever is possible to bring the people in danger in the vicinity of Dam to safety if directed by the Local Emergency Manager (anyone on the dam, downstream from the dam, boating on the reservoir, or evacuees).
3. Keep in frequent contact with the Local Emergency Manager to keep them up-to-date on the condition of the dam. They will tell you how you can help to handle the emergency.
4. If all means of communication are lost: (1) try to find out why, (2) try to get to another radio or telephone that works, or (3) get someone else to try to reestablish communications. If these means fail, handle the immediate problems as well as you can, and periodically try to reestablish contact with the Local Emergency Manager and emergency services.

   The following pre-scripted message (English format followed by Hindi format and Local Language) may be used as a guide for the Local Emergency Manager to communicate the status of the emergency with the public:

   "Attention: This is an emergency message from (the Local Emergency Manager). Listen carefully. Your life may depend on immediate action.

   Teesta-III Dam is failing. Repeat. Teesta-III Dam is failing. If you are in or near this area, proceed immediately to high ground away from the valley. Do not travel on (names of roads or highways) or return to your home to recover your possessions. You cannot outrun or drive away from the flood wave. Proceed immediately to high ground away from the valley."

------Repeat message------

15.4 Notification Responsibility

For emergency situations like release of water through spillways that can inundate downstream areas (i.e. Warning Notification), In-charge Control Room is responsible for issuing proper notification.

In case of slowly developing situations, earthquake or heavy rain in the catchment area, if anything abnormal noticed in the dam structure or reservoir rim shall be brought to the notice of Operation and maintenance and Engineering Department of Teesta Urja Ltd. immediately. Further action, either for remedial measures or for notification shall be taken by Operation and maintenance Department depending upon the situation (alert / pre-alert). Necessary notification will be issued as per notification flowchart. The notification flowchart does not include list of officials which are to be further notified by the District Magistrates.

15.5 Control Room and Communication System

A permanent control room at CFRD/ Spillway Control Room Building having landline phone, mobile phone and computer with internet connection for communication has been established to function round the clock throughout the year. A control room has also been established by Project security, adjacent to dam control room, wherein monitors of web cameras have been installed. The security personnel with phone/ wireless remain present there round the clock.

A list of telephone/ mobile numbers shall be maintained with each official involved in the Disaster Management Plan.

Any precarious situation during floods will be communicated either by an alert situation or by an alert situation followed by a warning situation. An alert situation would indicate that although failure or flooding is not imminent, a more serious situation could occur unless conditions improve. A warning situation would indicate that flooding is imminent as a result of an impending failure of the dam. It would normally include an order for evacuation of delineated inundation areas.

The Engineer-in-charge will be responsible for the entire operation including prompt determination of the flood situation from time to time. Once the red alert is declared the whole state machinery will come into swing and will start evacuating people in the inundation areas delineated in the Inundation maps. For successful execution, annually Demo exercise will be done.

In addition, guidelines that have to be followed by the inhabitants of flood prone areas, in the event of a flood resulting from dam failure, which form part of public awareness for disaster mitigation may also include following :

- Listen to the radio for advance information and advice.
- Disconnect all electrical appliances and move all valuable personal and household goods beyond the reach of floodwater, if one is warned or if one suspects that flood waters may enter the house.
- Move vehicles, farm animals and movable goods to the higher place nearby
- Keep sources of water pollution i.e. insecticides out of the reach of water.
- Turn off electricity and gas one has to leave the house.
- Lock all outside doors and windows if one has to leave the house.
- Do not enter floodwaters.

15.6 Downstream Warning

Responsibility for the decision to proceed with the warning and evacuation of affected occupants rests with the concerned District Magistrates. As per Disaster Management Act 2005, District Magistrates are required to prepare the Disaster Management Plans for the district concerned. Early Warning System for quick dissemination of information to State / District Administration and downstream population is to be established by Teesta Urja Ltd.

The efficient communication system and a downstream warning system are absolutely essential for the success of an emergency preparedness plan. The difference between a high flood and a dam-break situation must be made clear to the downstream population.

The Emergency Action Plan includes evacuation plans and procedures for implementation based on local needs. These could be:

- Demarcation/prioritization of areas to be evacuated.
- Notification procedures and evacuation instructions.
- Safe routes, transport and traffic control.
- Safe areas/shelters.
- Functions and responsibilities of members of evacuation team.

15.7 Management after receding of flood water

It is to be accepted that in the event of dam break, even with maximum efforts, the loss of human lives, livestock and property would be inevitable. Under such a scenario, a massive effort would be used by various government agencies to provide various relief measures to the evacuees. Some of the major measures which need to be implemented are listed as below:

1. Provision of various food items & shelter to the evacuees.
2. Provision of fuel for various evacuees.
3. Provision of adequate fodder supply.
4. Arrangements for potable water supply.
5. Commissioning of low cost sewage treatment & sanitation facilities, and disposal of treatment sewage.
6. Approximate disposal of dead bodies human & livestock.
7. Immunization programs for prevention of outbreak of epidemics of various water related diseases.
8. Adequate stocks of medicines of various diseases, especially water-related diseases.

****
****

~~352~~

Annexure-1

~~353~~

Salient Features of Teesta- III HE Project (1200 MW)

1. Location	
State, District	Sikkim, North District
Village	Dam near Chungthang village and Power House near Sanklan Village
River	Teesta
Coordinate:- Dam: Longitude & Latitude Powerhouse: Longitude & Latitude	 88° 39' E, 27° 36' N 88° 32' E, 27° 31' N
Access to the Project	
By Road	a) From Siliguri (210/ 178 km) via Rangpo/ Dikchu b) From Gangtok (130 km) via Mangan
Rail Head	a) New Jalpaiguri (broad gauge) (220/188 km) via Rangpo/ Dikchu b) Siliguri (meter gauge) (210/178 km) via Rangpo/ Dikchu
Airport	Bagdogra
2. Hydrology, Seismology and Climate	
Catchment area	2786.7 km^2
Probable maximum Flood	7000 m^3/s
Seismic Zone	IV as per IS:1893-1 (2002)
Maximum & Minimum annual rainfall in Catchment	2747 mm & 762 mm respectively
Maximum & Minimum observed flow at Dam Site	706 (Jul,86) & 18.5 (Jan,78) respectively
3. Reservoir	
Maximum Reservoir Level (M.R.L.) – PMF Case	EL. 1588.0 m
Full Reservoir Level (F.R.L.)	EL. 1585 m
Minimum Draw-down Level (M.D.D.L.)	EL. 1565 m
Gross Storage (EL.1530.0 to EL.1585.0 m)	5.08 MCM
Live Storage (EL. 1565.0 to EL. 1585.0 m)	3.33 MCM
4. Project Structures	
4.1 Dam	
Type of dam	Concrete Faced Rock-fill Dam (CFRD)
Maximum Height above river bed level	60 m
Top width of dam	10 m
Total length of dam at Top	298 m
Dam foundation	Cut-off wall made of Plastic Concrete
Maximum depth of Cut off wall	60 m (1 m to be Socketed to Sound Rock)
4.2 Diversion Tunnel (DT)	
Location	On left bank

Number		1
Size and shape		10 m diameter horse shoe
Length		992 m
4.3 Spillways		
Total number of Spillway arrangements		4
Type of Spillways		Two Nos. Tunnel spillway on Left Bank (DT to act as One Tunnel Spillway), One No. Chute spillway on left bank with 2 radial gate, One No. Flushing Tunnel spillway on right bank
4.3.1	**Diversion/Spillway Tunnel-1**	
	Size, Shape & Length	: 10.0 m ϕ, Horse-shoe shaped & 952 m
	Flow type, Discharge & Velocity	: Free Flowing, 1028 m^3/s & 12 m/s
	Crest Elevation	: EL.1537.0 m for diversion mode & : EL. 1555.0 m for Spillway mode
4.3.2	**Spillway Tunnel-2**	
	Size, Shape & Length	: 10.0 m ϕ, Horse-shoe shaped & 1089 m
	Flow type, Discharge & Velocity	: Free Flowing, 1400 m^3/s & 16.88 m/s
	Crest Elevation	: EL. 1572.0 m
4.3.3	**Chute Spillway**	
	Nos. of Bays & Gate Type	: 2 Nos. of 11.0 m width, Radial Gates
	Discharge & Velocity	: 3500 m^3/s and 24.0 m/s respectively
	Crest Elevation	: EL. 1565.5 m
	Energy dissipation	: Flip bucket with plunge pool
	Chute spillway length	: 296 m
4.3.4	**Flushing cum Spillway Tunnel**	
	Size, Shape & Length	: 11.0 m ϕ, Horse-shoe shaped & 1357 m
	Flow type, Discharge & Velocity	: Free Flowing, 1750 m^3/s & 25.0 m/s
	Crest Elevation	: EL. 1540.0 m
4.4 Intake		
Number (s) and Location		One intake on right bank immediate upstream of Flushing cum spillway tunnel.
Size and shape		7.5 m horseshoe, 150.78 m long
Sill level & Discharge		EL. 1549.0 m & 202 m^3/s
4.5 Desilting Chambers		
Number, Shape and Size		2 Nos. Oval Shaped, 320 m x 17 m x 23 m (LXBXH)
Upstream & Downstream Transition Length		40.0 & 10.0 m respectively
Flow through velocity		0.35 m/s
Flushing Discharge		27.0 m^3/s (15% of 175 m^3/s)
4.6 Head Race Tunnel		

~~345~~

Number, Size and Shape	One Nos. 7.5 m Diameter Horseshoe Shaped
Design discharge and velocity	175 m^3/s & 3.75 m/s
Length	13816m (from D/s of De-silting Chamber)
Bed Slope	1 in 285 to 1 in 353
4.7 Surge Shaft	
Type	Open to Sky, Circular Shaped Restricted Orifice Surge Shaft
Diameter& Height	13 m and 158 m respectively
Floor level	EL. 1506.25 m
4.8 Pressure Shaft	
Number and Type	2 Nos. Steel lined
Alignment	Horizontal-vertical-inclined-horizontal
Size	4 m /3.25 m/2.5 m ϕ
Length	Pressure Shaft 1 – 1450.80 m, Pressure Shaft 2 – 1431.71 m
Discharge and velocity through each shaft	87.5 m^3/s and 6.96 m/s
4.9 Powerhouse	
Type and Installed Capacity	Underground, 1200 MW
Machine Hall Dimensions (LXWXH)	214.3 m x 21.3 m x 44.8 m
Transformer Hall Dimensions (LXWXH)	187.88 m x 15.8 m x 16.0 m
Centre Line of Units	EL. 768.0 m
Service bay Level	EL. 777.9 m
Type of Turbine	Vertical Axis Peloton
Type of Generator	Vertical Shaft, water wheel driven, AC 3 phase synchronous generator Suspended type
Capacity of Transformer & Nos.	82 MVA, Single phase, 3x6 + 1 spare = 19 Nos.
Nos. of Units & Rated Capacity per Unit	6 Nos. and 200 MW each
Head	Maximum Gross Head : 817.0 m Rated Head : 780.33 m
4.10 Main Tailrace Tunnel	
Number, Size and Shape	One, 8.2 m (W) X 8.0 m (H), D-Shaped
Length and Slope	1327.552 m and 1:590.64 respectively
Type	Free Flowing
4.11 Pothead Yard	
Type, Area	Outdoor on Left Bank, 59.2 (L) x 31.0 (W) m
5. Energy Generation	
Annual Energy 90% Dependable Year	5329.37 Gwh
Annual Energy 50% Dependable Year	5767.74 Gwh
Design Energy	5228.00 Gwh

~~356~~

Annexure-2

रजिस्ट्री सं० डी० एल०—(एन)04/0007/2003—05 REGISTERED NO. DL—(N)04/0007/2003—05

भारत का राजपत्र
The Gazette of India

असाधारण
EXTRAORDINARY
भाग II — खण्ड 1
PART II — Section 1
प्राधिकार से प्रकाशित
PUBLISHED BY AUTHORITY

सं० 64] नई दिल्ली, सोमवार, दिसम्बर 26, 2005 / पौष 5, 1927
No. 64] NEW DELHI, MONDAY, DECEMBER 26, 2005 / PAUSA 5, 1927

इस भाग में भिन्न पृष्ठ संख्या दी जाती है जिससे कि यह अलग संकलन के रूप में रखा जा सके।
Separate paging is given to this Part in order that it may be filed as a separate compilation.

MINISTRY OF LAW AND JUSTICE
(Legislative Department)

New Delhi, the 26th December, 2005/*Pausa* 5, 1927 (*Saka*)

The following Act of Parliament received the assent of the President on the 23rd December, 2005 and is hereby published for general information:—

THE DISASTER MANAGEMENT ACT, 2005
No. 53 OF 2005

[23*rd December,* 2005.]

An Act to provide for the effective management of disasters and for matters connected therewith or incidental thereto.

BE it enacted by Parliament in the Fifty-sixth Year of the Republic of India as follows:—

CHAPTER I
PRELIMINARY

Short title, extent and commencement.

1. (*1*) This Act may be called the Disaster Management Act, 2005.

(*2*) It extends to the whole of India.

(*3*) It shall come into force on such date as the Central Government may, by notification in the Official Gazette appoint; and different dates may be appointed for different provisions of this Act and for different States, and any reference to commencement in any provision of this Act in relation to any State shall be construed as a reference to the commencement of that provision in that State.

Definitions.

2. In this Act, unless the context otherwise requires,—

(*a*) "affected area" means an area or part of the country affected by a disaster;

(*b*) "capacity-building" includes—

(*i*) identification of existing resources and resources to be acquired or created;

(*ii*) acquiring or creating resources identified under sub-clause (*i*);

(*iii*) organisation and training of personnel and coordination of such training for effective management of disasters;

(*c*) "Central Government" means the Ministry or Department of the Government of India having administrative control of disaster management;

(*d*) "disaster" means a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or man made causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, property, or damage to, or degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area;

(*e*) "disaster management" means a continuous and integrated process of planning, organising, coordinating and implementing measures which are necessary or expedient for—

(*i*) prevention of danger or threat of any disaster;

(*ii*) mitigation or reduction of risk of any disaster or its severity or consequences;

(*iii*) capacity-building;

(*iv*) preparedness to deal with any disaster;

(*v*) prompt response to any threatening disaster situation or disaster;

(*vi*) assessing the severity or magnitude of effects of any disaster;

(*vii*) evacuation, rescue and relief;

(*viii*) rehabilitation and reconstruction;

(*f*) "District Authority" means the District Disaster Management Authority constituted under sub-section (*1*) of section 25;

(*g*) "District Plan" means the plan for disaster management for the district prepared under section 31;

(*h*) "local authority" includes panchayati raj institutions, municipalities, a district board, cantonment board, town planning authority or Zila Parishad or any other body or authority, by whatever name called, for the time being invested by law, for rendering essential services or, with the control and management of civic services, within a specified local area;

(*i*) "mitigation" means measures aimed at reducing the risk, impact or effects of a disaster or threatening disaster situation;

(*j*) "National Authority" means the National Disaster Management Authority established under sub-section (*1*) of section 3;

(*k*) "National Executive Committee" means the Executive Committee of the National Authority constituted under sub-section (*1*) of section 8;

(*l*) "National Plan" means the plan for disaster management for the whole of the country prepared under section 11;

(*m*) "preparedness" means the state of readiness to deal with a threatening disaster situation or disaster and the effects thereof;

(*n*) "prescribed" means prescribed by rules made under this Act;

(*o*) "reconstruction" means construction or restoration of any property after a disaster;

(*p*) "resources" includes manpower, services, materials and provisions;

(*q*) "State Authority" means the State Disaster Management Authority established under sub-section (*1*) of section 14 and includes the Disaster Management Authority for the Union territory constituted under that section;

(*r*) "State Executive Committee" means the Executive Committee of a State Authority constituted under sub-section (*1*) of section 20;

(*s*) "State Government" means the Department of Government of the State having administrative control of disaster management and includes Administrator of the Union territory appointed by the President under article 239 of the Constitution;

(*t*) "State Plan" means the plan for disaster management for the whole of the State prepared under section 23.

CHAPTER II

THE NATIONAL DISASTER MANAGEMENT AUTHORITY

Establishment of National Disaster Management Authority.

3. (*1*) With effect from such date as the Central Government may, by notification in the Official Gazette appoint in this behalf, there shall be established for the purposes of this Act, an authority to be known as the National Disaster Management Authority.

(*2*) The National Authority shall consist of the Chairperson and such number of other members, not exceeding nine, as may be prescribed by the Central Government and, unless the rules otherwise provide, the National Authority shall consist of the following:—

(*a*) the Prime Minister of India, who shall be the Chairperson of the National Authority, *ex officio*;

(*b*) other members, not exceeding nine, to be nominated by the Chairperson of the National Authority.

(*3*) The Chairperson of the National Authority may designate one of the members nominated under clause (*b*) of sub-section (*2*) to be the Vice-Chairperson of the National Authority.

(*4*) The term of office and conditions of service of members of the National Authority shall be such as may be prescribed.

Meetings of National Authority.

4. (*1*) The National Authority shall meet as and when necessary and at such time and place as the Chairperson of the National Authority may think fit.

(*2*) The Chairperson of the National Authority shall preside over the meetings of the National Authority.

(*3*) If for any reason the Chairperson of the National Authority is unable to attend any meeting of the National Authority, the Vice-Chairperson of the National Authority shall preside over the meeting.

Appointment of officers and other employees of the National Authority.

5. The Central Government shall provide the National Authority with such officers, consultants and employees, as it considers necessary for carrying out the functions of the National Authority.

6. (*1*) Subject to the provisions of this Act, the National Authority shall have the responsibility for laying down the policies, plans and guidelines for disaster management for ensuring timely and effective response to disaster.

(*2*) Without prejudice to generality of the provisions contained in sub-section (*1*), the National Authority may —

(*a*) lay down policies on disaster management;

(*b*) approve the National Plan;

(*c*) approve plans prepared by the Ministries or Departments of the Government of India in accordance with the National Plan;

(*d*) lay down guidelines to be followed by the State Authorities in drawing up the State Plan;

(*e*) lay down guidelines to be followed by the different Ministries or Departments of the Government of India for the purpose of integrating the measures for prevention of disaster or the mitigation of its effects in their development plans and projects;

(*f*) coordinate the enforcement and implementation of the policy and plan for disaster management;

(*g*) recommend provision of funds for the purpose of mitigation;

(*h*) provide such support to other countries affected by major disasters as may be determined by the Central Government;

(*i*) take such other measures for the prevention of disaster, or the mitigation, or preparedness and capacity building for dealing with the threatening disaster situation or disaster as it may consider necessary;

(*j*) lay down broad policies and guidelines for the functioning of the National Institute of Disaster Management.

(*3*) The Chairperson of the National Authority shall, in the case of emergency, have power to exercise all or any of the powers of the National Authority but exercise of such powers shall be subject to *ex post facto* ratification by the National Authority.

7. (*1*) The National Authority may constitute an advisory committee consisting of experts in the field of disaster management and having practical experience of disaster management at the national, State or district level to make recommendations on different aspects of disaster management.

(*2*) The members of the advisory committee shall be paid such allowances as may be prescribed by the Central Government in consultation with the National Authority.

8. (*1*) The Central Government shall, immediately after issue of notification under sub-section (*1*) of section 3, constitute a National Executive Committee to assist the National Authority in the performance of its functions under this Act.

(*2*) The National Executive Committee shall consist of the following members, namely:—

(*a*) the Secretary to the Government of India in charge of the Ministry or Department of the Central Government having administrative control of the disaster management, who shall be Chairperson, *ex officio*;

(*b*) the Secretaries to the Government of India in the Ministries or Departments having administrative control of the agriculture, atomic energy, defence, drinking water supply, environment and forests, finance (expenditure), health, power, rural development, science and technology, space, telecommunication, urban development,

water resources and the Chief of the Integrated Defence Staff of the Chiefs of Staff Committee, *ex officio*.

(*3*) The Chairperson of the National Executive Committee may invite any other officer of the Central Government or a State Government for taking part in any meeting of the National Executive Committee and shall exercise such powers and perform such functions as may be prescribed by the Central Government in consultation with the National Authority.

(*4*) The procedure to be followed by the National Executive Committee in exercise of its powers and discharge of its functions shall be such as may be prescribed by the Central Government.

9. (*1*) The National Executive Committee may, as and when it considers necessary, constitute one or more sub-committees, for the efficient discharge of its functions.

(*2*) The National Executive Committee shall, from amongst its members, appoint the Chairperson of the sub-committee referred to in sub-section (*1*).

(*3*) Any person associated as an expert with any sub-committee may be paid such allowances as may be prescribed by the Central Government.

10. (*1*) The National Executive Committee shall assist the National Authority in the discharge of its functions and have the responsibility for implementing the policies and plans of the National Authority and ensure the compliance of directions issued by the Central Government for the purpose of disaster management in the country.

(*2*) Without prejudice to the generality of the provisions contained in sub-section (*1*), the National Executive Committee may —

(*a*) act as the coordinating and monitoring body for disaster management;

(*b*) prepare the National Plan to be approved by the National Authority;

(*c*) coordinate and monitor the implementation of the National Policy;

(*d*) lay down guidelines for preparing disaster management plans by different Ministries or Departments of the Government of India and the State Authorities;

(*e*) provide necessary technical assistance to the State Governments and the State Authorities for preparing their disaster management plans in accordance with the guidelines laid down by the National Authority;

(*f*) monitor the implementation of the National Plan and the plans prepared by the Ministries or Departments of the Government of India;

(*g*) monitor the implementation of the guidelines laid down by the National Authority for integrating of measures for prevention of disasters and mitigation by the Ministries or Departments in their development plans and projects;

(*h*) monitor, coordinate and give directions regarding the mitigation and preparedness measures to be taken by different Ministries or Departments and agencies of the Government;

(*i*) evaluate the preparedness at all governmental levels for the purpose of responding to any threatening disaster situation or disaster and give directions, where necessary, for enhancing such preparedness;

(*j*) plan and coordinate specialised training programme for disaster management for different levels of officers, employees and voluntary rescue workers;

(*k*) coordinate response in the event of any threatening disaster situation or disaster;

(*l*) lay down guidelines for, or give directions to, the concerned Ministries or Departments of the Government of India, the State Governments and the

State Authorities regarding measures to be taken by them in response to any threatening disaster situation or disaster;

(*m*) require any department or agency of the Government to make available to the National Authority or State Authorities such men or material resources as are available with it for the purposes of emergency response, rescue and relief;

(*n*) advise, assist and coordinate the activities of the Ministries or Departments of the Government of India, State Authorities, statutory bodies, other governmental or non-governmental organisations and others engaged in disaster management;

(*o*) provide necessary technical assistance or give advice to the State Authorities and District Authorities for carrying out their functions under this Act;

(*p*) promote general education and awareness in relation to disaster management; and

(*q*) perform such other functions as the National Authority may require it to perform.

11. (*1*) There shall be drawn up a plan for disaster management for the whole of the country to be called the National Plan.

(*2*) The National Plan shall be prepared by the National Executive Committee having regard to the National Policy and in consultation with the State Governments and expert bodies or organisations in the field of disaster management to be approved by the National Authority.

(*3*) The National Plan shall include—

(*a*) measures to be taken for the prevention of disasters, or the mitigation of their effects;

(*b*) measures to be taken for the integration of mitigation measures in the development plans;

(*c*) measures to be taken for preparedness and capacity building to effectively respond to any threatening disaster situations or disaster;

(*d*) roles and responsibilities of different Ministries or Departments of the Government of India in respect of measures specified in clauses (*a*), (*b*) and (*c*).

(*4*) The National Plan shall be reviewed and updated annually.

(*5*) Appropriate provisions shall be made by the Central Government for financing the measures to be carried out under the National Plan.

(*6*) Copies of the National Plan referred to in sub-sections (*2*) and (*4*) shall be made available to the Ministries or Departments of the Government of India and such Ministries or Departments shall draw up their own plans in accordance with the National Plan.

12. The National Authority shall recommend guidelines for the minimum standards of relief to be provided to persons affected by disaster, which shall include,—

(*i*) the minimum requirements to be provided in the relief camps in relation to shelter, food, drinking water, medical cover and sanitation;

(*ii*) the special provisions to be made for widows and orphans;

(*iii*) *ex gratia* assistance on account of loss of life as also assistance on account of damage to houses and for restoration of means of livelihood;

(*iv*) such other relief as may be necessary.

13. The National Authority may, in cases of disasters of severe magnitude, recommend relief in repayment of loans or for grant of fresh loans to the persons affected by disaster on such concessional terms as may be appropriate.

CHAPTER III

STATE DISASTER MANAGEMENT AUTHORITIES

14. (*1*) Every State Government shall, as soon as may be after the issue of the notification under sub-section (*1*) of section 3, by notification in the Official Gazette, establish a State Disaster Management Authority for the State with such name as may be specified in the notification of the State Government.

(*2*) A State Authority shall consist of the Chairperson and such number of other members, not exceeding nine, as may be prescribed by the State Government and, unless the rules otherwise provide, the State Authority shall consist of the following members, namely:—

(*a*) the Chief Minister of the State, who shall be Chairperson, *ex officio;*

(*b*) other members, not exceeding eight, to be nominated by the Chairperson of the State Authority;

(*c*) the Chairperson of the State Executive Committee, *ex officio.*

(*3*) The Chairperson of the State Authority may designate one of the members nominated under clause (*b*) of sub-section (*2*) to be the Vice-Chairperson of the State Authority.

(*4*) The Chairperson of the State Executive Committee shall be the Chief Executive Officer of the State Authority, *ex officio*:

Provided that in the case of a Union territory having Legislative Assembly, except the Union territory of Delhi, the Chief Minister shall be the Chairperson of the Authority established under this section and in case of other Union territories, the Lieutenant Governor or the Administrator shall be the Chairperson of that Authority:

Provided further that the Lieutenant Governor of the Union territory of Delhi shall be the Chairperson and the Chief Minister thereof shall be the Vice-Chairperson of the State Authority.

(*5*) The term of office and conditions of service of members of the State Authority shall be such as may be prescribed.

15. (*1*) The State Authority shall meet as and when necessary and at such time and place as the Chairperson of the State Authority may think fit.

(*2*) The Chairperson of the State Authority shall preside over the meetings of the State Authority.

(*3*) If for any reason, the Chairperson of the State Authority is unable to attend the meeting of the State Authority, the Vice-Chairperson of the State Authority shall preside at the meeting.

16. The State Government shall provide the State Authority with such officers, consultants and employees, as it considers necessary, for carrying out the functions of the State Authority.

17. (*1*) A State Authority may, as and when it considers necessary, constitute an advisory committee, consisting of experts in the field of disaster management and having practical experience of disaster management to make recommendations on different aspects of disaster management.

(*2*) The members of the advisory committee shall be paid such allowances as may be prescribed by the State Government.

18. (*1*) Subject to the provisions of this Act, a State Authority shall have the responsibility for laying down policies and plans for disaster management in the State.

(*2*) Without prejudice to the generality of provisions contained in sub-section (*1*), the State Authority may —

(*a*) lay down the State disaster management policy;

(*b*) approve the State Plan in accordance with the guidelines laid down by the National Authority;

(*c*) approve the disaster management plans prepared by the departments of the Government of the State;

(*d*) lay down guidelines to be followed by the departments of the Government of the State for the purposes of integration of measures for prevention of disasters and mitigation in their development plans and projects and provide necessary technical assistance therefor;

(*e*) coordinate the implementation of the State Plan;

(*f*) recommend provision of funds for mitigation and preparedness measures;

(*g*) review the development plans of the different departments of the State and ensure that prevention and mitigation measures are integrated therein;

(*h*) review the measures being taken for mitigation, capacity building and preparedness by the departments of the Government of the State and issue such guidelines as may be necessary.

(*3*) The Chairperson of the State Authority shall, in the case of emergency, have power to exercise all or any of the powers of the State Authority but the exercise of such powers shall be subject to *ex post facto* ratification of the State Authority.

19. The State Authority shall lay down detailed guidelines for providing standards of relief to persons affected by disaster in the State:

Provided that such standards shall in no case be less than the minimum standards in the guidelines laid down by the National Authority in this regard.

20. (*1*) The State Government shall, immediately after issue of notification under sub-section (*1*) of section 14, constitute a State Executive Committee to assist the State Authority in the performance of its functions and to coordinate action in accordance with the guidelines laid down by the State Authority and ensure the compliance of directions issued by the State Government under this Act.

(*2*) The State Executive Committee shall consist of the following members, namely:—

(*a*) the Chief Secretary to the State Government, who shall be Chairperson, *ex officio;*

(*b*) four Secretaries to the Government of the State of such departments as the State Government may think fit, *ex officio.*

(*3*) The Chairperson of the State Executive Committee shall exercise such powers and perform such functions as may be prescribed by the State Government and such other powers and functions as may be delegated to him by the State Authority.

(*4*) The procedure to be followed by the State Executive Committee in exercise of its powers and discharge of its functions shall be such as may be prescribed by the State Government.

21. (*1*) The State Executive Committee may, as and when it considers necessary, constitute one or more sub-committees, for efficient discharge of its functions.

(*2*) The State Executive Committee shall, from amongst its members, appoint the Chairperson of the sub-committee referred to in sub-section (*1*).

(*3*) Any person associated as an expert with any sub-committee may be paid such allowances as may be prescribed by the State Government.

22. (*1*) The State Executive Committee shall have the responsibility for implementing the National Plan and State Plan and act as the coordinating and monitoring body for management of disaster in the State.

(*2*) Without prejudice to the generality of the provisions of sub-section (*1*), the State Executive Committee may—

(*a*) coordinate and monitor the implementation of the National Policy, the National Plan and the State Plan;

(*b*) examine the vulnerability of different parts of the State to different forms of disasters and specify measures to be taken for their prevention or mitigation;

(*c*) lay down guidelines for preparation of disaster management plans by the departments of the Government of the State and the District Authorities;

(*d*) monitor the implementation of disaster management plans prepared by the departments of the Government of the State and District Authorities;

(*e*) monitor the implementation of the guidelines laid down by the State Authority for integrating of measures for prevention of disasters and mitigation by the departments in their development plans and projects;

(*f*) evaluate preparedness at all governmental or non-governmental levels to respond to any threatening disaster situation or disaster and give directions, where necessary, for enhancing such preparedness;

(*g*) coordinate response in the event of any threatening disaster situation or disaster;

(*h*) give directions to any Department of the Government of the State or any other authority or body in the State regarding actions to be taken in response to any threatening disaster situation or disaster;

(*i*) promote general education, awareness and community training in regard to the forms of disasters to which different parts of the State are vulnerable and the measures that may be taken by such community to prevent the disaster, mitigate and respond to such disaster;

(*j*) advise, assist and coordinate the activities of the Departments of the Government of the State, District Authorities, statutory bodies and other governmental and non-governmental organisations engaged in disaster management;

(*k*) provide necessary technical assistance or give advice to District Authorities and local authorities for carrying out their functions effectively;

(*l*) advise the State Government regarding all financial matters in relation to disaster management;

(*m*) examine the construction, in any local area in the State and, if it is of the opinion that the standards laid for such construction for the prevention of disaster is not being or has not been followed, may direct the District Authority or the local authority, as the case may be, to take such action as may be necessary to secure compliance of such standards;

(*n*) provide information to the National Authority relating to different aspects of disaster management;

(*o*) lay down, review and update State level response plans and guidelines and ensure that the district level plans are prepared, reviewed and updated;

(*p*) ensure that communication systems are in order and the disaster management drills are carried out periodically;

(*q*) perform such other functions as may be assigned to it by the State Authority or as it may consider necessary.

23. (*1*) There shall be a plan for disaster management for every State to be called the State Disaster Management Plan.

(*2*) The State Plan shall be prepared by the State Executive Committee having regard to the guidelines laid down by the National Authority and after such consultation with local authorities, district authorities and the people's representatives as the State Executive Committee may deem fit.

(*3*) The State Plan prepared by the State Executive Committee under sub-section (*2*) shall be approved by the State Authority.

(*4*) The State Plan shall include,—

(*a*) the vulnerability of different parts of the State to different forms of disasters;

(*b*) the measures to be adopted for prevention and mitigation of disasters;

(*c*) the manner in which the mitigation measures shall be integrated with the development plans and projects;

(*d*) the capacity-building and preparedness measures to be taken;

(*e*) the roles and responsibilities of each Department of the Government of the State in relation to the measures specified in clauses (*b*), (*c*) and (*d*) above;

(*f*) the roles and responsibilities of different Departments of the Government of the State in responding to any threatening disaster situation or disaster.

(*5*) The State Plan shall be reviewed and updated annually.

(*6*) Appropriate provisions shall be made by the State Government for financing for the measures to be carried out under the State Plan.

(*7*) Copies of the State Plan referred to in sub-sections (*2*) and (*5*) shall be made available to the Departments of the Government of the State and such Departments shall draw up their own plans in accordance with the State Plan.

24. For the purpose of, assisting and protecting the community affected by disaster or providing relief to such community or, preventing or combating disruption or dealing with the effects of any threatening disaster situation, the State Executive Committee may—

(*a*) control and restrict, vehicular traffic to, from or within, the vulnerable or affected area;

(*b*) control and restrict the entry of any person into, his movement within and departure from, a vulnerable or affected area;

(*c*) remove debris, conduct search and carry out rescue operations;

(*d*) provide shelter, food, drinking water, essential provisions, healthcare and services in accordance with the standards laid down by the National Authority and State Authority;

(*e*) give direction to the concerned Department of the Government of the State, any District Authority or other authority, within the local limits of the State to take such measure or steps for rescue, evacuation or providing immediate relief saving lives or property, as may be necessary in its opinion;

(*f*) require any department of the Government of the State or any other body or authority or person in charge of any relevant resources to make available the resources for the purposes of emergency response, rescue and relief;

(*g*) require experts and consultants in the field of disasters to provide advice and assistance for rescue and relief;

(*h*) procure exclusive or preferential use of amenities from any authority or person as and when required;

(*i*) construct temporary bridges or other necessary structures and demolish unsafe structures which may be hazardous to public;

(*j*) ensure that non-governmental organisations carry out their activities in an equitable and non-discriminatory manner;

(*k*) disseminate information to public to deal with any threatening disaster situation or disaster;

(*l*) take such steps as the Central Government or the State Government may direct in this regard or take such other steps as are required or warranted by the form of any threatening disaster situation or disaster.

CHAPTER IV

DISTRICT DISASTER MANAGEMENT AUTHORITY

25. (*1*) Every State Government shall, as soon as may be after issue of notification under sub-section (*1*) of section 14, by notification in the Official Gazette, establish a District Disaster Management Authority for every district in the State with such name as may be specified in that notification.

(*2*) The District Authority shall consist of the Chairperson and such number of other members, not exceeding seven, as may be prescribed by the State Government, and unless the rules otherwise provide, it shall consist of the following, namely:—

(*a*) the Collector or District Magistrate or Deputy Commissioner, as the case may be, of the district who shall be Chairperson, *ex officio*;

(*b*) the elected representative of the local authority who shall be the co-Chairperson, *ex officio*:

Provided that in the Tribal Areas, as referred to in the Sixth Schedule to the Constitution, the Chief Executive Member of the district council of autonomous district, shall be the co-Chairperson, *ex officio;*

(*c*) the Chief Executive Officer of the District Authority, *ex officio;*

(*d*) the Superintendent of Police, *ex officio;*

(*e*) the Chief Medical Officer of the district, *ex officio;*

(*f*) not exceeding two other district level officers, to be appointed by the State Government.

(*3*) In any district where zila parishad exists, the Chairperson thereof shall be the co-Chairperson of the District Authority.

(*4*) The State Government shall appoint an officer not below the rank of Additional Collector or Additional District Magistrate or Additional Deputy Commissioner, as the case may be, of the district to be the Chief Executive Officer of the District Authority to exercise such powers and perform such functions as may be prescribed by the State Government and such other powers and functions as may be delegated to him by the District Authority.

26. (*1*) The Chairperson of the District Authority shall, in addition to presiding over the meetings of the District Authority, exercise and discharge such powers and functions of the District Authority as the District Authority may delegate to him.

(*2*) The Chairperson of the District Authority shall, in the case of an emergency, have power to exercise all or any of the powers of the District Authority but the exercise of such powers shall be subject to *ex post facto* ratification of the District Authority.

(*3*) The District Authority or the Chairperson of the District Authority may, by general or special order, in writing, delegate such of its or his powers and functions, under sub-section (*1*) or (*2*), as the case may be, to the Chief Executive Officer of the District Authority, subject to such conditions and limitations, if any, as it or he deems fit.

27. The District Authority shall meet as and when necessary and at such time and place as the Chairperson may think fit.

28. (*1*) The District Authority may, as and when it considers necessary, constitute one or more advisory committees and other committees for the efficient discharge of its functions.

(*2*) The District Authority shall, from amongst its members, appoint the Chairperson of the Committee referred to in sub-section (*1*).

(*3*) Any person associated as an expert with any committee or sub-committee constituted under sub-section (*1*) may be paid such allowances as may be prescribed by the State Government.

29. The State Government shall provide the District Authority with such officers, consultants and other employees as it considers necessary for carrying out the functions of District Authority.

30. (*1*) The District Authority shall act as the district planning, coordinating and implementing body for disaster management and take all measures for the purposes of disaster management in the district in accordance with the guidelines laid down by the National Authority and the State Authority.

(*2*) Without prejudice to the generality of the provisions of sub-section (*1*), the District Authority may—

(*i*) prepare a disaster management plan including district response plan for the district;

(*ii*) coordinate and monitor the implementation of the National Policy, State Policy, National Plan, State Plan and District Plan;

(*iii*) ensure that the areas in the district vulnerable to disasters are identified and measures for the prevention of disasters and the mitigation of its effects are undertaken by the departments of the Government at the district level as well as by the local authorities;

(*iv*) ensure that the guidelines for prevention of disasters, mitigation of its effects, preparedness and response measures as laid down by the National Authority and the State Authority are followed by all departments of the Government at the district level and the local authorities in the district;

(*v*) give directions to different authorities at the district level and local authorities to take such other measures for the prevention or mitigation of disasters as may be necessary;

(*vi*) lay down guidelines for prevention of disaster management plans by the department of the Government at the districts level and local authorities in the district;

(*vii*) monitor the implementation of disaster management plans prepared by the Departments of the Government at the district level;

(*viii*) lay down guidelines to be followed by the Departments of the Government at the district level for purposes of integration of measures for prevention of disasters and mitigation in their development plans and projects and provide necessary technical assistance therefor;

(*ix*) monitor the implementation of measures referred to in clause (*viii*);

(*x*) review the state of capabilities for responding to any disaster or threatening disaster situation in the district and give directions to the relevant departments or authorities at the district level for their upgradation as may be necessary;

(*xi*) review the preparedness measures and give directions to the concerned departments at the district level or other concerned authorities where necessary for bringing the preparedness measures to the levels required for responding effectively to any disaster or threatening disaster situation;

(*xii*) organise and coordinate specialised training programmes for different levels of officers, employees and voluntary rescue workers in the district;

(*xiii*) facilitate community training and awareness programmes for prevention of disaster or mitigation with the support of local authorities, governmental and non-governmental organisations;

(*xiv*) set up, maintain, review and upgrade the mechanism for early warnings and dissemination of proper information to public;

(*xv*) prepare, review and update district level response plan and guidelines;

(*xvi*) coordinate response to any threatening disaster situation or disaster;

(*xvii*) ensure that the Departments of the Government at the district level and the local authorities prepare their response plans in accordance with the district response plan;

(*xviii*) lay down guidelines for, or give direction to, the concerned Department of the Government at the district level or any other authorities within the local limits of the district to take measures to respond effectively to any threatening disaster situation or disaster;

(*xix*) advise, assist and coordinate the activities of the Departments of the Government at the district level, statutory bodies and other governmental and non-governmental organisations in the district engaged in the disaster management;

(*xx*) coordinate with, and give guidelines to, local authorities in the district to ensure that measures for the prevention or mitigation of threatening disaster situation or disaster in the district are carried out promptly and effectively;

(*xxi*) provide necessary technical assistance or give advise to the local authorities in the district for carrying out their functions;

(*xxii*) review development plans prepared by the Departments of the Government at the district level, statutory authorities or local authorities with a view to make necessary provisions therein for prevention of disaster or mitigation;

(*xxiii*) examine the construction in any area in the district and, if it is of the opinion that the standards for the prevention of disaster or mitigation laid down for such construction is not being or has not been followed, may direct the concerned authority to take such action as may be necessary to secure compliance of such standards;

(*xxiv*) identify buildings and places which could, in the event of any threatening disaster situation or disaster, be used as relief centers or camps and make arrangements for water supply and sanitation in such buildings or places;

(*xxv*) establish stockpiles of relief and rescue materials or ensure preparedness to make such materials available at a short notice;

(*xxvi*) provide information to the State Authority relating to different aspects of disaster management;

(*xxvii*) encourage the involvement of non-governmental organisations and voluntary social-welfare institutions working at the grassroots level in the district for disaster management;

(*xxviii*) ensure communication systems are in order, and disaster management drills are carried out periodically;

(*xxix*) perform such other functions as the State Government or State Authority may assign to it or as it deems necessary for disaster management in the District.

31. (*1*) There shall be a plan for disaster management for every district of the State.

(*2*) The District Plan shall be prepared by the District Authority, after consultation with the local authorities and having regard to the National Plan and the State Plan, to be approved by the State Authority.

(*3*) The District Plan shall include—

(*a*) the areas in the district vulnerable to different forms of disasters;

(*b*) the measures to be taken, for prevention and mitigation of disaster, by the Departments of the Government at the district level and local authorities in the district;

(*c*) the capacity-building and preparedness measures required to be taken by the Departments of the Government at the district level and the local authorities in the district to respond to any threatening disaster situation or disaster;

(*d*) the response plans and procedures, in the event of a disaster, providing for–

(*i*) allocation of responsibilities to the Departments of the Government at the district level and the local authorities in the district;

(*ii*) prompt response to disaster and relief thereof;

(*iii*) procurement of essential resources;

(*iv*) establishment of communication links; and

(v) the dissemination of information to the public;

(*e*) such other matters as may be required by the State Authority.

(*4*) The District Plan shall be reviewed and updated annually.

(*5*) The copies of the District Plan referred to in sub-sections (*2*) and (*4*) shall be made available to the Departments of the Government in the district.

(*6*) The District Authority shall send a copy of the District Plan to the State Authority which shall forward it to the State Government.

(*7*) The District Authority shall, review from time to time, the implementation of the Plan and issue such instructions to different departments of the Government in the district as it may deem necessary for the implementation thereof.

32. Every office of the Government of India and of the State Government at the district level and the local authorities shall, subject to the supervision of the District Authority,—

(*a*) prepare a disaster management plan setting out the following, namely:—

(*i*) provisions for prevention and mitigation measures as provided for in the District Plan and as is assigned to the department or agency concerned;

(*ii*) provisions for taking measures relating to capacity-building and preparedness as laid down in the District Plan;

(*iii*) the response plans and procedures, in the event of, any threatening disaster situation or disaster;

(*b*) coordinate the preparation and the implementation of its plan with those of the other organisations at the district level including local authority, communities and other stakeholders;

(*c*) regularly review and update the plan; and

(*d*) submit a copy of its disaster management plan, and of any amendment thereto, to the District Authority.

33. The District Authority may by order require any officer or any Department at the district level or any local authority to take such measures for the prevention or mitigation of disaster, or to effectively respond to it, as may be necessary, and such officer or department shall be bound to carry out such order.

34. For the purpose of assisting, protecting or providing relief to the community, in response to any threatening disaster situation or disaster, the District Authority may—

(*a*) give directions for the release and use of resources available with any Department of the Government and the local authority in the district;

(*b*) control and restrict vehicular traffic to, from and within, the vulnerable or affected area;

(*c*) control and restrict the entry of any person into, his movement within and departure from, a vulnerable or affected area;

(*d*) remove debris, conduct search and carry out rescue operations;

(*e*) provide shelter, food, drinking water and essential provisions, healthcare and services;

(*f*) establish emergency communication systems in the affected area;

(*g*) make arrangements for the disposal of the unclaimed dead bodies;

(*h*) recommend to any Department of the Government of the State or any authority or body under that Government at the district level to take such measures as are necessary in its opinion;

(*i*) require experts and consultants in the relevant fields to advise and assist as it may deem necessary;

(*j*) procure exclusive or preferential use of amenities from any authority or person;

(*k*) construct temporary bridges or other necessary structures and demolish structures which may be hazardous to public or aggravate the effects of the disaster;

(*l*) ensure that the non-governmental organisations carry out their activities in an equitable and non-discriminatory manner;

(*m*) take such other steps as may be required or warranted to be taken in such a situation.

CHAPTER V

MEASURES BY THE GOVERNMENT FOR DISASTER MANAGEMENT

35. (*1*) Subject to the provisions of this Act, the Central Government shall take all such measures as it deems necessary or expedient for the purpose of disaster management.

(*2*) In particular and without prejudice to the generality of the provisions of sub-section (*1*), the measures which the Central Government may take under that sub-section include measures with respect to all or any of the following matters, namely:—

(*a*) coordination of actions of the Ministries or Departments of the Government of India, State Governments, National Authority, State Authorities, governmental and non-governmental organisations in relation to disaster management;

(*b*) ensure the integration of measures for prevention of disasters and mitigation by Ministries or Departments of the Government of India into their development plans and projects;

(*c*) ensure appropriate allocation of funds for prevention of disaster, mitigation, capacity-building and preparedness by the Ministries or Departments of the Government of India;

(*d*) ensure that the Ministries or Departments of the Government of India take necessary measures for preparedness to promptly and effectively respond to any threatening disaster situation or disaster;

(*e*) cooperation and assistance to State Governments, as requested by them or otherwise deemed appropriate by it;

(*f*) deployment of naval, military and air forces, other armed forces of the Union or any other civilian personnel as may be required for the purposes of this Act;

(*g*) coordination with the United Nations agencies, international organisations and governments of foreign countries for the purposes of this Act;

(*h*) establish institutions for research, training, and developmental programmes in the field of disaster management;

(*i*) such other matters as it deems necessary or expedient for the purpose of securing effective implementation of the provisions of this Act.

(*3*) The Central Government may extend such support to other countries affected by major disaster as it may deem appropriate.

36. It shall be the responsibility of every Ministry or Department of the Government of India to —

(*a*) take measures necessary for prevention of disasters, mitigation, preparedness and capacity-building in accordance with the guidelines laid down by the National Authority;

(*b*) integrate into its development plans and projects, the measures for prevention or mitigation of disasters in accordance with the guidelines laid down by the National Authority;

(*c*) respond effectively and promptly to any threatening disaster situation or disaster in accordance with the guidelines of the National Authority or the directions of the National Executive Committee in this behalf;

(*d*) review the enactments administered by it, its policies, rules and regulations, with a view to incorporate therein the provisions necessary for prevention of disasters, mitigation or preparedness;

(*e*) allocate funds for measures for prevention of disaster, mitigation, capacity-building and preparedness;

(*f*) provide assistance to the National Authority and State Governments for—

(*i*) drawing up mitigation, preparedness and response plans, capacity-building, data collection and identification and training of personnel in relation to disaster management;

(*ii*) carrying out rescue and relief operations in the affected area;

(*iii*) assessing the damage from any disaster;

(*iv*) carrying out rehabilitation and reconstruction;

(*g*) make available its resources to the National Executive Committee or a State Executive Committee for the purposes of responding promptly and effectively to any threatening disaster situation or disaster, including measures for—

(*i*) providing emergency communication in a vulnerable or affected area;

(*ii*) transporting personnel and relief goods to and from the affected area;

(*iii*) providing evacuation, rescue, temporary shelter or other immediate relief;

(*iv*) setting up temporary bridges, jetties and landing places;

(*v*) providing, drinking water, essential provisions, healthcare, and services in an affected area;

(*h*) take such other actions as it may consider necessary for disaster management.

37. (*1*) Every Ministry or Department of the Government of India shall—

(*a*) prepare a disaster management plan specifying the following particulars, namely:—

(*i*) the measures to be taken by it for prevention and mitigation of disasters in accordance with the National Plan;

(*ii*) the specifications regarding integration of mitigation measures in its development plans in accordance with the guidelines of the National Authority and the National Executive Committee;

(*iii*) its roles and responsibilities in relation to preparedness and capacity-building to deal with any threatening disaster situation or disaster;

(*iv*) its roles and responsibilities in regard to promptly and effectively responding to any threatening disaster situation or disaster;

(*v*) the present status of its preparedness to perform the roles and responsibilities specified in sub-clauses (*iii*) and (*iv*);

(*vi*) the measures required to be taken in order to enable it to perform its responsibilities specified in sub-clauses (*iii*) and (*iv*);

(*b*) review and update annually the plan referred to in clause (*a*);

(*c*) forward a copy of the plan referred to in clause (*a*) or clause (*b*), as the case may be, to the Central Government which Government shall forward a copy thereof to the National Authority for its approval.

(*2*) Every Ministry or Department of the Government of India shall—

(*a*) make, while preparing disaster management plan under clause (*a*) of sub-section (*1*), provisions for financing the activities specified therein;

(*b*) furnish a status report regarding the implementation of the plan referred to in clause (*a*) of sub-section (*1*) to the National Authority, as and when required by it.

38. (*1*) Subject to the provisions of this Act, each State Government shall take all measures specified in the guidelines laid down by the National Authority and such further measures as it deems necessary or expedient, for the purpose of disaster management.

(*2*) The measures which the State Government may take under sub-section (*1*) include measures with respect to all or any of the following matters, namely:—

(*a*) coordination of actions of different departments of the Government of the State, the State Authority, District Authorities, local authority and other non-governmental organisations;

(*b*) cooperation and assistance in the disaster management to the National Authority and National Executive Committee, the State Authority and the State Executive Committee, and the District Authorities;

(*c*) cooperation with, and assistance to, the Ministries or Departments of the Government of India in disaster management, as requested by them or otherwise deemed appropriate by it;

(*d*) allocation of funds for measures for prevention of disaster, mitigation, capacity-building and preparedness by the departments of the Government of the State in accordance with the provisions of the State Plan and the District Plans;

(*e*) ensure that the integration of measures for prevention of disaster or mitigation by the departments of the Government of the State in their development plans and projects;

(*f*) integrate in the State development plan, measures to reduce or mitigate the vulnerability of different parts of the State to different disasters;

(*g*) ensure the preparation of disaster management plans by different departments of the State in accordance with the guidelines laid down by the National Authority and the State Authority;

(*h*) establishment of adequate warning systems up to the level of vulnerable communities;

(*i*) ensure that different departments of the Government of the State and the District Authorities take appropriate preparedness measures;

(*j*) ensure that in a threatening disaster situation or disaster, the resources of different departments of the Government of the State are made available to the National Executive Committee or the State Executive Committee or the District Authorities, as the case may be, for the purposes of effective response, rescue and relief in any threatening disaster situation or disaster;

(*k*) provide rehabilitation and reconstruction assistance to the victims of any disaster; and

(*l*) such other matters as it deems necessary or expedient for the purpose of securing effective implementation of provisions of this Act.

39. It shall be the responsibility of every department of the Government of a State to—

(*a*) take measures necessary for prevention of disasters, mitigation, preparedness and capacity-building in accordance with the guidelines laid down by the National Authority and the State Authority;

(*b*) integrate into its development plans and projects, the measures for prevention of disaster and mitigation;

(*c*) allocate funds for prevention of disaster, mitigation, capacity-building and preparedness;

(*d*) respond effectively and promptly to any threatening disaster situation or disaster in accordance with the State Plan, and in accordance with the guidelines or directions of the National Executive Committee and the State Executive Committee;

(*e*) review the enactments administered by it, its policies, rules and regulations with a view to incorporate therein the provisions necessary for prevention of disasters, mitigation or preparedness;

(*f*) provide assistance, as required, by the National Executive Committee, the State Executive Committee and District Authorities, for—

(*i*) drawing up mitigation, preparedness and response plans, capacity-building, data collection and identification and training of personnel in relation to disaster management;

(*ii*) assessing the damage from any disaster;

(*iii*) carrying out rehabilitation and reconstruction;

(*g*) make provision for resources in consultation with the State Authority for the implementation of the District Plan by its authorities at the district level;

(*h*) make available its resources to the National Executive Committee or the State Executive Committee or the District Authorities for the purposes of responding promptly and effectively to any disaster in the State, including measures for—

(*i*) providing emergency communication with a vulnerable or affected area;

(*ii*) transporting personnel and relief goods to and from the affected area;

(*iii*) providing evacuation, rescue, temporary shelter or other immediate relief;

(*iv*) carrying out evacuation of persons or live-stock from an area of any threatening disaster situation or disaster;

(*v*) setting up temporary bridges, jetties and landing places;

(*vi*) providing drinking water, essential provisions, healthcare and services in an affected area;

(*i*) such other actions as may be necessary for disaster management.

40. (*1*) Every department of the State Government, in conformity with the guidelines laid down by the State Authority, shall—

(*a*) prepare a disaster management plan which shall lay down the following :—

(*i*) the types of disasters to which different parts of the State are vulnerable;

(*ii*) integration of strategies for the prevention of disaster or the mitigation of its effects or both with the development plans and programmes by the department;

(*iii*) the roles and responsibilities of the department of the State in the event of any threatening disaster situation or disaster and emergency support function it is required to perform;

(*iv*) present status of its preparedness to perform such roles or responsibilities or emergency support function under sub-clause (*iii*);

(*v*) the capacity-building and preparedness measures proposed to be put into effect in order to enable the Ministries or Departments of the Government of India to discharge their responsibilities under section 37;

(*b*) annually review and update the plan referred to in clause (*a*); and

(*c*) furnish a copy of the plan referred to in clause (*a*) or clause (*b*), as the case may be, to the State Authority.

(*2*) Every department of the State Government, while preparing the plan under sub-section (*1*), shall make provisions for financing the activities specified therein.

(*3*) Every department of the State Government shall furnish an implementation status report to the State Executive Committee regarding the implementation of the disaster management plan referred to in sub-section (*1*).

CHAPTER VI

LOCAL AUTHORITIES

41. (*1*) Subject to the directions of the District Authority, a local authority shall—

(*a*) ensure that its officers and employees are trained for disaster management;

(*b*) ensure that resources relating to disaster management are so maintained as to be readily available for use in the event of any threatening disaster situation or disaster;

(*c*) ensure all construction projects under it or within its jurisdiction conform to the standards and specifications laid down for prevention of disasters and mitigation by the National Authority, State Authority and the District Authority;

(*d*) carry out relief, rehabilitation and reconstruction activities in the affected area in accordance with the State Plan and the District Plan.

(*2*) The local authority may take such other measures as may be necessary for the disaster management.

CHAPTER VII

NATIONAL INSTITUTE OF DISASTER MANAGEMENT

42. (*1*) With effect from such date as the Central Government may, by notification in the Official Gazette appoint in this behalf, there shall be constituted an institute to be called the National Institute of Disaster Management.

(*2*) The National Institute of Disaster Management shall consist of such number of members as may be prescribed by the Central Government.

(*3*) The term of office of, and vacancies among, members of the National Institute of Disaster Management and manner of filling such vacancies shall be such as may be prescribed.

(*4*) There shall be a governing body of the National Institute of Disaster Management which shall be constituted by the Central Government from amongst the members of the National Institute of Disaster Management in such manner as may be prescribed.

(*5*) The governing body of the National Institute of Disaster Management shall exercise such powers and discharge such functions as may be prescribed by regulations.

(*6*) The procedure to be followed in excercise of its powers and discharge of its functions by the governing body, and the term of office of, and the manner of filling vacancies among the members of the governing body, shall be such as may be prescribed by regulations.

(*7*) Until the regulations are made under this section, the Central Government may make such regulations; and any regulation so made may be altered or rescinded by the National Institute of Disaster Management in exercise of its powers.

(*8*) Subject to the provisions of this Act, the National Institute of Disaster Management shall function within the broad policies and guidelines laid down by the National Authority and be responsible for planning and promoting training and research in the area of disaster

management, documentation and development of national level information base relating to disaster management policies, prevention mechanisms and mitigation measures.

(9) Without prejudice to the generality of the provisions contained in sub-section (8), the National Institute, for the discharge of its functions, may –

(a) develop training modules, undertake research and documentation in disaster management and organise training programmes;

(b) formulate and implement a comprehensive human resource development plan covering all aspects of disaster management;

(c) provide assistance in national level policy formulation;

(d) provide required assistance to the training and research institutes for development of training and research programmes for stakeholders including Government functionaries and undertake training of faculty members of the State level training institutes;

(e) provide assistance to the State Governments and State training institutes in the formulation of State level policies, strategies, disaster management framework and any other assistance as may be required by the State Governments or State training institutes for capacity-building of stakeholders, Government including its functionaries, civil society members, corporate sector and people's elected representatives;

(f) develop educational materials for disaster management including academic and professional courses;

(g) promote awareness among stakeholders including college or school teachers and students, technical personnel and others associated with multi-hazard mitigation, preparedness and response measures;

(h) undertake, organise and facilitate study courses, conferences, lectures, seminars within and outside the country to promote the aforesaid objects;

(i) undertake and provide for publication of journals, research papers and books and establish and maintain libraries in furtherance of the aforesaid objects;

(j) do all such other lawful things as are conducive or incidental to the attainment of the above objects; and

(k) undertake any other function as may be assigned to it by the Central Government.

43. The Central Government shall provide the National Institute of Disaster Management with such officers, consultants and other employees, as it considers necessary, for carrying out its functions.

CHAPTER VIII

NATIONAL DISASTER RESPONSE FORCE

44. (1) There shall be constituted a National Disaster Response Force for the purpose of specialist response to a threatening disaster situation or disaster.

(2) Subject to the provisions of this Act, the Force shall be constituted in such manner and, the conditions of service of the members of the Force, including disciplinary provisions therefor, be such as may be prescribed.

45. The general superintendence, direction and control of the Force shall be vested and exercised by the National Authority and the command and supervision of the Force shall vest in an officer to be appointed by the Central Government as the Director General of the National Disaster Response Force.

CHAPTER IX

FINANCE, ACCOUNTS AND AUDIT

46. (*1*) The Central Government may, by notification in the Official Gazette, constitute a fund to be called the National Disaster Response Fund for meeting any threatening disaster situation or disaster and there shall be credited thereto—

(*a*) an amount which the Central Government may, after due appropriation made by Parliament by law in this behalf provide;

(*b*) any grants that may be made by any person or institution for the purpose of disaster management.

(*2*) The National Disaster Response Fund shall be made available to the National Executive Committee to be applied towards meeting the expenses for emergency response, relief and rehabilitation in accordance with the guidelines laid down by the Central Government in consultation with the National Authority.

47. (*1*) The Central Government may, by notification in the Official Gazette, constitute a Fund to be called the National Disaster Mitigation Fund for projects exclusively for the purpose of mitigation and there shall be credited thereto such amount which the Central Government may, after due appropriation made by Parliament by law in this behalf, provide.

(*2*) The National Disaster Mitigation Fund shall be applied by the National Authority.

48. (*1*) The State Government shall, immediately after notifications issued for constituting the State Authority and the District Authorities, establish for the purposes of this Act the following funds, namely:—

(*a*) the fund to be called the State Disaster Response Fund;

(*b*) the fund to be called the District Disaster Response Fund;

(*c*) the fund to be called the State Disaster Mitigation Fund;

(*d*) the fund to be called the District Disaster Mitigation Fund.

(*2*) The State Government shall ensure that the funds established—

(*i*) under clause (*a*) of sub-section (*1*) is available to the State Executive Committee;

(*ii*) under sub-clause (*c*) of sub-section (*1*) is available to the State Authority;

(*iii*) under clauses (*b*) and (*d*) of sub-section (*1*) are available to the District Authority.

49. (*1*) Every Ministry or Department of the Government of India shall make provisions, in its annual budget, for funds for the purposes of carrying out the activities and programmes set out in its disaster management plan.

(*2*) The provisions of sub-section (*1*) shall, *mutatis mutandis*, apply to departments of the Government of the State.

50. Where by reason of any threatening disaster situation or disaster, the National Authority or the State Authority or the District Authority is satisfied that immediate procurement of provisions or materials or the immediate application of resources are necessary for rescue or relief,—

(*a*) it may authorise the concerned department or authority to make the emergency procurement and in such case, the standard procedure requiring inviting of tenders shall be deemed to be waived;

(*b*) a certificate about utilisation of provisions or materials by the controlling officer authorised by the National Authority, State Authority or District Authority, as the case may be, shall be deemed to be a valid document or voucher for the purpose of accounting of emergency, procurement of such provisions or materials.

CHAPTER X

OFFENCES AND PENALTIES

51. Whoever, without reasonable cause—

(*a*) obstructs any officer or employee of the Central Government or the State Government, or a person authorised by the National Authority or State Authority or District Authority in the discharge of his functions under this Act; or

(*b*) refuses to comply with any direction given by or on behalf of the Central Government or the State Government or the National Executive Committee or the State Executive Committee or the District Authority under this Act,

shall on conviction be punishable with imprisonment for a term which may extend to one year or with fine, or with both, and if such obstruction or refusal to comply with directions results in loss of lives or imminent danger thereof, shall on conviction be punishable with imprisonment for a term which may extend to two years.

52. Whoever knowingly makes a claim which he knows or has reason to believe to be false for obtaining any relief, assistance, repair, reconstruction or other benefits consequent to disaster from any officer of the Central Government, the State Government, the National Authority, the State Authority or the District Authority, shall, on conviction be punishable with imprisonment for a term which may extend to two years, and also with fine.

53. Whoever, being entrusted with any money or materials, or otherwise being, in custody of, or dominion over, any money or goods, meant for providing relief in any threatening disaster situation or disaster, misappropriates or appropriates for his own use or disposes of such money or materials or any part thereof or wilfully compels any other person so to do, shall on conviction be punishable with imprisonment for a term which may extend to two years, and also with fine.

54. Whoever makes or circulates a false alarm or warning as to disaster or its severity or magnitude, leading to panic, shall on conviction, be punishable with imprisonment which may extend to one year or with fine.

55. (*1*) Where an offence under this Act has been committed by any Department of the Government, the head of the Department shall be deemed to be guilty of the offence and shall be liable to be proceeded against and punished accordingly unless he proves that the offence was committed without his knowledge or that he exercised all due diligence to prevent the commission of such offence.

(*2*) Notwithstanding anything contained in sub-section (*1*), where an offence under this Act has been committed by a Department of the Government and it is proved that the offence has been committed with the consent or connivance of, or is attributable to any neglect on the part of, any officer, other than the head of the Department, such officer shall be deemed to be guilty of that offence and shall be liable to be proceeded against and punished accordingly.

56. Any officer, on whom any duty has been imposed by or under this Act and who ceases or refuses to perform or withdraws himself from the duties of his office shall, unless he has obtained the express written permission of his official superior or has other lawful excuse for so doing, be punishable with imprisonment for a term which may extend to one year or with fine.

57. If any person contravenes any order made under section 65, he shall be punishable with imprisonment for a term which may extend to one year or with fine or with both.

58. (*1*) Where an offence under this Act has been committed by a company or body corporate, every person who at the time the offence was committed, was in charge of, and was responsible to, the company, for the conduct of the business of the company, as well as the company, shall be deemed to be guilty of the contravention and shall be liable to be proceeded against and punished accordingly:

Provided that nothing in this sub-section shall render any such person liable to any punishment provided in this Act, if he proves that the offence was committed without his knowledge or that he exercised due diligence to prevent the commission of such offence.

(*2*) Notwithstanding anything contained in sub-section (*1*), where an offence under this Act has been committed by a company, and it is proved that the offence was committed with the consent or connivance of or is attributable to any neglect on the part of any director, manager, secretary or other officer of the company, such director, manager, secretary or other officer shall also, be deemed to be guilty of that offence and shall be liable to be proceeded against and punished accordingly.

Explanation.—For the purpose of this section –

(*a*) "company" means any body corporate and includes a firm or other association of individuals; and

(*b*) "director", in relation to a firm, means a partner in the firm.

59. No prosecution for offences punishable under sections 55 and 56 shall be instituted except with the previous sanction of the Central Government or the State Government, as the case may be, or of any officer authorised in this behalf, by general or special order, by such Government.

60. No court shall take cognizance of an offence under this Act except on a complaint made by—

(*a*) the National Authority, the State Authority, the Central Government, the State Government, the District Authority or any other authority or officer authorised in this behalf by that Authority or Government, as the case may be; or

(*b*) any person who has given notice of not less than thirty days in the manner prescribed, of the alleged offence and his intention to make a complaint to the National Authority, the State Authority, the Central Government, the State Government, the District Authority or any other authority or officer authorised as aforesaid.".

CHAPTER XI

MISCELLANEOUS

61. While providing compensation and relief to the victims of disaster, there shall be no discrimination on the ground of sex, caste, community, descent or religion.

62. Notwithstanding anything contained in any other law for the time being in force, it shall be lawful for the Central Government to issue direction in writing to the Ministries or Departments of the Government of India, or the National Executive Committee or the State Government, State Authority, State Executive Committee, statutory bodies or any of its officers or employees, as the case may be, to facilitate or assist in the disaster management and such Ministry or Department or Government or Authority, Executive Committee, statutory body, officer or employee shall be bound to comply with such direction.

63. Any officer or authority of the Union or a State, when requested by the National Executive Committee, any State Executive Committee or District Authority or any person authorised by such Committee or Authority in this behalf, shall make available to that Committee or authority or person, such officers and employees as requested for, to perform any of the functions in connection with the prevention of disaster or mitigation or rescue or relief work.

64. Subject to the provisions of this Act, if it appears to the National Executive Committee, State Executive Committee or the District Authority, as the case may be, that provisions of any rule, regulation, notification, guideline, instruction, order, scheme or bye-laws, as the case may be, are required to be made or amended for the purposes of prevention of disasters or the mitigation thereof, it may require the amendment of such rules, regulation, notification, guidelines, instruction, order, scheme or bye-laws, as the case may be, for that purpose, and the appropriate department or authority shall take necessary action to comply with the requirements.

65. (*1*) If it appears to the National Executive Committee, State Executive Committee or District Authority or any officer as may be authorised by it in this behalf that—

(*a*) any resources with any authority or person are needed for the purpose of prompt response;

(*b*) any premises are needed or likely to be needed for the purpose of rescue operations; or

(*c*) any vehicle is needed or is likely to be needed for the purposes of transport of resources from disaster affected areas or transport of resources to the affected area or transport in connection with rescue, rehabilitation or reconstruction,

such authority may, by order in writing, requisition such resources or premises or such vehicle, as the case may be, and may make such further orders as may appear to it to be necessary or expedient in connection with the requisitioning.

(*2*) Whenever any resource, premises or vehicle is requisitioned under sub-section (*1*), the period of such requisition shall not extend beyond the period for which such resource, premises or vehicle is required for any of the purposes mentioned in that sub-section.

(*3*) In this section,—

(*a*) "resources" includes men and material resources;

(*b*) "services" includes facilities;

(*c*) "premises" means any land, building or part of a building and includes a hut, shed or other structure or any part thereof;

(*d*) "vehicle" means any vehicle used or capable of being used for the purpose of transport, whether propelled by mechanical power or otherwise.

66. (*1*) Whenever any Committee, Authority or officer referred to in sub-section (*1*) of section 65, in pursuance of that section requisitions any premises, there shall be paid to the persons interested compensation the amount of which shall be determined by taking into consideration the following, namely:—

(*i*) the rent payable in respect of the premises, or if no rent is so payable, the rent payable for similar premises in the locality;

(*ii*) if as consequence of the requisition of the premises the person interested is compelled to change his residence or place of business, the reasonable expenses (if any) incidental to such change:

Provided that where any person interested being aggrieved by the amount of compensation so determined makes an application within the thirty days to the Central Government or the State Government, as the case may be, for referring the matter to an arbitrator, the amount of compensation to be paid shall be such as the arbitrator appointed in this behalf by the Central Government or the State Government, as the case may be, may determine:

Provided further that where there is any dispute as to the title to receive the compensation or as to the apportionment of the amount of compensation, it shall be referred by the Central Government or the State Government, as the case may be, to an arbitrator appointed in this behalf by the Central Government or the State Government, as the case may be, for determination, and shall be determined in accordance with the decision of such arbitrator.

Explanation.—In this sub-section, the expression "person interested" means the person who was in actual possession of the premises requisitioned under section 65 immediately before the requisition, or where no person was in such actual possession, the owner of such premises.

(*2*) Whenever any Committee, Authority or officer, referred to in sub-section (*1*) of section 65 in pursuance of that section requisitions any vehicle, there shall be paid to the owner thereof compensation the amount of which shall be determined by the Central Government or the State Government, as the case may be, on the basis of the fares or rates prevailing in the locality for the hire of such vehicle:

Provided that where the owner of such vehicle being aggrieved by the amount of compensation so determined makes an application within the prescribed time to the Central Government or the State Government, as the case may be, for referring the matter to an arbitrator, the amount of compensation to be paid shall be such as the arbitrator appointed in this behalf by the Central Government or the State Government, as the case may be, may determine:

Provided further that where immediately before the requisitioning the vehicle or vessel was by virtue of a hire purchase agreement in the possession of a person other than the owner, the amount determined under this sub-section as the total compensation payable in respect of the requisition shall be apportioned between that person and the owner in such manner as they may agree upon, and in default of agreement, in such manner as an arbitrator appointed by the Central Government or the State Government, as the case may be, in this behalf may decide.

67. The National Authority, the State Authority, or a District Authority may recommend to the Government to give direction to any authority or person in control of any audio or audio-visual media or such other means of communication as may be available to carry any warning or advisories regarding any threatening disaster situation or disaster, and the said means of communication and media as designated shall comply with such direction.

68. Every order or decision of the National Authority or the National Executive Committee, the State Authority, or the State Executive Committee or the District Authority, shall be authenticated by such officers of the National Authority or the National Executive Committee or, the State Executive Committee, or the District Authority, as may be authorised by it in this behalf.

69. The National Executive Committee, State Executive Committee, as the case may be, by general or special order in writing, may delegate to the Chairperson or any other member or to any officer, subject to such conditions and limitations, if any, as may be specified in the order, such of its powers and functions under this Act as it may deem necessary.

70. (*1*) The National Authority shall prepare once every year, in such form and at such time as may be prescribed, an annual report giving a true and full account of its activities during the previous year and copies thereof shall be forwarded to the Central Government and that Government shall cause the same to be laid before both Houses of Parliament within one month of its receipt.

(*2*) The State Authority shall prepare once in every year, in such form and at such time as may be prescribed, an annual report giving a true and full account of its activities during the previous year and copies thereof shall be forwarded to the State Government and that Government shall cause the same to be laid before each House of the State Legislature where it consists of two Houses, or where such Legislature consists of one House, before that House.

71. No court (except the Supreme Court or a High Court) shall have jurisdiction to entertain any suit or proceeding in respect of anything done, action taken, orders made, direction, instruction or guidelines issued by the Central Government, National Authority, State Government, State Authority or District Authority in pursuance of any power conferred by, or in relation to its functions, by this Act.

72. The provisions of this Act, shall have effect, notwithstanding anything inconsistent therewith contained in any other law for the time being in force or in any instrument having effect by virtue of any law other than this Act.

73. No suit or prosecution or other proceeding shall lie in any court against the Central Government or the National Authority or the State Government or the State Authority or the District Authority or local authority or any officer or employee of the Central Government or the National Authority or the State Government or the State Authority or the District Authority or local authority or any person working for on behalf of such Government or authority in respect of any work done or purported to have been done or intended to be done in good faith by such authority or Government or such officer or employee or such person under the provisions of this Act or the rules or regulations made thereunder.

74. Officers and employees of the Central Government, National Authority, National Executive Committee, State Government, State Authority, State Executive Committee or District Authority shall be immune from legal process in regard to any warning in respect of any impending disaster communicated or disseminated by them in their official capacity or any action taken or direction issued by them in pursuance of such communication or dissemination.

75. (*1*) The Central Government may, by notification in the Official Gazette, make rules for carrying out the purposes of this Act.

(*2*) In particular, and without prejudice to the generality of the foregoing power, such rules may provide for all or any of the following matters, namely :—

(*a*) the composition and number of the members of the National Authority under sub-section (*2*), and the term of office and conditions of service of members of the National Authority under sub-section (*4*), of section 3;

(*b*) the allowances to be paid to the members of the advisory committee under sub-section (*2*) of section 7;

(*c*) the powers and functions of the Chairperson of the National Executive Committee under sub-section (*3*) of section 8 and the procedure to be followed by the National Executive Committee in exercise of its powers and discharge of its functions under sub-section (*4*) of section 8;

(*d*) allowances to be paid to the persons associated with the sub-committee constituted by the National Executive Committee under sub-section (*3*) of section 9;

(*e*) the number of members of the National Institute of Disaster Management under sub-section (*2*), the term of the office and vacancies among members and the manner of filling such vacancies under sub-section (*3*) and the manner of constituting the Governing Body of the National Institute of Disaster Management under sub-section (*4*) of section 42;

(*f*) the manner of constitution of the Force, the conditions of service of the members of the Force, including disciplinary provisions under sub-section (*2*) of section 44;

(*g*) the manner in which notice of the offence and of the intention to make a complaint to the National Authority, the State Authority, the Central Government, the State Government or the other authority or officer under clause (*b*) of section 60;

(*h*) the form in which and the time within which annual report is to be prepared under section 70;

(*f*) any other matter which is to be, or may be, prescribed, or in respect of which provision is to be made by rules.

76. (*1*) The National Institute of Disaster Management, with the previous approval of the Central Government may, by notification in the Official Gazette, make regulations consistent with this Act and the rules made thereunder to carry out the purposes of this Act.

(*2*) In particular, and without prejudice to the generality of the foregoing power, such regulations may provide for all or any of the following matters, namely:—

(*a*) powers and functions to be exercised and dicharged by the governing body;

(*b*) procedure to be followed by the governing body in exercise of the powers and discharge of its functions;

(*c*) any other matter for which under this Act provision may be made by the regulations.

77. Every rule made by the Central Government and every regulation made by the National Institute of Disaster Management under this Act shall be laid, as soon as may be after it is made, before each House of Parliament, while it is in session, for a total period of thirty days which may be comprised of one session or in two or more successive sessions, and if, before the expiry of the session immediately following the session or the successive sessions aforesaid, both Houses agree in making any modification in the rule or regulation or both Houses agree that the rule or regulation should not be made, the rule or regulation shall thereafter have effect only in such modified form or be of no effect, as the case may be; so, however, that any such modification or annulment shall be without prejudice to the validity of anything previously done under that rule or regulation.

78. (*1*) The State Government may, by notification in the Official Gazette, make rules to carry out the provisions of this Act.

(*2*) In particular, and without prejudice to the generality of the foregoing power, such rules may provide for all or any of the following matters, namely:—

(*a*) the composition and number of the members of the State Authority under sub-section (*2*), and the term of office and conditions of service of the members of the State Authority under sub-section (*5*), of section 14;

(*b*) the allowances to be paid to the members of the advisory committee under sub-section (*2*) of section 17;

(*c*) the powers and functions of the Chairperson of the State Executive Committee under sub-section (*3*), and the procedure to be followed by the State Executive Committee in exercise of its powers and discharge of its functions under sub-section (*4*) of section 20;

(*d*) allowances to be paid to the persons associated with the sub-committee constituted by the State Executive Committee under sub-section (*3*) of section 21;

(*e*) the composition and the number of members of the District Authority under sub-section (*2*), and the powers and functions to be exercised and discharged by the Chief Executive Officer of the District Authority under sub-section (*3*) of section 25;

(*f*) allowances payable to the persons associated with any committee constituted by the District Authority as experts under sub-section (*3*) of section 28;

(*g*) any other matter which is to be, or may be, prescribed, or in respect of which provision is to be made by rules.

(*3*) Every rule made by the State Government under this Act shall be laid, as soon as may be after it is made, before each House of the State Legislature where it consists of two Houses, or where such Legislature consists of one House before that House.

79. (*1*) If any difficulty arises in giving effect to the provisions of this Act, the Central Government or the State Government, as the case may be, by notification in the Official Gazette, make order not inconsistent with the provisions of this Act as may appear to it to be necessary or expedient for the removal of the difficulty:

Provided that no such order shall be made after the expiration of two years from the commencement of this Act.

(*2*) Every order made under this section shall be laid, as soon as may be after it is made, before each House of Parliament or the Legislature, as the case may be.

T. K. VISWANATHAN,
Secy. to the Govt. of India.

~~386~~

Annexure-3

~~387~~

Government of India
Ministry of Water Resources
Central Water Commission

Guidelines

for

Safety Inspection of Dams

New Delhi
June 1987 (Revised)

~~388~~

CWC Publication No.21/87

Government of India
Ministry of Water Resources
Central Water Commission

Guidelines
for
Safety Inspection of Dams

Compiled by
Dam Safety Organization

New Delhi
June 1987 (Revised)

~~389~~

CONTENTS

Chapter	I	Introduction	4
Chapter	II	General Requirements	6
Chapter	III	Phase I Investigation	9
Chapter	IV	Phase II Investigation	15
Chapter	V	Reports	31
Chapter	VI	Acknowledgements	33
Appendix	I	Format for Engineering Data	34
Appendix	II	Inspection Items	36
Annexure	I	Definition of Terms associated with Durability of Concrete	44
Appendix	III	Structures, Features, Events and Evidence to be examined during Inspections	48

~~380~~

Chapter I

INTRODUCTION

1.1 The dams are national property – constructed for the development of the national economy and in which large investments and other resources have been deployed.

1.2 The safety of the dam is a very important aspect for safeguarding the national investment and the benefits derived by the nation from the project. In addition, an unsafe dam constitutes a hazard to human life and property in the downstream reaches.

1.3 The safety of the dams and allied structures is an important aspect to be examined for ensuring public confidence in the continued accrual of benefits from the national investment made and to protect the downstream area from any potential hazard.

1.4 This document provides guidelines for the inspection and evaluation to determine the safety of dams and allied structures.

1.5 The procedures and guidelines outlined in this document apply to the inspection and evaluation of all dams / barriers together with appurtenant works which impound or divert water and which (1) are 8 metres or more in height or (2) have an impounding capacity of six hectare metres or more. Barriers which are 2 metres or less in height regardless of storage capacity or barriers which have a storage capacity at maximum water storage elevation of 2 hectare metres or less regardless of height are exempted.

1.6 Authority : "Resolution VI – Dam Safety Service" adopted at the First Conference of State Ministers of Irrigation held at New Delhi on 17-18 July 1975 reads thus "The Conference recommends that in view of the increasing number of large dams in India, the Government of India may constitute an Advisory Dams Safety Service to be operated by the Central Water Commission." Accordingly, the Government of India constituted Dam Safety Organization in the Central Water Commission during June 1979 to assist the State Governments to locate causes of potential distress affecting safety of dams and allied structures and to advise / guide the State Governments in providing suitable remedial measure. The Dam Safety Organization, Central Water Commission issues these guidelines in pursuant to the above resolution and constitution of the service.

1.7 The guidelines outline principal factors to be weighed in the determination of existing or potential hazards and define the scope of activities to be undertaken in the safety inspection of dams. The establishment of rigid criteria of standards is not intended. Safety must be evaluated in the light of peculiarities and local conditions at a particular dam and in recognition of the many factors involved, some of which may not be precisely known. This can only be done by competent & experienced engineering judgement, which the guidelines are intended to supplement and not supplant. The guidelines are intended to be flexible, and the proper flexibility must be achieved through the employment of experienced engineering personnel.

1.8 The guidelines provide for two phases of investigations since the scope and completeness of each investigation depend upon the availability and suitability of engineering data, the validity of original design assumptions and the physical condition of the dam. Phase I would be an inspection to assess the general condition of the dam and determine the need for any additional engineering investigations and analyses. It would consist of a visual examination of the dam and a review of available engineering data, including operating records. It is not intended that costly explorations or analyses would be performed during a Phase I inspection.

1.9 Phase II investigations would be performed where the results of the Phase I inspection indicate the need for additional investigations and studies. Phase II would include, as required, all additional visual examinations, measurements, foundation exploration & testing, materials testing, hydraulic & hydrologic analyses and structural stability analyses deemed essential to evaluate the safety of the dam.

1.10 The guidelines present only procedures for investigating and evaluating existing conditions. Their scope does not encompass the studies and engineering required for project modification to correct deficiencies found by the investigation.

~~382~~

Chapter II

GENERAL REQUIREMENTS

Classification of dams

2.1 Dams should be classified in accordance with size and hazard potential in order to formulate a basis for selecting dams to be included in the inspection programme and their priority and also to provide compatibility between guideline requirements and involved risks.

2.1.1 Size: The classification for size based on the height of the dam and storage capacity should be in accordance with Table I. The height of the dam is established with respect to the maximum storage potential measured from the natural bed of the stream or watercourse at the downstream toe of the barrier. For the purpose of determining dam size, the maximum storage elevation may be considered equal to the top of dam elevation. Size classification may be determined by either storage or height, whichever gives the large size category.

TABLE I

Size Classification

Category	Storage (Hectare Metres)	Height (Metres)
Minor	<125 and ≥6	<12 and ≥8
Medium	≥125 and <6250	≥12 and <30
Major	≥6250	≥30

2.1.2 Hazard Potential : The classification for potential hazards should be in accordance with Table II. The hazards pertain to potential loss of human life or property damage in the area downstream of the dams in the event of failure or misoperation of the dam or appurtenant facilities. Dams conforming to criteria for the low hazard potential category generally will be located in the rural or agricultural areas where failure may damage farm buildings, limited agricultural land or township and country roads. Significant hazard potential category structures will be those located in predominantly rural or agricultural areas where failure may damage isolated homes, secondary highways or minor railroads or cause interruption of use or service of relatively important public utilities. Dams in the high hazard potential

category will be those located where failure may cause serious damage to homes, extensive agricultural, industrial and commercial facilities, important public utilities, main highways or railroads.

Table II

Hazard Potential Classification

Category	Loss of Life (Extent of Development)	Economic Loss (Extent of Development)
Low	None expected (non-permanent structures for human habitation)	Minimal (undeveloped to occasional structures or agriculture)
Significant	Few (no urban developments and no more than a small number of inhabitable structures)	Appreciable (notable agriculture, industry or structures)
High	More than few	Excessive (extensive community, industry or agriculture)

Selection of dams to be investigated

2.2 The selection of dams to be investigated should be based upon an assessment of existing developments in flood hazard area. Those dams possessing a hazard potential classified high or significant as indicated in Table II should be given first and second priorities, respectively, in the inspection programme. Inspection priorities within each category may be developed from a consideration of factors such as size classification and age of the dam, the population size in the downstream flood area, and potential developments anticipated in flood hazard areas.

Technical investigations

2.3 A detailed, systematic, technical inspection and evaluation should be made of each dam selected for investigation in which the hydraulic and hydrologic capabilities, structural stability and operational adequacy of project features are analysed and evaluated to determine if the dam constitutes a danger to human life or property. The investigation should vary in scope and completeness depending upon the availability and suitability of

engineering data, the validity of design assumptions and analyses and the condition of the dam. The minimum investigation will be designated Phase I, and an in-depth investigation designated Phase II should be made where deemed necessary. Phase I investigations should consist of a visual inspection of the dam, abutments and critical appurtenant structures and a review of readily available engineering data. It is not intended to perform costly explorations or analyses during Phase I. Phase II investigations should consist of all additional engineering investigations and analyses found necessary by results of the Phase I investigation.

Qualification of investigators

2.4 The technical investigation should be conducted under the direction of competent professional engineers experienced in the investigation, design construction and operation of dams, applying the disciplines of hydrologic, hydraulic, soils & structural engineering and engineering geology. All field inspections should be conducted by qualified engineers, engineering geologist and other specialists, including experts on mechanical and electrical operation of gates and controls, knowledgeable in the investigation, design, construction and operation of dams.

Chapter III

PHASE I INVESTIGATION

Purpose

3.1 The primary purpose of the Phase I investigation programme is to identify expeditiously those dams which may pose hazards to human life or property.

Scope

3.2 The Phase I investigation will develop an assessment of the general condition with respect to safety of the project based upon available data and a visual inspection, determines any need for emergency measures and conclude if additional studies, investigation and analyses are necessary and warranted. A review will be made of pertinent, existing and available engineering data relative to the design, construction and operation of the dam and appurtenant structures, including electrical and mechanical operating equipment and measurement from inspection and performance instruments and devices and a detailed systematic visual inspection will be performed of those features relating to the stability and operational adequacy of the project. Based upon the findings of the review of engineering data and the visual inspection, an evaluation will be made of the general condition of the dam, including where possible the assessment of the hydraulic and hydrologic capabilities and the structural stability.

Engineering data

3.3 To the extent feasible the requisite engineering data listed in Appendix I relating to the design, construction and operation of the dam and appurtenant structures, should be collected from existing records and reviewed to aid in evaluating the adequacy of hydraulic and hydrologic capabilities and stability of the dam. Where the necessary engineering data are not available, inadequate or invalid, a listing should be made of these specific additional data deemed necessary by the engineer in charge of the investigation and included in the Phase I report.

Field inspections

3.4 The field inspection of the dam, appurtenant structures, reservoir area and downstream channel in the vicinity of the dam should

be conducted in a systematic manner to minimize the possibility of any significant feature being overlooked. A detailed checklist should be developed and followed for each dam inspection to document the examination of each significant structural and hydraulic feature, including electrical and mechanical equipment for operation of the control facilities that affect the safety of the dam. Model checklist in a generalized form for embankment (earth and rockfill), concrete dam and ancillary works is given in Appendix II. The checklist can be altered to suit the characteristics of the particular project or structure. The "Special Items" category listed at the end of each major heading as for listing those items which are specific to the structure but have not been included in the general checklist items.

3.4.1 Particular attention should be given to detecting evidence of leakage, erosion, seepage, excessive wetness or slushiness in the areas downstream of dam, presence of sand boils, change in water table conditions downstream, slope instability, undue settlement, displacement, tilting, cracking, deterioration and improper functioning of drains and relief wells. If the dam is instrumented, look for any evidence of excessive pore pressure conditions. It may be examined whether there had been any encroachment on the free board allowance made in the design. The adequacy and quality of maintenance and operating procedures and operation of control facilities should be examined as they pertain to the safety of the dam.

3.4.2 Photographs and drawings should be used freely to record conditions in order to minimize descriptions.

3.4.3 The field inspection should include appropriate features and items, including but not limited to those listed in Appendix III, which may influence the safety of the dam or indicate potential hazards to human life or property.

3.5 Evaluation of hydraulic and hydrologic features

3.5.1 Design data

Original hydraulic and hydrologic design assumptions obtained from the project records should be assessed to determine their acceptability in evaluating the safety of the dam. All constraints on water control such as block entrances, restrictions on operation of spillway and outlet gates, inadequate energy dissipater or restrictive channel conditions, significant reduction in reservoir capacity by sediment deposition and other factors

should be considered in evaluating the validity of discharge ratings, storage capacity hydrographs, routings and regulation plan. The discharge capacity and / or storage capacity should be capable of safely handling the recommended spillway design flood.

The Indian Standard IS : 11223 – 1985 "Guidelines for fixing spillway capacity" gives the criteria for inflow design flood as under:

The dams may be classified according to size by using the hydraulic head (from normal or annual average flood level on the downstream to the maximum water level) and the gross storage behind the dam as given below. The overall size classification for the dam would be greater of that indicated by either of the following two parameters:

Classification	Gross Storage	Hydraulic Head
Small	Between 0.5 & 10 million m^3	Between 7.5 m & 12 m.
Intermediate	Between 10 & 60 million m^3	Between 12 m & 30 m.
Large	Greater than 60 million m^3	Greater than 30 m.

The inflow design flood for safety of the dam would be as follows:

Size as determined in classification	Inflow design flood for safety of dam
Small	100 year flood
Intermediate	SPF
Large	PMF

Floods of larger or smaller magnitude may be used if the hazard involved in the eventuality of a failure is particularly high or low. The relevant parameters to be considered in judging the hazard in addition to the size would be:

(i) distance to and location of the human habitations on the downstream after considering the likely future developments.
(ii) Maximum hydraulic capacity of the downstream channel at a level at which catastrophic damage is not expected.

For more important projects, dam break studies may be done as an aid to the judgement in deciding whether PMF needs to be used. Where the studies or judgement indicate an imminent danger to present or future human settlements, the PMF should be used. Any departure from the general criteria as above on account of larger or smaller hazard should be clearly brought out and recorded.

Each site is individual in its local conditions and evaluation of cause and effects. While, therefore, the norms mentioned above may be taken as general guidelines, the criteria could be varied in special cases where the same are justifiable on account of local conditions and keeping in view the hazard potential.

When a dam capable of impounding large quantity of water is constructed above an area having extensive community, industry and agriculture, a distinct hazard from a possible failure is created. The failure of a dam so located would have disastrous effects. In addition to loss of life, loss to property, loss of revenue from the project, the deliberate acceptance of a calculated risk in the spillway design and free board would reduce the public confidence in the safety of similar structures.

The spillway capacities and free board allowances of such a dam should be adequate to insure against failure of the dam during the most severe flood or sequence of floods considered reasonably possible, irrespective of the apparent infrequency of occurrence of controlling conditions.

In determining the spillway capacity of relatively low dams and which do not have large storage capacity, where possible failure would not result in serious danger to life and property, (taking into account future development) a less severe condition may be adopted. The selection of spillway capacity would be governed by overall economic considerations, such as cost of replacing the dam, maintenance and loss of revenue when the project is impaired. The margin of safety may be made consistent with economic analysis.

3.5.2 Experience data

In some cases where design data are lacking, an evaluation of overtopping potential may be based on watershed characteristics and rainfall and reservoir records. An estimate of the probable maximum flood may also be developed from a conservative, generalized comparison of the drainage area, size and the

magnitude of recently adopted probable maximum floods for dam sites in comparable hydrologic regions. Where the review of such experience data indicates that the recommended spillway design flood would not cause overtopping, additional hydraulic and hydrologic determinations will be unnecessary.

3.6 Evaluation of structural stability

The Phase I evaluations of structural adequacy of project features are expected to be based principally on existing conditions as revealed by the visual inspection, together with available design and construction information and records of performance. The objectives are to determine the existence of conditions which are hazardous, or which with time might develop into safety hazards, and to formulate recommendations, pertaining to the need for any additional studies, investigations or analyses. The results of this phase of the inspection must rely very substantially upon the experience and judgement of the inspecting engineer.

3.6.1 Design and construction data

The principal design assumptions and analyses obtained from the project records should be assessed. Original design and construction records should be used judiciously, recognizing the restricted applicability of such data as material strengths and permeabilities, geological factors and construction descriptions. Original stability studies and analyses should be acceptable if conventional techniques and procedures were employed, provided that review of operational and performance data confirm that the original design assumptions were adequately conservative. The need for such analyses, where either or none exist or the originals are incomplete or unsatisfactory, will be determined by the inspecting engineer, based upon other factors such as condition of structures. Design assumptions and analyses should include all applicable loads, including earthquake and indicate the structure's capability to resist overturning, sliding and overstressing with adequate factors of safety. In general, seepage and stability analysis comparable to the requirements of paragraph 4.4 should be on record for all dams in the high hazard category and large dams in the significant hazard category. This requirement for other dams will be subject to the option with the inspecting engineer.

3.6.2 Operating records

The performance of structures under maximum loading conditions should in some instances provide partial basis for stability evaluation. Satisfactory experience under loading conditions not expected to be exceeded in the future should generally be indicative of satisfactory stability, provided adverse changes in physical conditions have not occurred. Instrumentation, observation of forces, pressures, loads, stresses, strains, displacements, deflections or other related conditions should also be utilized in the safety evaluation. Where such data indicate abnormal behaviour, unsafe movement or deflections, or loadings which adversely affect the stability or functioning of the structure, it should find place conspicuously in the report.

3.6.3 Post construction changes

Data should be collected on changes which have occurred since project construction that might influence the safety of the dam such as road cuts, quarries, mining and groundwater changes and changes in the upstream watersheds.

3.6.4 Seismic stability

An assessment should be made of the potential vulnerability of the dam to seismic events and a recommendation developed with regard to the need for additional seismic investigation. The seismic zones together with appropriate coefficients for use in such analysis are given in IS : 1983-84 "Criteria for Earthquake Resistant Design of Structures." All high hazard category dams in zone V should have a stability assessment based upon knowledge of regional and local geology engineering seismology, in-situ properties of materials and appropriate dynamic, analytical and testing procedures. The assessment should include the possibility of physical displacement of the structures due to movements along active faults. Departure from this general guidance should be made whenever, in the judgement of the investigating engineer, different seismic stability requirements are warranted because of local geological conditions or other reasons.

~~401~~

Chapter IV

PHASE II INVESTIGATION

Scope

4.1 The Phase II investigation will be supplementary to Phase I and should be conducted when the results of the Phase I investigation indicates the need for additional in-depth studies, investigations or analyses.

4.1.1 The Phase II investigation should include all additional studies, investigations and analyses necessary to evaluate the safety of the dam. Included, as required, will be additional visual inspections, measurements, foundation exploration and testing, materials, testing hydraulic and hydrologic analysis and structural stability analyses.

Hydraulic and Hydrologic Analysis

4.2 Hydraulic and hydrologic capabilities should be determined using the following criteria and procedures. Depending on the project characteristics, either the spillway design flood peak inflow or the spillway design flood hydrograph should be the basis for determining the maximum water surface elevation and maximum outflow. If the operation or failure of upstream water control projects would have significant impact on peak flow or hydrograph analyses, the impact should be assessed.

4.2.1 Maximum water surface based on SDF peak inflow

When the total project discharge capability at maximum pool exceeds the peak inflow of the spillway design flood (SDF) and operational constraints would not prevent such a release at controlled projects, a reservoir routing is not required. The maximum discharge should be assumed equal to the peak inflow of the spillway design flood. Flood volume is not controlling in this situation and surcharge storage is either absent or is significant only to the extent that it provides the head necessary to develop the release capability required.

In the case of structures like bridges, weirs, barrages, where no absorptive capacity is allowed for, the flood peak has to be passed down without any moderation and, therefore, determination of the peak value becomes important.

On the other hand, in the flood control and the storage projects where full flood absorptive capacity is provided, the aspect of volume is of greater importance.

4.3 Peak for Standard Project Flood

When the SPF flood is applicable under the provisions of Table III and data are available, the spillway design flood peak inflow may be determined by usual conventional methods. Flow frequency information from regional analysis is generally preferred over a single station results when available and appropriate. Rainfall runoff techniques may be necessary when there are inadequate runoff data available to make a reasonable estimate of flow frequency.

4.3.1 Peak for PMF

The unit hydrograph – infiltration loss technique is generally the most expeditious method computing the spillway design flood peak for most projects. This technique is discussed in the following paragraph.

4.3.2 Maximum water surface based on SDF Hydrograph

Both peak and volume are required in this analysis. Where surcharge storage is significant, or where there is insufficient discharge capability at maximum pool to pass the peak inflow of the SDF, considering all possible operational constraints, a flood hydrograph is required. When there are upstream hazard areas that would be imperiled by fast rising reservoir levels, SDF hydrographs should be routed to ascertain available time for warning and escape. Determination of probable maximum precipitation of SPF or 100 year precipitation, whichever is applicable, and unit hydrographs or runoff models will be required, followed by the determination of the PMF or SPF or 100 year flood. Conservative loss rates (significantly reduced by antecedent rainfall conditions where appropriate) should be estimated for computing the rainfall excess to be utilized with unit hydrographs. Rainfall values are usually arranged with gradually ascending and descending rates with the maximum rate late in the storm. When applicable, conservatively high snow melt runoff rates and appropriate releases from upstream project should be assumed. The maximum water surface elevation and spillway design flood outflow are then determined by routing the inflow hydrograph through the reservoir surcharge storage, assuming a starting water surface at the bottom of surcharge

storage, or lower when appropriate. For projects where the bottom of surcharge space is not distinct or the flood control storage space (exclusive of surcharge) is appreciable, it may be appropriate to select starting water surface elevations below the top of the flood control storage for routings. Conservatively high starting levels should be estimated on the basis of hydrometeorological conditions reasonably characteristic for the region and flood release capability of the project. Necessary adjustment of reservoir storage capacity due to existing or future sediment or other encroachment may be approximated when accurate determination of deposition is not practicable.

4.3.3 Acceptable procedures

Techniques for performing hydraulic and hydrologic analyses are generally available from publications prepared by Central / State agencies involved in water resources development or text books written by the academic community. Some of these procedures are rather sophisticated and require expensive computational equipment and large data banks. While results of such procedure are generally more reliable than simplified methods, their use are generally not warranted in studies connected with this programme unless they can be performed quickly and inexpensively. There may be situations where more complex techniques have to be employed to obtain reliable results. However, these cases will be exceptions rather than the rule. Whenever the acceptability of procedures is in question, the advice of competent experts should be sought. Such expertise is generally available in the Central Water Commission, India Meteorological Department and National Institute of Hydrology.

4.3.4 Freeboard allowances

Guidelines on specific minimum freeboard allowances are not considered appropriate because of the many factors involved in such determinations. The investigator will have to access the critical parameters for each project and develop its minimum requirements. Many projects are reasonably safe without freeboard allowances because they are designed for overtopping, or other factors minimize possible overtopping. Conversely, freeboard allowance of several feet may be necessary to provide a safe condition. Parameters that should be considered include the duration of high water levels in the reservoir during the design floods, the effective wind fetch and reservoir depth available to support wave generation; the probability of high wind speed occurring from a critical direction; the potential wave run-

up on the dam based on roughness and slope; and the ability of the dam to resist erosion from overtopping waves.

The present day practice is to check the freeboard allowance in earth / rockfill dam by Savillie's method which takes into account the effective fetch, reservoir depths, wave generation, wind speed, wave run-up depending upon the roughness and slope of embankment face.

For final selection of freeboard, the hazard potential of dam should also be taken into consideration.

4.4 Stability investigations

The Phase II stability investigations should be compatible with the guidelines of this paragraph.

4.4.1 Foundation and material investigations

The scope of the foundation and material investigation should be limited to obtaining the information required to analyse the structural stability and to investigate any suspected condition which would adversely affect the safety of the dam. Such investigations may include borings to obtain concrete, embankment, soil foundation and bedrock samples; testing specimens from these samples to determine the strength and elastic parameters of the materials, including the soft seams, joints, fault gouge and expansive clays or other critical materials in the foundation, determining the character of the bedrock, including joints, bedding planes, fractures, faults, voids & caverns and other geological irregularities; and installing instruments for determining movements, strains, suspected excessive internal seepage, pressure seepage gradients and uplift forces. Special investigations may be necessary where suspect rock type such as limestone, gypsum, salt, basalt, claystone, shales or others are involved in foundations or abutments in order to determine the extent of cavities, piping or other deficiencies in the rock foundation. A concrete core drilling programme should be undertaken only when the existence of significant structural cracks is suspected or the general qualitative condition of the concrete is in doubt. The tests of materials will be necessary only where such data are lacking or are outdated.

4.4.2 Stability assessment

Stability assessments should utilize in-situ properties of the structure and its foundation and pertinent geologic information. Geologic information that should be considered includes groundwater and seepage conditions, lithology, stratigraphy and geologic details disclosed by borings, available records & geologic interpretation, maximum past overburden at site as deduced from geologic evidence of bedding, folding & faulting; joints & joint systems; weathering; slickensides, and field evidence relating to slides, faults, movements and earthquake activity. Foundations may present problems where they contain adversely oriented joints, slickensides or fissured material, faults, seams of soft materials or weak layers. Such defects and excess pore water pressures may contribute to instability. Special tests may be necessary to determine physical properties of particular materials. The results of stability analyses afford a means of evaluating the structure's existing resistance to failure and also the effect of any proposed modifications. Results of stability analyses should be reviewed for compatibility with performance experience when possible.

4.4.2.1 Seismic stability

The inertial forces for use in the conventional equivalent static force method of analysis should be obtained by multiplying the weight by the seismic coefficient and should be applied as a horizontal force at the centre of gravity of the section or element. Seismic stability investigations for all high hazard category dams located in Seismic Zone 5 and high hazard dams of the hydraulic fill type in Zone 4 should include suitable dynamic procedures and analyses. Dynamic analyses for other dams and higher seismic coefficients are appropriate if in the judgement of the investigating engineer they were warranted because of proximity to active faults or other reasons. Seismic stability investigations should utilize "state-of-the-art" procedures involving seismological and geological studies to establish earthquake parameters for use in dynamic stability analyses and, where appropriate, the dynamic testing of materials. Stability analyses may be based upon either time-history or response spectra techniques. The results of dynamic analyses should be assessed on the basis of whether or not the dam would have sufficient residual integrity to retain the reservoir during and after the greatest or more adverse earthquake which might occur near the project location.

A study of the seismic events that have occurred in the past may be made and compared with the seismic events occurring during the period after construction for any particular variations in the pattern and intensity in the earthquake occurrence and their impact on the reservoir and dam stability.

4.4.2.2 Clay shale foundation

Clay shale is a highly over consolidated sedimentary rock comprised predominantly of clay minerals, with little or no cementation. Foundations of clay shales, particularly those containing montmorillonite, may be highly susceptible to expansion and consequent loss of strength upon unloading. The shear strength and the resistance to deformation of clay shales may be quite low and high pore water pressures may develop under increase in load. The presence of slickenside in clay shales is usually an indication of low shear strength. Prediction of field behaviour of clay shales should not be based solely on results of conventional laboratory tests since they may be misleading. The use of peak shear strengths for clay shales in stability analysis may be unconservative because of non-uniform stress distribution and possible progressive failures. Thus, the available shear resistance may be less than if the peak shear strengths were mobilized simultaneously along the entire failure surface. In such cases, either greater safety factors or residual shear strength should be used.

4.4.2.3 Karstic foundation

'Karst' is a general term for terrain in which surface and subsurface features, especially the relief and the drainage are directly related to the existence of bed rocks that are notably soluble in water. Karstic foundation can start creating problems even after dam construction. In Karstic and limestone region, it is essential to investigate whether the seepage losses are large so as to defeat the purpose of the project and also whether the water seeping around and beneath the dam itself does not imperil the safety of the structure. Observations for development in such foundation, like chemical analysis of seepage water downstream of the dam for lime content etc., may be carried out.

4.4.3 Embankment dams

4.4.3.1 Liquefaction

The phenomenon of liquefaction of loose, saturated sands and silts may occur when such materials are subjected to shear deformation or earthquake shocks. The possibility of liquefaction must presently be evaluated on the basis of empirical knowledge supplemented by special laboratory tests and engineering judgedment. The possibility of liquefaction in sands diminishes as the relative density increases above approximately 70 percent. Hydraulic fill dams in Seismic Zones 4 and 5 should receive particular attention since such dams are susceptible to liquefaction under earthquake shocks.

4.4.3.2 Shear failure

Shear failure is one in which a portion of an embankment or of an embankment and foundation moves by sliding or rotating relative to the remainder of the mass. It is conventionally represented as occurring along a surface and is so assumed in stability analyses, although shearing may occur in a zone of substantial thickness. The circular arc or the sliding wedge method of analyzing stability, as pertinent, should be used. The circular arc method is generally applicable to essentially homogeneous embankments and to soil foundations consisting of thick deposits of fine grained soil containing no layers significantly weaker than other strata in the foundation. The wedge method is generally applicable to rockfill dams and to earth dams on foundations containing weak layers. Other methods of analysis such as those employing complex shear surfaces may be appropriate depending on the soil and rock in the dam and foundation. Such methods should be in reputable usage in the engineering profession.

4.4.3.3 Loading conditions and safety factors

The loading conditions for which the embankment structures should be investigated are:

1. Construction condition with or without partial pool (for upstream and downstream slopes).

2. Reservoir partial pool (for upstream slope).

3. Sudden drawdown (for upstream slope).

4. Steady seepage (for downstream slope).

5. Steady seepage with sustained rainfall (for downstream slope).

6. Earthquake condition (for upstream and downstream slopes).

~~488~~

The various design condition of analysis along with the minimum values of factors of safety to be aimed at and use of type of shear strength for each condition of analysis is given in I.S.:7894 – 1975 Code of Practice for Stability Analysis of Earth Dams and reproduced at Table III.

4.4.3.4 Safety factors

Safety factors for embankment dam stability studies should be based on the ratio of available shear strength to developed shear strength, S_D :

$$S_D = \frac{C}{F.S.} + \sigma \frac{\tan \phi}{F.S}$$

C = cohesion

ϕ = angle of internal friction

σ = normal stress

The factors of safety listed in Table III are recommended as minimum acceptable. Final accepted factors of safety should depend upon the degree of confidence the investigating engineer has in the engineering data available to him. The consequences of a failure with respect to human life and property damage are important considerations in establishing factors of safety for specific investigations.

4.4.3.5 Seepage failure

A critical uncontrolled under seepage or through seepage condition that develops during a rising pool can quickly reduce a structure which was stable under previous conditions, to a total structural failure. The visually confirmed seepage conditions to be avoided are (1) the exit of the phreatic surface on the downstream slope of the dam, (2) development of hydrostatic heads sufficient to create in the area downstream of the dam sand boils that erode materials by the phenomenon as "piping" and (3) localized concentrations of seepage along conduits or through previous zones. The dams most susceptible to seepage problems are those built of or on semi pervious materials of uniform fine particle size, with no provisions for an internal drainage zone and / or no under seepage controls.

~~409~~

Table III

Minimum Desired Values of Factors of Safety
[as per Code IS 7894 of 1975]

Code No.	Loading Conditions	Slope most likely to be critical	Pore Pressure Assumption	Type of shear strength test to be adopted	Minimum desired factor of safety
I	Construction condition with or without partial pool. *	Upstream & downstream	To be accounted for the Hilf's method.	QR *	1.0
II	Reservoir partial pool.	Upstream	Weights of material in all zones above phreatic line to be taken as moist and those below as buoyant.	RS +	1.3
III	Sudden drawdown				
(a)	Max.head water to min.with tail water at max.	Upstream	As given in 5.4.2 **	RS +	1.3
(b)	Max.tail water to min. with reservoir full	Downstream	As given in 5.4.5 **	RS +	1.3
IV	Steady seepage with reservoir full	Downstream	As given in 5.5.2 **	RS +	1.5
V	Steady seepage with sustained rainfall	Downstream	As given in 5.6.1 **	RS +	1.3
VI	Earthquake condition:				
(a)	Steady seepage	Downstream	As given in Case IV	RS +	1.0 Ψ
(b)	Reservoir full	Upstream	As given in Case II	RS +	1.0 Ψ

Note: These factors of safety are applicable for the method of analysis mentioned in the Code.

* Where the reservoir is likely to be filled immediately after completion of dam, construction pore pressure would not have dissipated and these should be taken into consideration. This is to be adopted for failure planes passing through impervious foundation layer.

\+ S Test may be adopted only in cases where the material is cohesionless and free draining.

Ψ Values are according to IS:1893-1984 "Criteria for earthquake resistant design of structures (3rd rev.).

** These refer to the Code.

Q Test = Unconsolidated undrained test
R Test = Consolidated undrained test and
S Test = Consolidated drained test.

4.4.3.6 Seepage analyses

Review and modifications to original seepage design analyses should consider conditions observed in the field inspection and piezometer instrumentation. A seepage analysis should consider the permeability ratios resulting from natural deposition and from compaction placement of materials with appropriate variation between horizontal and vertical permeability. An under seepage analysis of the embankment should provide a critical gradient factor of safety for the maximum head condition of not less than 1.5 in the area downstream of the embankment.

$$F.S. = i_c / i = \frac{H_c / D_b}{H / D_b} = D_b \frac{(\gamma_m - \gamma_w)}{H\gamma_w} \quad .....(2)$$

i_c = Critical gradient
i = Design gradient
H = Uplift head at downstream toe of dam measured above tailwater.
H_c = The critical uplift
D_b = The thickness of the top impervious blanket at the downstream toe of the dam.
γ_m = The estimated saturated unit weight of the material in the top impervious blanket
γ_w = The unit weight of water

Where a factor of safety less than 1.5 is obtained, the provision of an under seepage control system is indicated. The factor of safety of 1.5 is a recommended minimum and may be adjusted by the responsible engineer based on the competence of the engineering data.

4.4.4 Concrete dams and appurtenant structures

4.4.4.1 Requirements for stability

Concrete dams and structures appurtenant to embankment dams should be capable of resisting overturning, sliding and overstressing with adequate factors of safety for normal and maximum loading conditions.

4.4.4.2 Loads

Loadings to be considered in stability analyses include the water load on the upstream face of the dam; the weight of the structure, internal hydrostatic pressures (uplift) within the body of the dam, at the base of the dam and within the foundation;

earth and silt loads; ice pressure, seismic and thermal loads, and other loads, as applicable. Where tailwater or backwater exists on the downstream side of the structure, it should be considered, and assumed uplift pressures should be compatible with drainage provisions and uplift measurements, if available. Where applicable, ice pressure should be applied to the contact surface of the structure at normal pool elevation. Till specific reliable procedures become available for assessment of ice pressure, it may be provided for at the rate of 250 k Pa applied to the face of the dam (IS 6512-1984). Normally, ice thickness should not be assumed greater than 2/3 m. Earthquake forces should consist of the inertial forces due to the horizontal acceleration of the dam itself and hydrodynamic forces resulting from the reaction of the reservoir water against the structure. Dynamic water pressures for use in conventional methods of analysis may be computed as per IS 1893-1984 "Criteria for earthquake resistant design of structures" or similar method.

4.4.4.3 Strength

The concrete strength should be based on in-situ properties of concrete which varies with age, the kind of cement and other ingredients and their proportions.

Comprehensive strength

As per Indian Standard IS : 6512-1984, the compressive strength of concrete and masonry shall conform to the following requirements:

(a) Concrete: Concrete strength is determined by compressing to failure 150 mm cubes. The strength of concrete should satisfy early load and construction requirements and at the age of one year it should be four times the maximum computed stress in the dam or 14 N/mm^2, whichever is more. The allowable working stress in any part of the structure shall not also exceed $7N/mm^2$.

(b) Masonry: The compressive strength of masonry is determined by compressing to failure 75 cm cubes of the masonry fabricated and cured at temperatures approximating to those expected in the structures (or 45 x 90 cm cylinders cored out of the structures or blocks made for the purpose). This strength should satisfy early load and construction requirements and at one year it should be

five times the maximum computed stress on the dam or 12.5 N/mm^2, whichever is more.

Note: For the purpose of quality control, correlation between the strength of mortar and that of masonry may be established in suitable smaller size specimen.

Tensile strength

(a) No tensile stress shall be permitted at the upstream face of the dam for load combination B. Nominal tensile stresses, however, may be permitted in other load combinations and their permissible values shall not exceed the values given below:

Values of permissible tensile stress in concrete and masonry

Load combination	Permissible Tensile Stress	
	Concrete	Masonry
C	0.01 fc	0.005 fc
E	0.02 fc	0.01 fc
F	0.02 fc	0.01 fc
G	0.04 fc	0.02 fc

Where fc is the cube compressive strength of concrete / mortar for masonry.

(b) Small values of tension on the downstream face may be permitted since it is very improbable that a fully constructed dam is kept empty and downstream cracks which are not extensive and for limited depths from the surface may not be detrimental to the safety of the structure.

4.4.4.4 Overturning

A gravity structure should be capable of resisting all overturning forces. It can be considered safe against overturning if the resultant of all combinations of horizontal and vertical forces, excluding earthquake forces, acting above any horizontal plane through the structure or at its base is located within the middle third of the section. When earthquake is included, the resultant should fall within the limits of the plane or base, and foundation

pressures must be acceptable. When these requirements for location of the resultant are not satisfied, the investigating engineer should assess the importance to stability of the deviations.

4.4.4.5 Sliding

Sliding of concrete gravity structures and of abutment and foundation rock masses for all types of concrete dams should be evaluated by the shear friction resistance concept. The available sliding resistance is compared with the driving force which tends to include sliding to arrive at a sliding stability safety factor. The investigation should be along all potential sliding paths. The critical path is that plane or combination of planes which offers the least resistance.

4.4.4.5.1 Sliding resistance

Sliding resistance is a function of the unit shearing strength at no normal load (cohesion) and the angle of friction on a potential failure surface. It is determined by computing the maximum horizontal driving force which could be resisted along the sliding path under investigation. The following general formula is obtained from the principles of statics and may be derived by resolving forces parallel and perpendicular to the sliding plane:

$$R_R = V \tan(\phi+\alpha) + \frac{CA}{\cos\alpha\,(1-\tan\phi\tan\alpha)} \quad \text{.....(3)}$$

where

R_R = Sliding Resistance (maximum horizontal driving force which can be resisted by the critical path).

ϕ = Angle of internal friction of foundation material or, where applicable, angle of sliding friction.

V = Summation of vertical forces (including uplift).

C = Unit shearing strength at zero normal loading along potential failure plane.

A = Area of potential failure plane developing unit shear strength "C"

α = Angle between inclined plane and horizontal (positive for uphill sliding).

for sliding downhill, the angle α is negative and equation (1) becomes:

$$R_R = V \tan (\phi - \alpha) + \frac{CA}{\cos \alpha (1 + \tan \phi \tan \alpha)} \quad \text{.....(4)}$$

when the plane of investigation is horizontal, and the angle is zero and equation (4) reduced to the following:

$$R_R = V \tan \phi + CA$$

4.4.4.5.2 Downstream resistance

When the base of a concrete structure is embedded in rock or the potential failure plane lies below the base, the passive resistance of the downstream layer of rock may sometimes be utilized for sliding resistance. Rock that may be subjected to high velocity water scouring should not be used. The magnitude of the downstream resistance is the lesser of (a) the shearing resistance along the continuation of the potential sliding plane until it daylights or (b) the resistance available from the downstream rock wedge along an inclined plane. The theoretical resistance offered by the passive wedge can be computed by a formula equivalent to formula (3) :

$$P_P = W \tan (\phi + \alpha) + \frac{CA}{\cos \alpha (1 - \tan \phi \tan \alpha)} \quad \text{.....(5)}$$

P_P = Passive resistance of rock wedge

W = Weight (buoyant weight, if applicable) of downstream rock wedge above inclined plane of resistance, plus any superimposed loads.

α = Angle of internal friction or, if applicable, angle of sliding friction.

α = Angle between inclined failure plane and horizontal.

C = Unit shearing strength at zero normal load along failure plane.

A = Area of inclined plane of resistance.

~~445~~

When considering cross-bed shear through a relatively shallow, competent rock strut, without adverse jointing or faulting, W and α may be taken as zero and 45^0 respectively, and an estimate of passive wedge resistance per unit width obtained by the following equation:

$P_P = 2CD$

where D = Thickness of the rock strut.

The shear friction safety factor is obtained by dividing the resistance R_R by H, the summation of horizontal loads to be applied to the structure:

$$S_{s-f} = \frac{R_R}{H} \qquad \text{.....(8)}$$

When the downstream passive wedge contributes to the sliding resistance, the shear friction safety factor formula becomes:

$$S_{s-f} = \frac{R_R + P_P}{H} \qquad \text{.....(9)}$$

The above direct superimposition of passive wedge resistance is valid only if shearing rigidities of the foundation components are similar. Also, the compressive strength and buckling resistance of the downstream rock layer must be sufficient to develop the wedge resistance. For example, a foundation with closely spaced, near horizontal, relatively weak seams might not contain sufficient buckling strength to develop the magnitude of wedge resistance computed from the cross-bed shear strength. In this case, wedge resistance should not be assumed without resorting to special treatment (such as installing foundation anchors).

4.4.4.5.3 Factors of safety against sliding

The IS 6512-1984 states that the factor of safety against sliding may be calculated on the basis of partial factor of safety in respect of friction ($F\phi$) and partial factor of safety in respect of cohesion (F_c) as given in the next page:

~~416~~

Partial factors of safety against sliding

Sl. No.	Loading Condition	Ff	Fc		
			For dams and the contact plane with foundation	For foundation	
				Thoroughly investigated	Others
(i)	A,B,C	1.50	3.60	4.00	4.50
(ii)	D,E	1.20	2.40	2.70	3.00
(iii)	F,G	1.00	1.20	1.35	1.50

The factor of safety against sliding shall be computed from the following equation and shall not be less than 1.0.

$$F = \frac{\dfrac{(w - u)\tan\phi}{F\phi} + \dfrac{CA}{F_c}}{P_P}$$

where

F = factor of safety against sliding.

w = total mass of the dam

u = total uplift force

$\tan\phi$ = coefficient of internal friction of the material

C = cohesion of the material at the plane considered

A = area under consideration for cohesion

$F\phi$ = partial factor of safety in respect of friction

F_c = partial factor of safety in respect of cohesion, and

P = total horizontal force

The value of cohesion and internal friction may be estimated for the purpose of preliminary designs on the basis of available data on similar or comparable materials. For final designs, however, the value of cohesion and internal friction shall be determined by actual laboratory and field tests.

The IS: 6512-1984 does not take into consideration the passive wedge contribution.

Chapter V

REPORTS

5.1 The first report on the project evaluation would be compilation of information in the format given at Appendix I.

5.2 The study of the data and the classification of the dam in respect of its hazard potential form the second report. In case the hazard potential of a dam is classified as high, the same should be reported immediately to the project authority, State Government, Central Water Commission (Dam Safety Organization).

5.3 Phase – I Report

5.3.1 The Phase I report is an investigation report after a study of the design data and behaviour of the dam and a detailed inspection of the site. Appendix II gives the guidelines for performing field inspection and can serve as a basis for developing a detailed checklist to suit the characteristics of the particular project or structure. The fundamental objective of the inspection is the detection of any existing or developing structural or hydraulic weakness. Appendix III indicates the structures, features, events and evidence which should be looked for.

5.3.2 The Phase I report should contain a summary of existing engineering data, including geological maps and information, results of inspections and photographs.

5.3.3 Evaluation of operational adequacy of reservoir regulation and maintenance of dam and operating facilities and features that pertain to the safety of the dam.

5.3.4 Description of warning system in effect, if any. Evaluation of the hydraulic and hydrological assumptions and structural stability.

5.3.5 An assessment of the general condition of the dam with respect to safety based upon the findings of the visual inspection and review of engineering data. Where data on the original design indicate significant departures from or non-conformance with guidelines contained herein, the engineer-in-charge of the investigation will give his opinion of the significance, with regard to safety, of such factors. Any

additional studies, investigations and analyses considered essential to assessment of the safety of the dam should be listed, together with an opinion about the urgency of such additional work.

5.3.6 Possible remedial measures or revisions in operating and maintenance procedures which may (subject to further evaluation) correct deficiencies and hazardous conditions found during the investigations.

5.4 Phase – II Report

5.4.1 Phase II investigations which are supplementary to Phase I investigation are conducted when the results of the Phase I investigations indicate the need for additional in-depth studies, investigations or analysis.

5.4.2 Phase II report should describe the detailed investigations and should supplement Phase I report. They should contain the following information:

5.4.2.1 Summary of additional engineering data obtained to determine the hydraulic and hydrologic capabilities and / or structural stability.

5.4.2.2 Results of all additional studies, investigations and analyses performed.

5.4.2.3 Technical assessment of dam safety, including deficiencies and hazardous conditions found to exist.

5.4.2.4 Indicate alternative possible remedial measures or revision in maintenance and operating procedures, which my (subject to further evaluation), correct deficiencies and hazardous conditions found during the investigation.

~~419~~

Chapter VI

ACKNOWLEDGEMENTS

The following references have been made use of in compilation of the guidelines:

1. Recommended guidelines for safety inspection of dams – Department of the Army – Office of the Chief Engineers, Washington DC, USA.

2. The Evaluation of Dam Safety – Engineering Foundation Conference Proceedings.

3. Selection of Design Flood – by Fennil Mosonyi and Werner Buchi.

4. Guide for Making a Condition Survey of Concrete in Service – Reported by ACI Committee 201 – Journal of the American Concrete Institute – November 1968, No.11, Proceedings V.65.

5. Developments in Geotechnical Engineering – Dams, Dam Foundations and Reservoir Sites – by Ernest E.Wahlstrom.

6. Criteria for Design of Solid Gravity Dams – IS 6512-1984.

7. Guidelines for Fixing Spillway Capacity – IS 11223-1985.

8. Criteria for Earthquake Resistant Design of Structures IS 1893 -1984.

9. Code of Practice for Stability Analysis for Earth Dams – IS 7894 – 1975.

~~420~~

Appendix I

Format for ENGINEERING DATA

(A) GENERAL

1. Name of the Dam - Project
2. Location – River, Sub-basin, Basin, Village/Tehsil/District/State
3. Type of Dam
4. Year of completion
5. Height of Dam (Elevations: Deepest foundation, River bed, FRL, MWL, Top of Dam)
6. Impounding capacity at F.R.L., at M.W.L.
7. Index map showing location of dam, catchment area, downstream area subject to potential damage due to failure of dam or failure of operating equipment
8. Nearest downstream city, town, village which can be located on the map. Its distances from dam and population
9. Extent of economic development in downstream area

(B) PROJECT FEATURES

1. Salient features
2. Construction drawings indicating plans, elevation and sections of the dam and appurtenant structures including the details of the discharge facilities such as outlet works, spillways and operating equipment
3. Emergency preparedness – Communications Downstream Warning Systems Auxiliary power – Remote Operation – Security of the site

(C) HYDROLOGY

1. Description of Drainage basin – Drainage area and basin runoff characteristics
2. Design flood-design assumptions and analysis, storage of flood control zone
3. Spillway capacity and flood routing criteria

~~421~~

4. Area capacity curves

5. Elevation of crest, type, width, crest length, location of spillway and number size and type of gates

6. Type, location, capacity entrance and exit levels of other outlet works

7. Emergency drawdown capacity

8. Type, location, observations and records of hydrometeorological data

(D) GEOLOGY AND FOUNDATION

1. Rock types, logs of borings of geological maps profiles and cross-section location and special problems (fault, shear zones, solutions, channels etc.)

2. Effects of geology on design

3. Adequacy of investigation

4. Foundation treatment-grouting-drainage etc.

5. Cut-off

(E) Construction History-including diversion scheme, construction sequence, construction problems, alterations, repairs

(F) Operation and regulation plan under normal conditions and during floods and other emergency conditions. Flood Warning Systems

(G) Operation record-experiences during past major floods

(H) Stability and stress analysis of the dam, spillway and appurtenant structures and features including the assumed properties of materials and all pertinent applied loads

(I) Instrumentations and records of performance observations

(J) Any known deficiency that may pose a threat to the safety of the dam or to human life and property

~~422~~

Appendix II

INSPECTION ITEMS

This appendix provides guidance for performing field inspections and may serve as the basis for developing a detailed checklist for each dam.

1. CONCRETE STRUCTURES IN GENERAL

(a) Concrete Surfaces

The condition of the concrete surfaces should be examined to evaluate the deterioration and continuing serviceability of the concrete. Descriptions of concrete conditions should conform with the appendix to "Guide for making a conditions survey of concrete in service", American Concrete Institute (ACI) Journal, Proceedings Vol.65, No.11, November 1968 pages 905-918 vide Annexure I.

(b) Structural Cracking

Concrete structures should be examined for structural cracking resulting from overstress due to applied loads, shrinkage and temperature effects or differential movements.

(c) Movement – Horizontal and Vertical Alignment

Concrete structures should be examined for evidence of any abnormal settlements, heaving, deflections or lateral movements.

(d) Junctions

The condition at the junction of the structure with abutments or embankments should be determined.

(e) Drains – Foundation, Joint, Face

All drains should be examined to determine that they are capable of performing their design function.

(f) Water Passages

All water passages and other concrete surface subject to running water should be examined for erosion, cavitation, obstructions, leakage or significant structural cracks.

(g) Seepage or Leakage

The faces, abutments and toes of the concrete structures should be examined for evidence of seepage or abnormal leakage, and records of flow of downstream springs reviewed for variation with reservoir pool level. The sources of seepage should be determined, if possible.

(h) Monolith Joints – Construction Joints

All monolith and construction joints should be examined to determine the condition of the joint and filler material, any movement of joints, or any indication of distress or leakage.

(i) Foundation

Foundation should be examined for damage or possible undermining of the downstream toe.

(j) Abutments

The abutments should be examined for sign of instability or excessive weathering.

2. EMBANKMENT STRUCTURES

(a) Settlement

The embankments and downstream toe areas should be examined for any evidence of localized or overall settlement, depressions or sink holes.

(b) Slope Stability

Embankment slopes should be examined for irregularities in alignment and variances from smooth uniform slopes, unusual changes from original crest alignment and elevation, evidence of movement at or beyond the toe, and surface cracks which indicate movement.

(c) Seepage

The downstream face of abutments, embankment slopes and toes, embankment-structure contacts and the downstream valley areas should be examined for evidence of existing or past seepage. The sources of seepage should be investigated

to determine cause and potential severity to dam safety under all operating conditions. The presence of animal burrows and tree growth on slopes which might cause detrimental seepage should be examined.

(d) Drainage Systems

The slope protection should be examined to determine whether the systems can freely pass discharge and that the discharge water is not carrying embankment or foundation material. Systems used to monitor drainage should be examined to assure they are operational and functioning properly.

(e) Slope Protection

The slope protection should be examined for erosion-formed gullies and wave-formed notches and benches that have reduced the embankment cross-section or exposed less wave resistant materials. The adequacy of slope protection against waves, currents and surface run-off that may occur at the site should be evaluated. The condition of vegetative cover should be evaluated where pertinent.

3. SPILLWAY STRUCTURES

Examination should be made of the structures and features, including bulkheads, flash-boards and fuse plugs of all service and auxiliary spillways which serve as principal or emergency spillways for any condition, which may impose operational constraints on the functioning of the spillway.

(a) Control Gates and Operating Machinery

The structural members, connections, hoists, cables and operating machinery and the adequacy of normal and emergency power supplies should be examined and tested to determine the structural integrity and verify the operational adequacy of the equipment where cranes are intended to be used for handling gates and bulkheads, the availability, capacity and condition of the cranes and lifting beams should be investigated. Operation of control systems and protective & alarm devices such as limit switches, sump high water alarms and drainage pumps should be investigated.

~~425~~

(b) Unlined Saddle Spillways

Unlined saddle spillways should be examined for evidence of erosion and any conditions which may impose constraints on the functioning of the spillway. The ability of the spillway to resist erosion due to operation and the potential hazard to the safety of the dam from such operation should be determined.

(c) Approach and Outlet Channels

The approach and outlet channels should be examined for any conditions which may impose constraints on the functioning of the spillway and present a potential hazard to the safety of the dam.

(d) Stilling Basin (Energy Dissipators)

Stilling basins, including baffles, flip buckets or other energy dissipators should be examined for any conditions which may pose constraints on the ability of the stilling basin to prevent downstream scour or erosion which may create or present a potential hazard to the safety of the dam. The existing condition of the channel downstream of the stilling basin should be determined.

4. OUTLET WORKS

The outlet works examination should include all structures and features designed to release reservoir water below the spillway crest through or around the dam.

(a) Intake Structure

The structure and all features should be examined for any condition which may impose operational constraints on the outlet works. Entrances to intake structure should be examined for conditions such as silt or debris accumulation which may reduce the discharge capabilities of the outlet works.

(b) Operating and Emergency Control Gates

The structural members, connections, guides, hoists, cables and operating machinery, including the adequacy of normal and emergency power supplies should be examined and tested to determine the structural integrity and verify the operational

adequacy of the operating and emergency gates, valves, bulkheads and other equipments.

(c) Conduits, Sluices, Water Passages, etc.

The interior surfaces of conduits should be examined for erosion, corrosion, cavitation, cracks, joint separation and leakage at cracks or joints.

(d) Stilling Basin (Energy Dissipator)

The stilling basin or other energy dissipater should be examined for conditions which may impose any constraints on the ability of the stilling basin to prevent downstream scour or erosion which may create or present a potential hazard to the safety of the dam. The existing condition of the channel downstream of the stilling basin should be determined by soundings.

(e) Approach and Outlet Channels

The approach and outlet channels should be examined for any conditions which may impose constraints on the functioning of the discharge facilities of the outlet works, or present a hazard to the safety of the dam.

(f) Drawdown Facilities

Facilities provided for drawdown of the reservoir to avert impending failure of the dam or to facilitate repairs in the event of stability or foundation problems should be examined for any conditions which may impose constraints on their functioning as planned.

5. SAFETY AND PERFORMANCE INSTRUMENTATION

Instruments which have been installed to measure behaviour of the structures should be examined for proper functioning. The available records and readings of the installed instruments should be reviewed to detect any unusual performance of the instruments or evidence of unusual performance or distress of the structure. The adequacy of the installed instrumentation to measure the performance and safety of the dam should be determined.

(a) Headwater and Tailwater Gauges

The existing records of the headwater and tailwater gauges should be examined to determine the relationship between other instrumentation measurements such as stream flow, uplift pressures, alignment and drainage system discharge with the upper and lower water surface elevations.

(b) Horizontal and Vertical Alignment Instrumentation (Concrete Structures)

The existing records of alignment and elevation surveys and measurements from inclinometers, inverted plumb bobs, gauge points across cracks and joints, or other devices should be examined to determine any change from the original position of the structure.

(c) Horizontal and Vertical Movement, Consolidation and Pore-water Pressure Instrumentation (Embankment Structures)

The existing records of measurements from settlement plates or gauges surface should be examined to determine the movement history of the embankment. Existing piezometer measurements should be examined to determine if the pore-water pressures in the embankment and foundation would under given conditions impair the safety of the dam.

(d) Uplift Instrumentation

The existing records of uplift measurements should be examined to determine if the uplift pressures for the maximum pool would impair the safety of the dam.

(e) Drainage System - Instrumentation

The existing records of measurements of the drainage system flow should be examined to establish the normal relationship between pool elevations and discharge quantities and any changes that have occurred in this relationship during the history of the project.

(f) Seismic Instrumentation

The existing records of seismic instrumentation should be examined to determine the seismic activity in the area and the response of the structures to past earthquakes.

~~428~~

6. RESERVOIR

The following features of the reservoir should be examined to determine to what extent the water impounded by the dam would constitute a danger to the safety of the dam or a hazard to human life or property.

(a) Shore Line

The land forms around the reservoir should be examined for indications of major active or inactive landslide areas and to determine susceptibility of bedrock stratigraphy to massive landslides of sufficient magnitude to significantly reduce reservoir capacity or create waves that might overtop the dam.

(b) Sedimentation

The reservoir and drainage area should be examined for excessive sedimentation of recent developments in the drainage basin which could cause a sudden increase in sediment load thereby reducing the reservoir capacity, with attendant increase in maximum outflow and maximum pool elevation.

(c) Potential Upstream Hazard Areas

The reservoir area should be examined for features subject to potential back-water flooding resulting in loss of human life or property at reservoir levels upto the maximum water storage capacity including any surcharge storage.

(d) Watershed Runoff Potential

The drainage basin should be examined for any extensive alternations to the surface of the drainage basin such as changed agriculture practices, timber clearing, railroad or highway construction or real estate developments that might extensively affect the runoff characteristics. Upstream projects that could have impact on the safety of the dam should be identified.

~~429~~

7. DOWNSTREAM CHANNEL

The channel immediately downstream of the dam should be examined for conditions which might impose any constraints on the operation of the dam or present any hazards to the safety of the dam. Development of the potential flooded area downstream of the dam should be assessed for compatibility with the hazard classification.

8. OPERATION AND MAINTENANCE FEATURES

(a) Reservoir Regulation Plan

The actual practices in regulating the reservoir and discharges under normal and emergency conditions should be examined to determine if they comply with the designed reservoir regulation plan and to assure that they do not constitute a danger to the safety of the dam or to human life or property.

(b) Maintenance

The maintenance of the operating facilities and features that pertain to the safety of the dam should be examined to determine the adequacy and quality of the maintenance procedures followed in maintaining the dam and facilities in safe operating condition.

~~460~~

Annexure I

Definition of Terms Associated with Durability of Concrete

A.1 **Cracks**: An incomplete separation into one or more parts with or without space between.

A.1.1 **Cracks will be classified by direction, width & depth**: The following adjectives can be used: Longitudinal, transverse, vertical, diagonal and random. Three width ranges are suggested as follows: fine – generally less than 1 mm; medium – between 1 & 2mm; and wide – over 2 mm.

A.1.2 **Pattern cracking**: Fine openings on concrete surfaces in the form of a pattern, resulting from a decrease in volume of the material near the surface or increase in volume of the material below the surface, or both.

A.1.3 **Checking**: Development of shallow cracks at closely spaced but irregular intervals on the surface of mortar or concrete.

A.1.4 **Hairline cracking**: Small cracks of random pattern in an exposed concrete surface.

A.1.5 **D-cracking**: The progressive formation on a concrete surface of a series of fine cracks at rather close intervals, often of random patterns, but in highway slabs paralleling edges, joints & cracks and usually curving across slab corners.

A.2 **Deterioration**: Deterioration in any adverse change of normal mechanical, physical and chemical properties either on the surface or in the whole body of concrete generally through separation of its components.

A.2.1 **Disintegration**: Deterioration into small fragments or particles due to any cause.

A.2.2 **Distortions**: Any abnormal deformation of concrete from its original shape.

A.2.3 **Efflorescence**: A deposit of salts, usually white, formed on a surface, the substance having emerged from below the surface.

A.2.4 **Exudation**: A liquid or viscous gel-like material discharged through a pore, crack or opening in the surface.

A.2.5 **Incrustation**: A crust or coating generally hard formed on the surface of concrete or masonry construction.

A.2.6 **Pitting**: Development of relatively small cavities in a surface due to phenomena such as corrosion or cavitation, or in concrete, localized disintegration.

A.2.7 **Popout**: The breaking away of small portions of a concrete surface due to internal pressure which leaves a shallow, typical & conical depression.

A.2.7.1 **Popouts, small**: Popouts leaving holes upto 1 cm in diameter, or the equivalent.

A.2.7.2 **Popouts, medium**: Popouts leaving holes between 1 and 5 cm in diameter, or the equivalent.

A.2.7.3 **Popouts, large**: Popouts leaving holes greater than 5 cm in diameter, or the equivalent.

A.2.8 **Erosion**: Deterioration brought about by the abrasive action of fluids or solids in motion.

A.2.9 **Scaling**: Local flaking or peeling away of the near surface portion of concrete or mortar.

A.2.9.1 **Peeling**: A process in which thin flakes of mortar are broken away from a concrete surface; such as by deterioration or by adherence of surface mortar to forms as forms are removed.

A.2.9.2 **Scaling, light**: Loss of surface mortar without exposure of coarse aggregate.

A.2.9.3 **Scaling, medium**: Loss of surface mortar upto ½ to 1 cm in depth and exposure of coarse aggregate.

A.2.9.4 **Scaling, severe**: Loss of surface mortar ½ to 1 cm in depth with some loss of mortar surrounding aggregate particles 1 to 2 cm in depth so that aggregate is clearly exposed and stands out from the concrete.

A.2.9.5 **Scaling, very severe**: Loss of coarse aggregate particles as well as surface mortar and mortar surrounding aggregate, generally greater than 2 cm in depth.

~~492~~

A.2.10 **Spall**: A fragment, usually in the shape of a flake, detached from a larger mass by a blow, by the action of weather, by pressure, or by expansion within the large mass.

A.2.10.1 **Small Spall**: A roughly circular or oval depression, generally not greater than 2 cm depth nor greater than 15 cm in any dimension, caused by the separation of a portion of the surface concrete.

A.2.10.2 **Large Spall**: May be a roughly circular or oval depression, or in some cases an elongated depression over a reinforcing bar, generally 2 cm or more in depth and 15 cm or greater in any dimension, caused by a separation of the surface concrete.

A.2.11 **Joint Spall**: Elongated cavity along a joint.

A.2.12 **Dummy area**: Area of concrete surface which gives off a hollow sound when struck.

A.2.13 **Stalactite**: A downward pointing formation, hanging from the surface of concrete, shaped like an icicle.

A.2.14 **Stalagmite**: As stalactite, but upward formation.

A.2.15 **Dusting**: The development of a powdered material at the surface of hardened concrete.

A.2.16 **Corrosion:** Disintegration or deterioration of concrete or reinforcement by electrolysis or by chemical attack.

A.3 **Textural Defects**

A.3.1 **Bleeding channels**: Essentially vertical localized open channel caused by heavy bleeding.

A.3.2 **Sand streak**: Streak in surface of formed concrete caused by bleeding.

A.3.3 **Water pocket**: Voids along the underside of aggregate particles or reinforcing steel which formed during the bleeding period. Initially filled with bleeding water.

A.3.4 **Stratification**: The separation of overwet or over-vibrated concrete into horizontal layers with increasingly lighter materials towards the top: water, laitance, mortar and coarse aggregate will tend to occupy successively lower positions in

that order; a layered structure in concrete resulting from placing of successive batches that differ in appearance.

A.3.5 **Honeycomb**: Voids left in concrete due to failure of the mortar to effectively fill the spaces among coarse aggregate particles.

A.3.6 **Sand pocket**: Part of concrete containing sand without cement.

A.3.7 **Segregation**: The differential concentration of the components of mixed concrete, resulting in non-uniform proportions in the mass.

A.3.8 **Discolouration**: Departure of colour from that which is normal or desired.

~~434~~

Appendix III

STRUCTURES, FEATURES, EVENTS AND EVIDENCE TO BE EXAMINED DURING INSPECTIONS

1 GENERAL

The performance of dams and appurtenant structures is controlled by

(1) their designs,
(2) the characteristics of their constituent materials,
(3) the nature of their foundations, and
(4) their regional settings.

The fundamental objective of dam safety inspections is the detection of any existing or developing structural of hydraulic weakness. In searching for weaknesses, dam inspectors must recognize and understand the inter-relationship of the demands which control performance.

2. CHANGES IN THE CHARACTERISTICS OF MATERIALS

2.1 General : Observe for defective, unsuited or deteriorated materials. A variety of different materials makes up the different types of dams and appurtenances. The quality and durability of these materials must always be determined in every instance and the need for such critical examination and what to look for as listed in this section are not normally repeated in the sections on specific structures.

2.2 Concrete

(1) Alkali – aggregate reaction, pattern of crushing and cracking.
(2) Leaching
(3) Abrasion
(4) Spalling
(5) General deterioration
(6) Strength loss

2.3 Rock

(1) Degradation
(2) Softening
(3) Dissolution

2.4 Soils

(1) Degradation
(2) Dissolution
(3) Loss of plasticity
(4) Strength loss
(5) Mineralogical change

2.5 Soil - Cement

(1) Loss of cementation
(2) Crumbling

2.6 Metals

(1) Loss of cementation
(2) Corrosion
(3) Stress-corrosion
(4) Fatigue
(5) Tearing and rupture
(6) Galling

2.7 Timber

(1) Rotting
(2) Shrinkage
(3) Combustion
(4) Attack by organisms

2.8 Rubber

(1) Hardening
(2) Loss of elasticity
(3) Heat deterioration
(4) Chemical degradation

2.9 Joint sealers

(1) Loss of plasticity
(2) Shrinkage
(3) Melting

3 GENERIC OCCURRENCES

3.1 General : Observe occurrences for their characteristics, locations and recency. These occurrences are of a universal nature

~~406~~

regardless of structure type of foundation class. The details of what to look for in observing these occurrences, actual or evidential, are not repeated in the sections on specific structures.

3.2 Seepage and leakage

(1) Discharge – stage relationship
(2) Increasing or decreasing
(3) Turbidity and piping
(4) Colour
(5) Dissolved solids
(6) Location and pattern
(7) Temperature
(8) Taste
(9) Evidence of pressure
(10) Boils
(11) Recency and duration

3.3 Drainage

(1) Obstructions
(2) Chemical precipitates and deposits
(3) Unimpeded cutfall
(4) Sump pump facilities
(5) Bacterial growth

3.4 Cavitation

(1) Surface pitting
(2) Sonic evidence
(3) Vapour pockets

3.5 Stress and strain : Evidence and clues

(1) In concrete-cracks, crushing, displacements, offsets, shears & creep
(2) In steel-cracks, extensions, contractions, bending & buckling
(3) In timber crushing, buckling, bending, shears, extensions & compressions
(4) In rock and soils-cracks, displacements, settlement, consolidation, subsidence, compression, zones of extension & compression.

~~497~~

3.6 Stability, evidence and clues

(1) In concrete and steel structures – tilting, tipping, sliding & over-turning
(2) In embankment structures, cutslopes natural slopes – bulging, sloughing, slumping, sliding, cracks & escarpments
(3) In rock cutslopes, foundation and unlined tunnels – slumps, slides, rockfalls, bulges & cracks

4. OPERATION AND MAINTENANCE

4.1 Service reliability of outlet, spillway sump pump mechanical – electrical features

(1) Broken or disconnected lift chains and cables
(2) Test operation including auxiliary power sources
(3) Reliability and service connections of primary sources
(4) Verification of operators understanding and ability to operate
(5) Case and assurance of access to control stations
(6) Functioning of lubrication systems

4.2 Gate chamber, galleries, tunnels and conduits

(1) Ventilation and heat control of damp, corrosive environment of mechanical-electrical equipment.

4.3 Accessibility and visibility

(1) Obscuring & vegetal overgrowth
(2) Galleries-access ladders & lighting
(3) Access roads and bridges
(4) Communication and remote control lines, cables and telemetering systems

4.4 Control of vegetation and burrowing animals

(1) Harmful vegetation in embankments-oversize & dead root channels
(2) Harmful vegetation in structural concrete joints
(3) Obstructing vegetal growth in hydraulic flow channels
(4) Ground squirrels, rats and beavers

5. BEHAVIOUR

5.1 Every attempt should be made to anticipate and have engineer-observers present on site at items of large spillway and outlet

discharge. Resident operational personnel can often supply valuable information and may be the only available observers (during earthquakes) for example.

5.2 Warning, safety and performance instrumentation

(1) Piezometers, flow recorders, accelerometers, seismoscopes, joint meters & gauge points, strain meters, stress meters, inclinometers, direct & inverted plumblines, surface reference monuments, stage recorders, extension meters.
(2) Serviceability
(3) Access to readout stations
(4) Type and location suitable for conditions being observed
(5) Need for recalibration
(6) Faulty readings, sources and reasons
(7) Alarm systems operable and at appropriate set points
(8) Random check readings during inspections
(9) Quiz operators to determine their understanding of purpose and functioning of instruments.

5.3 During and after large floods

(1) Drift marked high waterlines
(2) Evidence of taxed spillway capacity
(3) Undesirable or dangerous spillway flow patterns directly observed or deduced from flow strains, erosion trails, swept vegetation & deposition of solids.

5.4 During and after large outlet releases

(1) Undesirable or dangerous spillway flow patterns, dynamic pressures, vibrations & cavitation sonics.

5.5 After earthquakes

(1) Cracks, displacements, offsets in structural features
(2) Cracks, slumps, slides, displacements, settlements in embankments, cut slopes and fill slopes.
(3) Broken stalactites in galleries, tunnels & chambers.
(4) Toppled mechanical equipment
(5) Sand boils.

~~469~~

6. CONCRETE DAMS

(Any of these observations are applicable also to reservoir impounding power intake structures, spillway control structures, lock walls).

6.1 Stress and strain : Evidence and clues

(1) Cracks, crushing, displacements, offsets in concrete monoliths, buttresses, face slabs, arch barrels visible on exterior surfaces and in galleries, valve & operating chambers and conduit interior surfaces.
(2) Typical stress and temperature crack patterns in buttresses, pilasters, diaphragms and arch barrels.
(3) Retention of design forces in post tensioned anchorages and tendons.

6.2 Stability : Evidence and clues

(1) Excessive or maldistributed uplift pressures revealed by piezometers, pressure spurts from foundation drain holes, construction joints and cracks.
(2) Differential displacements of adjacent monoliths, buttresses and supported arch barrels or face slabs.
(3) Disparities in region near the interface between arches and thrust blocks.
(4) Movement along construction joints.
(5) Uplift on horizontal surfaces revealed by seepage on downstream face and in galleries at construction lift elevations.

6.3 Hillsides and river channels adjacent to the abutments and river section foundation along the downstream toe of the dam.

(1) Leakage
(2) Seepage
(3) Stability
(4) Boils

6.4 Special attention to stability and seepage control at discontinuities and junctures.

(1) Embankment wraparound sections
(2) Waterstops in monoliths and face slabs
(3) Reservoir impounding backfill at spillway control sections and retaining walls.

~~440~~

6.5 Foundation

(1) Piping of weathering products from old solution channels and rock joint structure.
(2) Efficiency of foundation seepage control systems – drains, drainage holes, grout curtains, cutoffs & drainage tunnels.
(3) History of shear zones, faults & cavernous openings.
(4) Zones of varying permeability
(5) Orientation of stratification and bedding planes – effect on permeability, uplift & foundation stability.
(6) Subsurface erosion and piping.
(7) Thin weaker interbeds – effect on stability.

7. EMBANKMENT – TYPE DAMS

7.1 Stress and strain : Evidence and clues

(1) Settlement
(2) Consolidation
(3) Subsidence
(4) Compressibility
(5) Cracks, displacements, offsets, joint opening changes in concrete facing on rockfills
(6) Loss of freeboard from settlement
(7) Zones of extension and compression visible along dam crest or elsewhere
(8) Crushing of rock points of contact
(9) Differential settlement of embankment cross sectional zones visible along dam crest, indicating stress transfer along region of zone interface (increases possibility of hydraulic fracturing).

7.2 Stability : Evidence and clues

(1) Cracks, displacements, openings, offsets, sloughs, slides, bulges, escarpments on embankment crest and slopes and on hillsides adjacent to abutments.
(2) Sags and misalignments in parapet walls, quardrails, longitudinal conduits or other linaments parallel to embankment axis.
(3) Irregularities in alignment and variances from smooth, uniform face planes.
(4) Bulges in ground surfaces beyond toes of slopes.

7.3 Inadequate seepage control : Evidence and clues

(1) Wet spots

~~441~~

(2) New vegetal growth
(3) Seepage and leakage
(4) Boils
(5) Saturation patterns on slopes, hillsides and in streambed
(6) Depressions and sinkholes
(7) Evidence of high escape gradients.

7.4 Erosion control

(1) Loss, displacement & deterioration of upstream face riprap, underlayment and downstream face slope protection.
(2) Leaching

7.5 Foundation

(1) See 6.5 also
(2) Consolidation
(3) Liquefaction

7.6 Other endangerments

(1) Utility pressure conducts on, over or through embankments.
(2) Diversion ditches along abutment hillsides.

8 SPILLWAYS

8.1 Approach channel

(1) Obstructions
(2) Slides slumps and cracks & cutslopes

8.2 Log booms

(1) Submergence
(2) Uncleared accumulated drift
(3) Parting
(4) Loss of anchorage
(5) Inadequate sleck for low reservoir stages.

8.3 Hydraulic control structure

(1) Stability
(2) Retention of capacity rating
(3) Erosion at toe
(4) Unauthorized installations on crest, raising storage level and decreasing spilling capacity.

~~492~~

(5) Gate piers
(6) Trash control systems
(7) Nappe and crotch aeration
(8) Siphon prime settings

8.4 Headwater control (gates, flashboards, fuse plugs)

(1) Unauthorized position
(2) Wedging
(3) Gate trunnion displacements
(4) Loss of gate anchorage post-tensioning
(5) Undesirable eccentric loads from variable positions of adjacent gates.
(6) Gate-seal
(7) Erosive seal leakage
(8) Failure of system
(9) Availability of bulkhead facilities for unwatering, and of cranes and lifting beams.

8.5 Operating deck and hoists

(1) Broken or disconnected lift chains and cables
(2) Unprotected exposure of electrical-mechanical equipment to weather, sabotage, vandalism.
(3) Structural members and connections.

8.6 Shafts, conduits and tunnels

(1) Vulnerability to obstruction
(2) Evidence of excessive external overloading-pressure jets contorted cross-sections, cracks, displacements & circumferential joints.
(3) Serviceability of linings (concrete and steel), materials deterioration, cavitation & erosions.
(4) Rockfalls
(5) Severe leakage about tunnel plugs
(6) Support system for pressure conduits in walk-in tunnels.

8.7 Bridges

(1) Possibility of collapse with consequent flow obstruction.
(2) Serviceability of operational and emergency equipment transport.

~~413~~

8.8 Discharge carrier (open channel or conduit)

(1) Vulnerability to obstruction
(2) Evidence of excessive external sidewall loading – large wall deflections, cracks, differential deflections at vertical joints.
(3) Invert anchorage and foundation support – dummy soundings, buckled lining & excessive uplift.
(4) Observation of evidence of dangerous hydraulic flow patterns – cross water, inadequate freeboard, wall climb, unwetted surface, uneven distribution, ride up on horizontal curves, negative pressures at vertical curves & pressure flow deposition.
(5) Drain system serviceable
(6) Air injection and expulsion
(7) Tendency for jump formation in conduits
(8) Buckling & slipping of slope lining
(9) Erosion of unlined channels.

8.9 Terminal structures

(1) Inadequate dissipation of energy
(2) Jump sweepout
(3) Undercutting
(4) Retrogressive erosion
(5) Loss of foundation support for flip bucket substructure
(6) Unsafe jet trajectory and impingement
(7) Erosive endangerment of adjacent dam or other critical structures.

8.10 Return channels

(1) Impaired outfall
(2) Obstructions
(3) Slides, slumps & cracks in cutslopes.
(4) Erosion of deposition creating dangerous tailwater elevations or velocities.
(5) Evidence of destructive eddy currents.

9. OUTLETS

9.1 General : Many of the observations made of outlet components are similar in nature and purpose to these made for spillway components, stilling basins for example.

~~414~~

9.2 Approach channels (may seldom be directly visible and may require underwater inspection).

(1) Siltation
(2) Underwater slides and slumps.

9.3 Intake structure (including appended, inclined and free standing towers with wet and dry).

(1) Lack of dead storage
(2) Siltation
(3) Potential for burial by slides and slumps
(4) Damage or destruction of emergency and service bulkhead installation facilities
(5) Availability of bulkhead, cranes & lifting beams
(6) Serviceability of access bridges

9.4 Trash racks and raking equipment

(1) Clogging of bar spacing
(2) Lodged debris on horizontal surfaces
(3) Collapse

9.5 Gate chambers, gates, valves, hoists, controls, electrical equipments, air demand ducts.

(1) Accessibility to control station under all conditions
(2) Ventilation
(3) Unauthorized gate or valve positions
(4) Binding of gate seals
(5) Seizing
(6) Erosive seal leakage
(7) Failure of lubrication system
(8) Drainage arc sump pump serviceability
(9) Vulnerability to flooding under reservoir pressure through conduits, by-passes and gate bonnets surfacing in chamber.

9.6 Conduits and tunnels

(1) See 8.6 also
(2) Seepage or leakage along external periphery of conduit
(3) Extension strains in conduits extending through embankments
(4) Capacity and serviceability of air relief and vacuum valves on conduits.

9.7 Terminal structures
See 8.9

9.8 Return channels
See 8.10

DAM SAFETY DIRECTORATE

K.D.Thite - Director

S.K.Das - Deputy Director

R.G.Kelvekar - Deputy Director

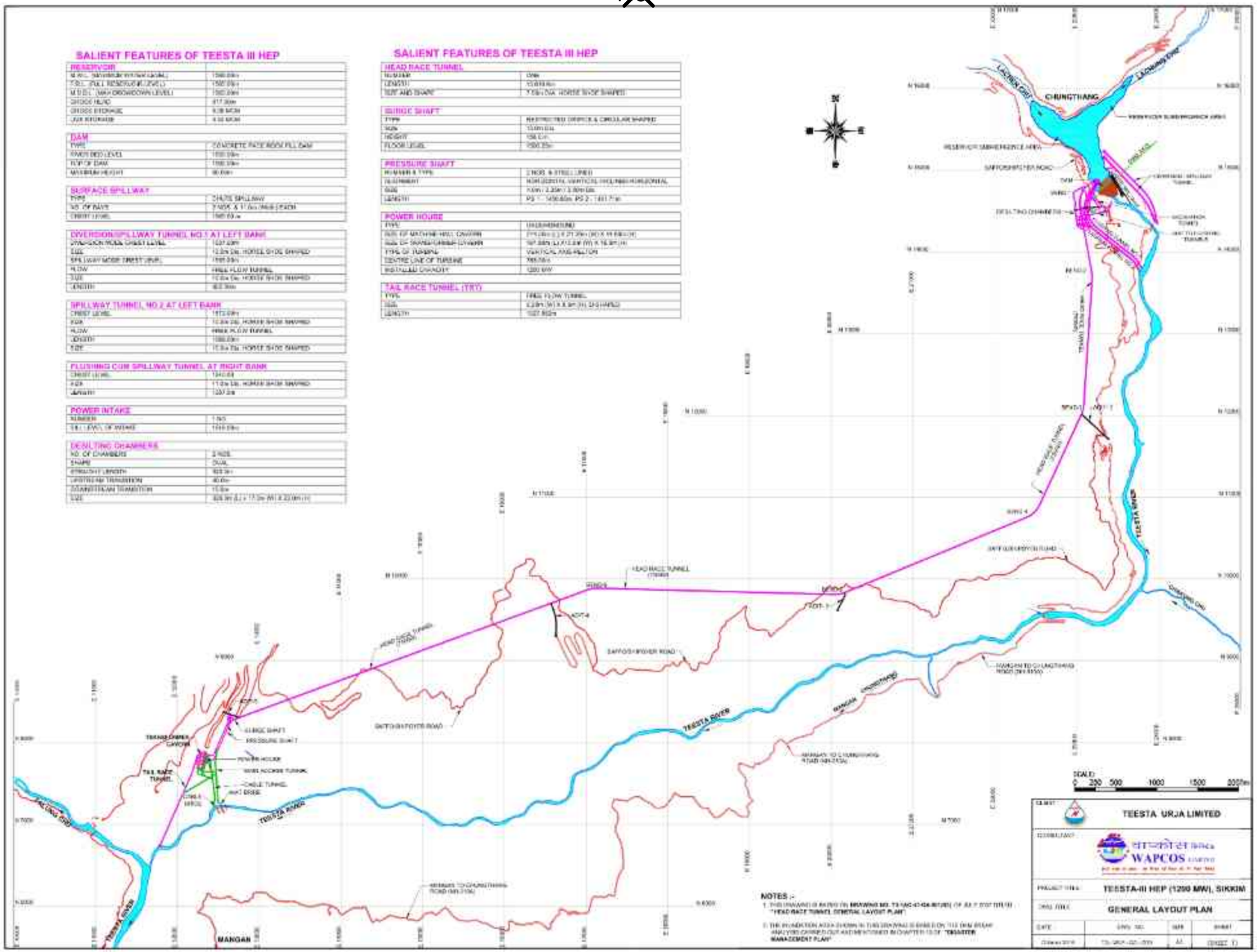
~~446~~

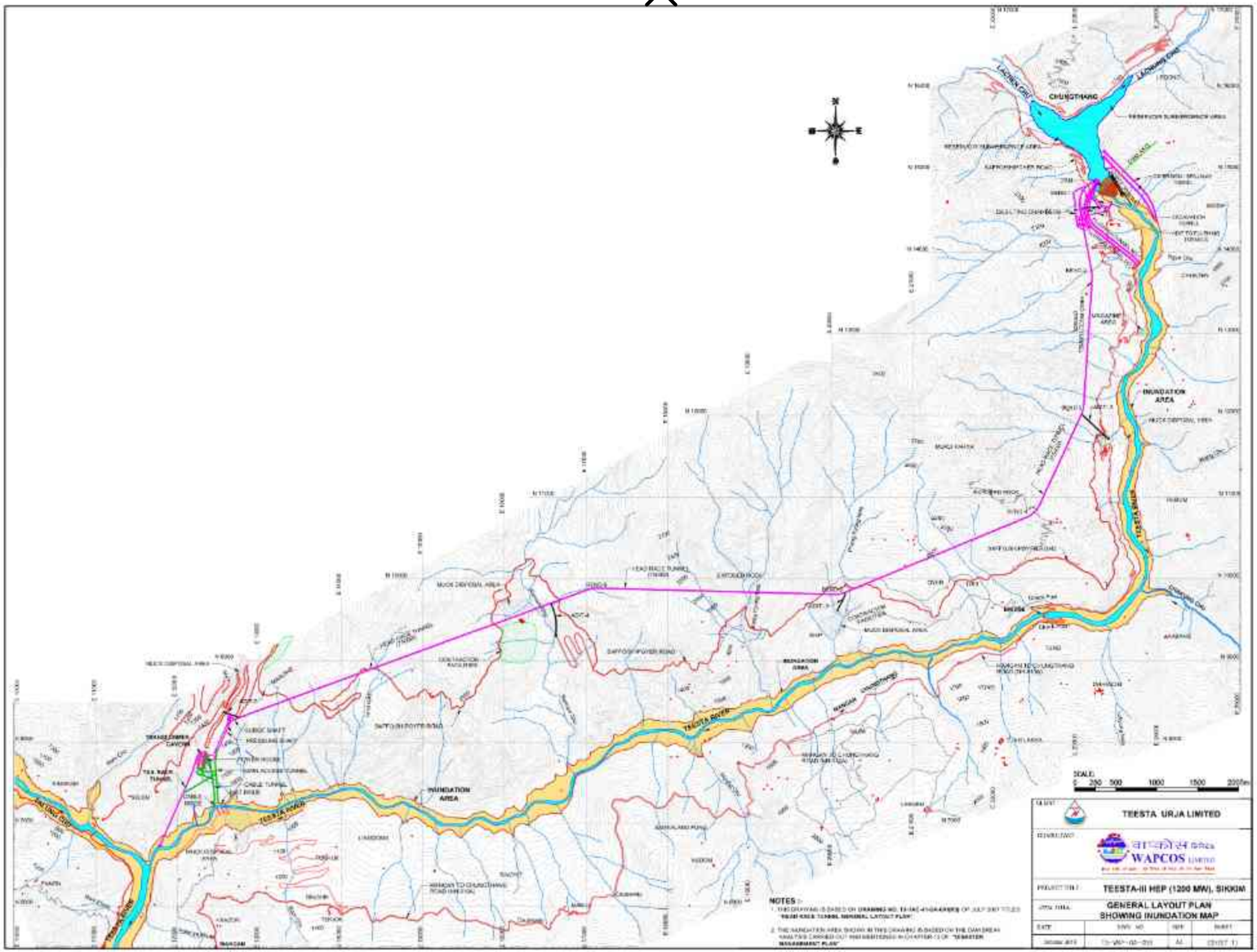
Annexure-4

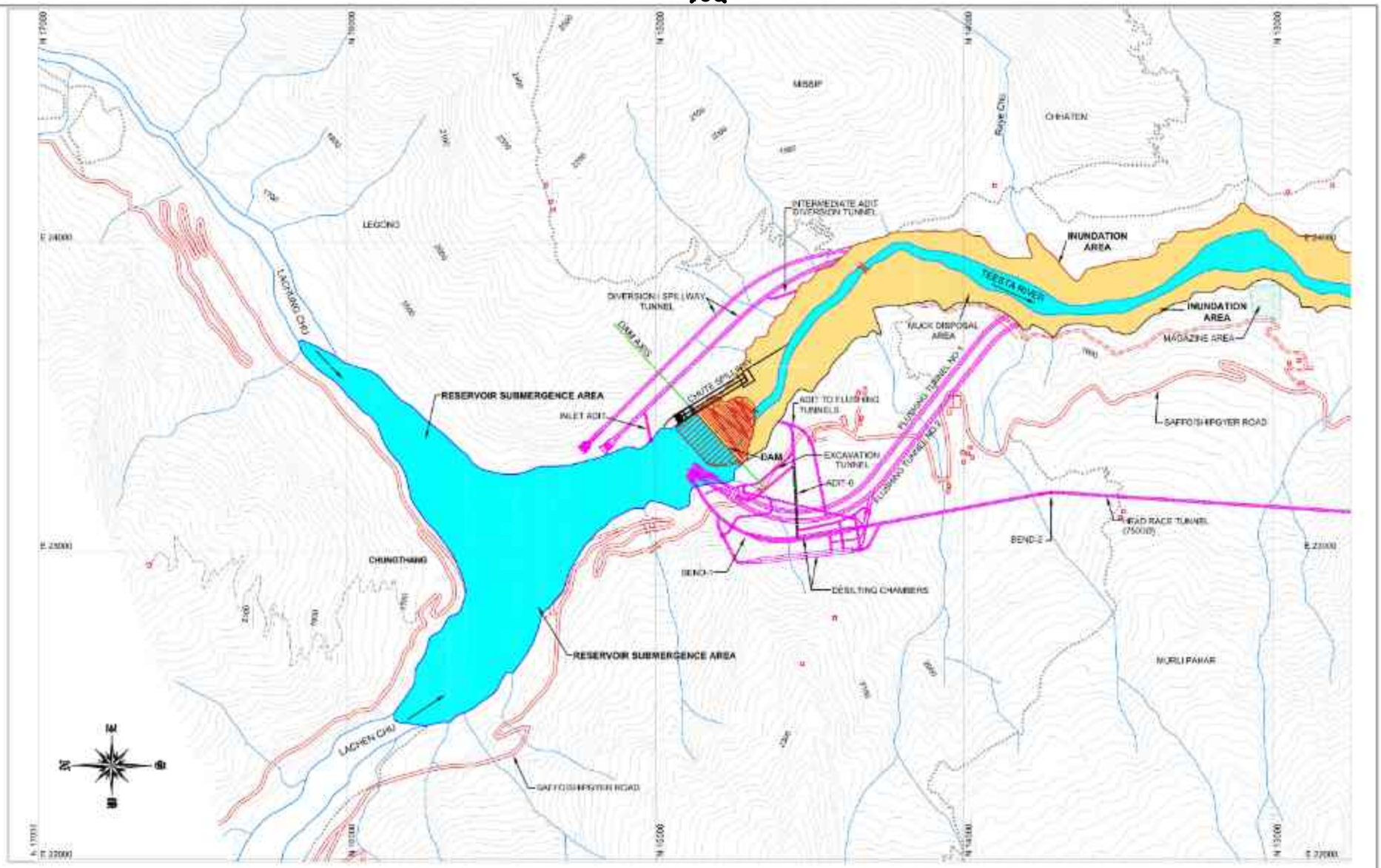
~~447~~

The following drawing showing the General Layout of Teesta-III HEP and the inundation map up to 20Km downstream of Dam and Approach Road to Dam & Power House Complex are appended:

1. General Lay out Plan **(Drawing No.- T3-WAP-GA-005)**
2. General Lay out Plan showing Inundation map **(Drawing No.- T3-WAP-GA-006)**
3. Inundation plan near the Dam area **(Drawing No.- T3-WAP-GA-007)**
4. Inundation plan near the Power House area **(Drawing No.- T3-WAP-GA-008)**
5. Plan showing the Approach Road to Dam complex **(Drawing No.- T3-WAP-GA-009)**
6. Plan showing the Approach Road to P.H. complex **(Drawing No.- T3-WAP-GA-010)**

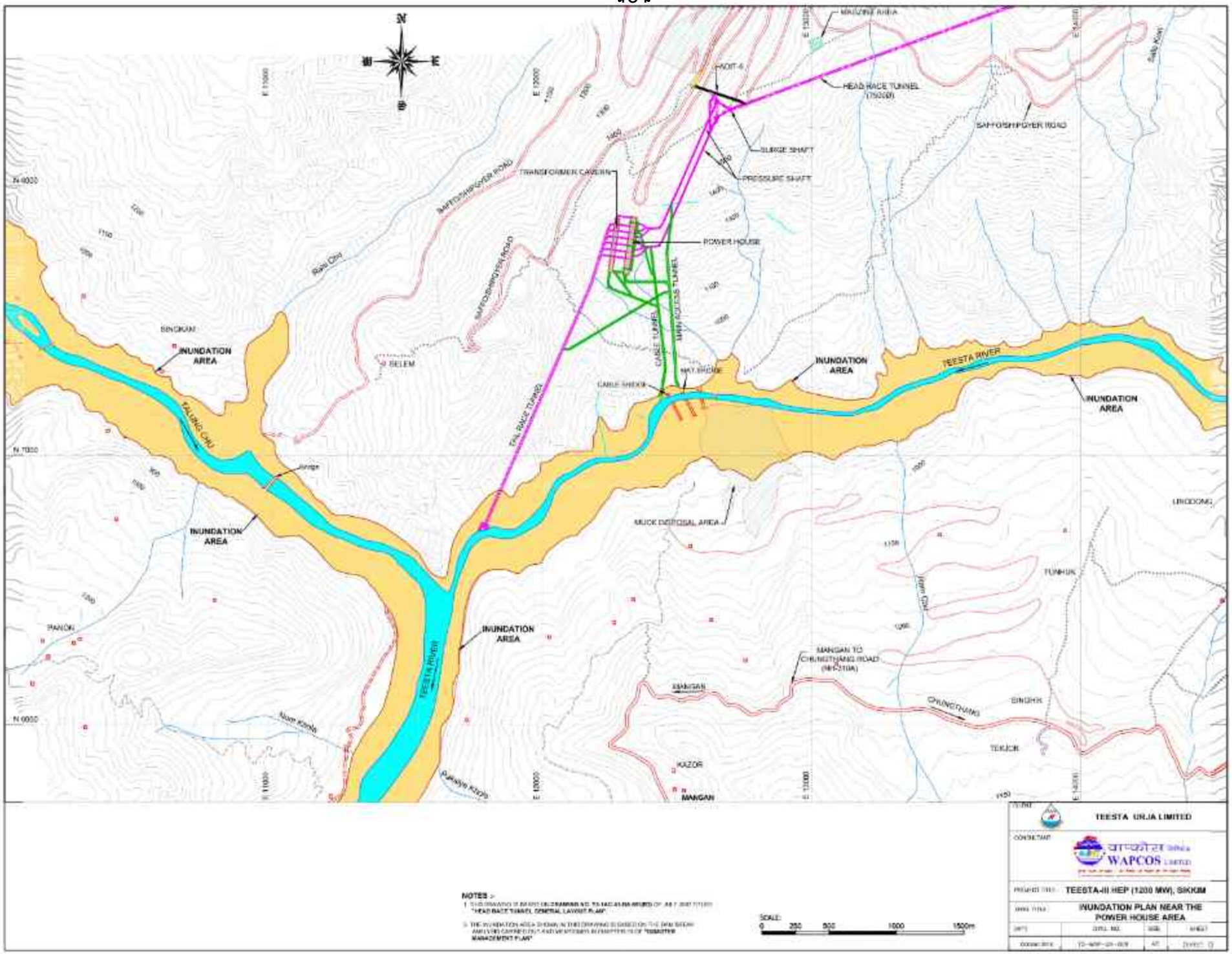

SALIENT FEATURES OF TEESTA III HEP
RESERVOIR
DAM
SURFACE SPILLWAY
DIVERSION/SPILLWAY TUNNEL NO.1 AT LEFT BANK
SPILLWAY TUNNEL NO.2 AT LEFT BANK
FLUSHING CUM SPILLWAY TUNNEL AT RIGHT BANK
POWER INTAKE
DESILTING CHAMBERS
SALIENT FEATURES OF TEESTA III HEP
HEAD RACE TUNNEL
SURGE SHAFT
PRESSURE SHAFT
POWER HOUSE
TAIL RACE TUNNEL (TRT)
CHUNGTHANG
LACHEN CHU
LACHUNG CHU
TEESTA RIVER
SAPPOSHYBOYER ROAD
MANGAN
NOTES :-
TEESTA URJA LIMITED
WAPCOS LIMITED
PROJECT TITLE : TEESTA-III HEP (1200 MW), SIKKIM
DWG. TITLE : GENERAL LAYOUT PLAN

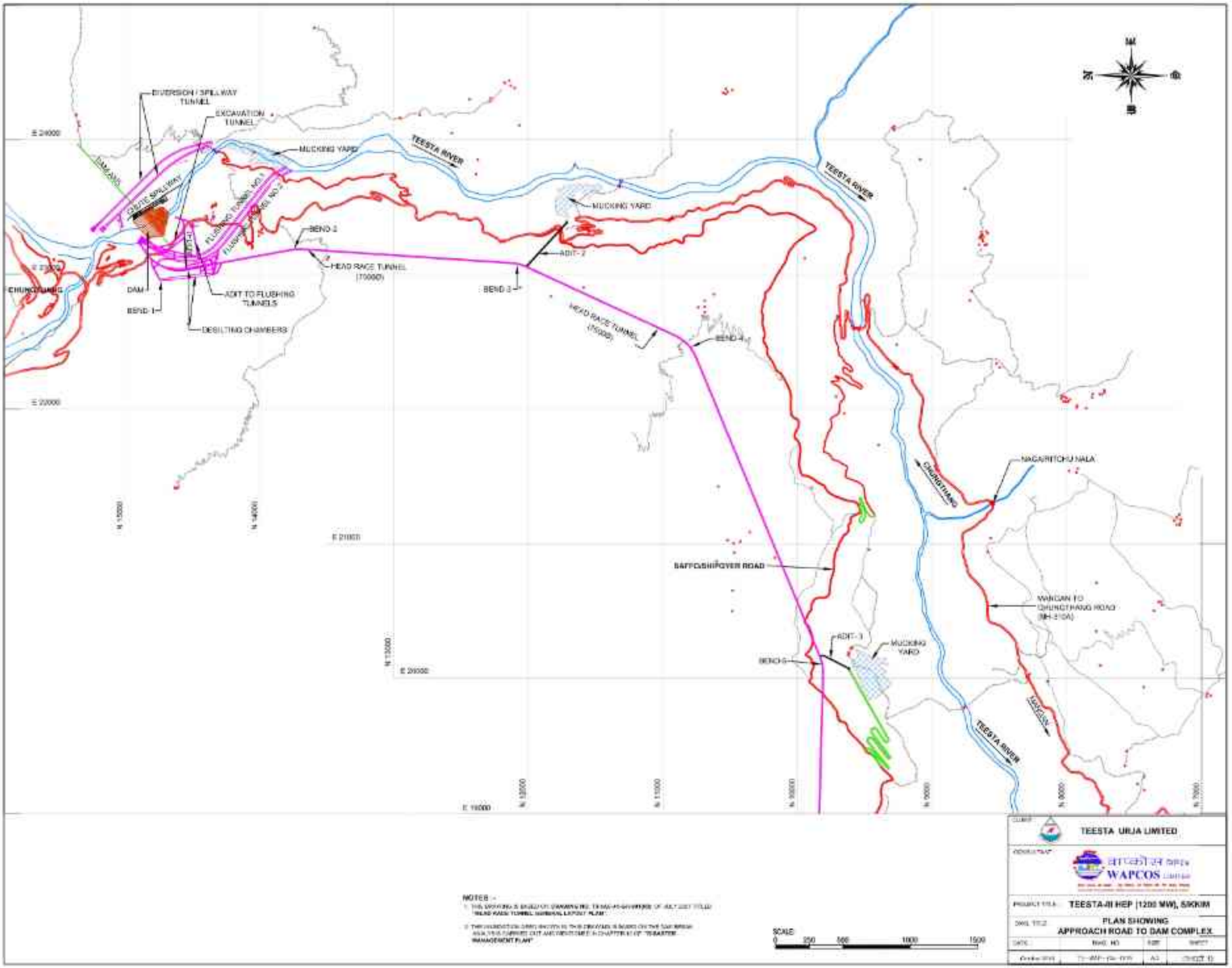

CHUNGTHANG
LACHEN CHU
LACHUNG CHU
TEESTA RIVER
INUNDATION AREA
SAFFOO POWER ROAD
HEAD RACE TUNNEL
SURGE SHAFT
POWER HOUSE
TAILRACE TUNNEL
TEESTA-III HEP (1200 MW), SIKKIM
GENERAL LAYOUT PLAN SHOWING INUNDATION MAP
TEESTA URJA LIMITED
WAPCOS LIMITED
NOTES :-

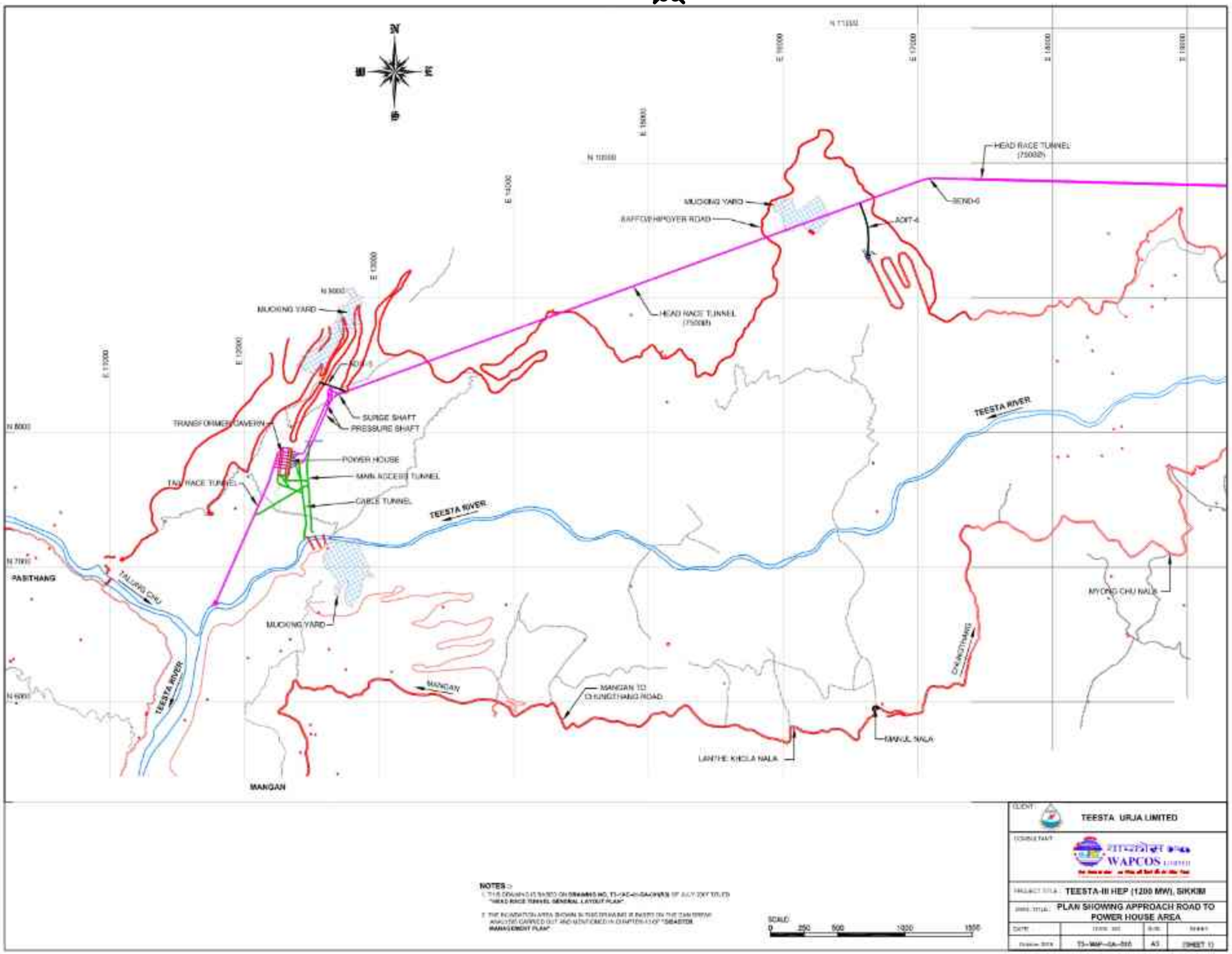


NOTES :-

1. THIS DRAWING IS BASED ON DRAWING NO. TE1A0-01-MA-W1R01 OF JULY 2007 TITLED "HEAD RACE TUNNEL CHAINAGE LAYOUT PLAN".
2. THE INUNDATION AREA SHOWN IN THIS DRAWING IS BASED ON THE SURVEY CARRIED OUT AND MAPPING INCORPORATED IN THE "DISASTER MANAGEMENT PLAN".


N
W
E
S
ADIT-6
HEAD RACE TUNNEL
SURGE SHAFT
PRESSURE SHAFT
TRANSFORMER CAVERN
POWER HOUSE
CABLE TUNNEL
MAIN ACCESS TUNNEL
TAIL RACE TUNNEL
CABLE SHEDDI
SAFFOSHIPGYER ROAD
Rabi Chu
SINGKIAM
BELEM
INUNDATION AREA
TEESTA RIVER
FALUNG CHU
PANOK
MUCK DISPOSAL AREA
LINGDONG
TUNHUK
MANGAN TO CHUNGTHANG ROAD (NH-310A)
KHANGAN
CHUNGTHANG
SINGHIK
TEKJOK
KAZOR
MANGAN
Nam Kanchi
Rukarye Khola
NOTES :
SCALE:
0 250 500 1000 1500m
TEESTA URJA LIMITED
CONSULTANT
WAPCOS LIMITED
PROJECT TITLE: TEESTA-III HEP (1200 MW), SIKKIM
DWG. TITLE: INUNDATION PLAN NEAR THE POWER HOUSE AREA


DIVERSION / SPILLWAY TUNNEL
EXCAVATION TUNNEL
DAM AXIS
CENTRE SPILLWAY
MUCKING YARD
TEESTA RIVER
FLUSHING TUNNEL NO.1
FLUSHING TUNNEL NO.2
ADIT-1
BEND-2
HEAD RACE TUNNEL (7000D)
ADIT-2
CHUNGTHANG
DAM
BEND-1
ADIT TO FLUSHING TUNNELS
DESILTING CHAMBERS
BEND-3
HEAD RACE TUNNEL (7500D)
BEND-4
NAGARITCHU NALA
CHUNGTHANG
SAFFOSHIPOVER ROAD
WAYGAN TO CHUNGTHANG ROAD (NH-510A)
ADIT-3
MUCKING YARD
BEND-5
TEESTA RIVER
TEESTA URJA LIMITED
WAPCOS Limited
TEESTA-III HEP (1200 MW), SIKKIM
PLAN SHOWING APPROACH ROAD TO DAM COMPLEX
NOTES :
SCALE
0 250 500 1000 1500


N
W
E
S
HEAD RACE TUNNEL (7500M)
MUCKING YARD
BAFFOW HIPOVER ROAD
ADIT-4
SENG-G
HEAD RACE TUNNEL (7500M)
MUCKING YARD
ADIT-5
SURGE SHAFT
PRESSURE SHAFT
TRANSFORMER CAVERN
POWER HOUSE
MAIN ACCESS TUNNEL
TAIL RACE TUNNEL
CABLE TUNNEL
TEESTA RIVER
TEESTA RIVER
PASITHANG
TALUNG CHU
MUCKING YARD
TEESTA RIVER
MANGAN
MANGAN TO CHUNGTHANG ROAD
CHUNGTHANG
MYONG CHU NALA
MANJIL NALA
LANTHE KHOLA NALA
MANGAN
NOTES :-
SCALE
0 250 500 1000 1500
CLIENT
TEESTA URJA LIMITED
CONSULTANT
WAPCOS LIMITED
PROJECT TITLE : TEESTA-III HEP (1200 MW), SIKKIM
DRWG. TITLE : PLAN SHOWING APPROACH ROAD TO POWER HOUSE AREA
DATE
DRAWING NO. TS-WAP-GA-005
A3
(SHEET 1)

~~454~~

Annexure-5

~~4.5~~

The location of the various instruments provided in Diversion Dam and other appurtenant structures are tabulated below and the Instrumentation drawings are appended:

1. **Left Bank Spillway Tunnel (LBST) No.-1 and 2**

(As per Drawing Number: T3-2BC-41-DD-126)

INSTRUMENT/ ARRAY OF INSTRUMENTS	ELEVATION (m)	NO. OF INSTRUMENTS	
		MPBHX	LC
Multi Point Bore Hole Extensometer (MPBHX) and Load Cell (LC)	1543.5	1	1
Multi Point Bore Hole Extensometer (MPBHX) and Load Cell (LC)	1558.5	1	1
Multi Point Bore Hole Extensometer (MPBHX) and Load Cell (LC)	1591.5	2	2
Multi Point Bore Hole Extensometer (MPBHX) and Load Cell (LC)	1606.5	1	1

(As per Drawing Number: T3-2BC-41-DD-139)

LOCATION	R.D. (m)	NO. OF INSTRUMENTS		
		Multi Point Bore Hole Extensometer (MPBHX)	Load Cell (LC)	Tape Convergence Stud (TCS)
1	80	3	3	4
2	480	3	3	4
3	760	3	3	4
4	950	3	3	4

(As per Drawing Number: T3-2BC-41-DD-204)

INSTRUMENT/ ARRAY OF INSTRUMENTS	LOCATION	ELEVATION (m)	NO. OF INSTRUMENTS
			MPBHX
Multi Point Bore Hole Extensometer (MPBHX)	Construction adit to spillway tunnel no. 2, Instrumentation at crossing with diversion tunnel	1527.35	1

~~456~~

(As per Drawing Number: T3-2BC-41-DD-237)

LOCATION	ELEVATION (m)	NO. OF INSTRUMENTS		
		Multi Point Bore Hole Extensometer (MPBHX)	Load Cell (LC)	Tape Convergence Stud (TCS)
P1	1615.00	1	1	1
P2	1592.00	1	1	1
P3	1588.00	1	1	1
P4	1607.00	1	1	1
P5	1592.00	1	1	1
P6	1588.00	1	1	1
P7	1588.00	3	3	4
P8	1592.00	3	3	4
P9	1700.00	3	3	4
P10	1607.00	3	3	4
P11	1592.00	3	3	4
P12	1588.00	3	3	4
P13	1568.00	1	1	1
P14	1592.00	1	1	1
P15	1588.00	1	1	1
P16	1568.00	1	1	1
P17	1572.00	1	1	1
P18	1560.00	1	1	1
P19	1609.00	1	1	1

(As per Drawing Number: T3-2BC-41-DD-240)

LOCATION	R.D. (m)	NO. OF INSTRUMENTS			REMARKS
		Multi Point Bore Hole Extensometer (MPBHX)	Load Cell (LC)	Tape Convergence Stud (TCS)	
1	85.15	1	1	3	Near Portal of Access tunnel Limb to ST-2 Inlet
2	157.294	3	3	3	In Access Tunnel
3	233.263	1	1	3	Near Portal of Access tunnel Limb to ST-1 Inlet
4	395.194	3	3	3	In Access Tunnel
5	446.154	3	3	3	In Access Tunnel

~~457~~

(As per Drawing Number: T3-2BC-41-DD-312)

LOCATION	ELEVATION (m)	NO. OF INSTRUMENTS		DESCRIPTION
		Multi Point Bore Hole Extensometer (MPBX)	Single Point Bore Hole Extensometer (SPBX)	
Drift Anchors-1	1591.5	1	1	MPBX-1 (23M,15M,10M) SPBX-1(23M)
Drift Anchors-2	1591.5	1	1	MPBX-1 (23M,15M,10M) SPBX-1(23M)
Drift Anchors-3	1591.5	1	1	MPBX-1 (20M,15M,10M) SPBX-1(20M)

2. CONCRETE FACE ROCK FILL DAM

As per Drawing Number: T3-2DC-41-DD-012)

INSTRUMENT	LOCATION		
	DISTANCE FROM DAM AXIS	CHAINAGE (M)	ELEVATION (M)
Hydraulic Settlement Gauges (HSG1)	10m D/S Dam Axis	115.00	1536.00
Hydraulic Settlement Gauges (HSG2)	10m D/S Dam Axis	115.00	1560.00
Hydraulic Settlement Gauges (HSG1)	10m D/S Dam Axis	45.00	1560.00

(As per Drawing Number: T3-2DC-41-DD-013)

INSTRUMENT	LOCATION		
	DISTANCE FROM DAM AXIS	CHAINAGE (M)	ELEVATION (M)
Surface Settlement Point (SP-1)	1.5m U/S of Dam Axis on face slab	10.00	1586.00
Surface Settlement Point (SP-2)	1.5m U/S of Dam Axis on face slab	45.00	1586.00
Surface Settlement Point (SP-3)	1.5m U/S of Dam Axis on face slab	80.00	1586.00

Surface Settlement Point (SP-4)	1.5m U/S of Dam Axis on face slab	115.00	1586.00
Surface Settlement Point (SP-5)	1.5m U/S of Dam Axis on face slab	150.00	1586.00
Surface Settlement Point (SP-6)	1.5m U/S of Dam Axis on face slab	185.00	1586.00
Surface Settlement Point (SP-7)	(Dam Axis) Top of Parapet Wall	2.00	1591.5
Surface Settlement Point (SP-8)	(Dam Axis) Top of Parapet Wall	37.00	1591.5
Surface Settlement Point (SP-9)	(Dam Axis) Top of Parapet Wall	72.00	1591.5
Surface Settlement Point (SP-10)	(Dam Axis) Top of Parapet Wall	107.00	1591.5
Surface Settlement Point (SP-11)	(Dam Axis) Top of Parapet Wall	142.00	1591.5
Surface Settlement Point (SP-12)	(Dam Axis) Top of Parapet Wall	177.00	1591.5
Surface Settlement Point (SP-13)	(Dam Axis) Top of Parapet Wall	205.00	1591.5
Surface Settlement Point (SP-14)	71.02m D/S of Dam Axis	10.00	1560.00
Surface Settlement Point (SP-15)	64.88m D/S of Dam Axis	45.00	1560.00
Surface Settlement Point (SP-16)	64.88m D/S of Dam Axis	80.00	1560.00
Surface Settlement Point (SP-17)	59.94m D/S of Dam Axis	115.00	1560.00
Surface Settlement Point (SP-18)	59.94m D/S of Dam Axis	150.00	1560.00
Surface Settlement Point (SP-19)	59.94m D/S of Dam Axis	183.00	1560.00
Surface Settlement Point (SP-20)	109.99m D/S of Dam Axis	45.00	1540.00
Surface Settlement Point (SP-21)	104.77m D/S of Dam Axis	80.00	1540.00
Surface Settlement Point (SP-22)	99.83m D/S of Dam Axis	115.00	1540.00
Surface Settlement Point (SP-23)	103.22m D/S of Dam Axis	150.00	1540.00

(As per Drawing Number: T3-2BC-41-DD-014)

INSTRUMENT	**LOCATION**
Stand Pipe Piezometer (SPM-1)	D/S of Dam Axis Near the toe of Dam
Stand Pipe Piezometer (SPM-2)	D/S of Dam Axis Near the toe of Dam
Stand Pipe Piezometer (SPM-3)	D/S of Dam Axis Near the toe of Dam
Stand Pipe Piezometer (SPM-4)	D/S of Dam Axis Near the toe of Dam
Stand Pipe Piezometer (SPM-5)	D/S of Dam Axis Near the toe of Dam
Stand Pipe Piezometer (SPM-6)	D/S of Dam Axis Near the toe of Dam
Stand Pipe Piezometer (SPM-7)	D/S of Dam Axis Near the toe of Dam

(As per Drawing Number: T3-2DC-41-DD-015)

INSTRUMENT	LOCATION CHAINAGE (m)
Perimetric Joint Meter (PJM-1)	45.00
Perimetric Joint Meter (PJM-2)	45.00
Perimetric Joint Meter (PJM-3)	45.00
Perimetric Joint Meter (PJM-4)	45.00
Perimetric Joint Meter (PJM-5)	115.00
Perimetric Joint Meter (PJM-6)	115.00
Perimetric Joint Meter (PJM-7)	115.00
Perimetric Joint Meter (PJM-8)	115.00

(As per Drawing Number: T3-2DC-41-DD-015)

INSTRUMENT	LOCATION	
	CHAINAGE (m)	DESCRIPTION
Joint Meter (JM-1)	2.00	Between Parapet Wall and Face Slab
Joint Meter (JM-2)	45.00	Between Parapet Wall and Face Slab
Joint Meter (JM-3)	115.00	Between Parapet Wall and Face Slab
Joint Meter (JM-4)	185.00	Between Parapet Wall and Face Slab
Joint Meter (JM-5)	15.00	At EL.1573.50 (20.25m U/S of Dam Axis) Between Face Slab Panels
Joint Meter (JM-6)	180.00	At EL.1573.50 (20.25m U/S of Dam Axis) Between Face Slab Panels

(As per Drawing Number: T3-2DC-41-DD-073)

INSTRUMENT	CHAINAGE (m)
Pore Pressure Gauges (PPG-1)	139.00
Pore Pressure Gauges (PPG-2)	139.00
Pore Pressure Gauges (PPG-3)	89.00
Pore Pressure Gauges (PPG-4)	89.00
Pore Pressure Gauges (PPG-5)	89.00
Pore Pressure Gauges (PPG-6)	34.00
Pore Pressure Gauges (PPG-7)	139.00
Pore Pressure Gauges (PPG-8)	89.00
Pore Pressure Gauges (PPG-9)	89.00
Pore Pressure Gauges (PPG-10)	89.00

3. POWER INTAKE:

(As per Drawing Number: T3-2GC-41-DD-009)

~~400~~

INSTRUMENT/ ARRAY OF INSTRUMENTS	ELEVATION (m)	NO. OF INSTRUMENTS	
		MPBHX	LC
Multi Point Bore Hole Extensometer (MPBHX) and Load Cell (LC)	1591.5	2	2
Multi Point Bore Hole Extensometer (MPBHX) and Load Cell (LC)	1606.5	1	1
Multi Point Bore Hole Extensometer (MPBHX) and Load Cell (LC)	1621.5	1	1
Multi Point Bore Hole Extensometer (MPBHX) and Load Cell (LC)	1651.5	1	1

4. DESILTING CHAMBER
(As per Drawing Number: T3-2HC-41-DD-029)

LOCATION	DISTANCE FROM END OF U/S TRANSITION (m)	NO. OF INSTRUMENTS		
		Multi Point Bore Hole Extensometer (MPBHX)	Load Cell (LC)	Tape Convergence Stud (TCS)
1	20.00	3	3	4
2	34.00	3	3	4
3	48.00	3	3	4
4	20.00	3	3	4
5	34.00	3	3	4
5	48.00	3	3	4

DESILTING CHAMBER (As per Drawing Number: T3-2HC-41-DD-093)

DISTANCE FROM END OF U/S TRANSITION (m)	DESILTING CHAMBER	NO. OF PIEZOMETER	REMARKS
20	DC-1	2+2=4	P1 and P2 Each at 10m depth beneath the concrete face P3 and P4 Each at 10m depth beneath the concrete face
	DC-2	2+2=4	P5 and P6 Each at 10m depth beneath the concrete face P7 and P8 Each at 10m depth beneath the concrete face
160	DC-1	2+2=4	P9 and P10 Each at 10m depth beneath the concrete face P11 and P12 Each at 10m depth beneath the concrete face
	DC-2	2+2=4	P13 and P14 Each at 10m depth beneath the concrete face P15 and P16 Each at 10m depth beneath the concrete face
300	DC-1	2+2=4	P17 and P18 Each at 10m depth beneath the concrete face P19 and P20 Each at 10m depth

			beneath the concrete face
	DC-2	2+2=4	P21 and P22 Each at 10m depth beneath the concrete face P23 and P24 Each at 10m depth beneath the concrete face

5. CHUTE SPILLWAY:

(As per Drawing Number: T3-2SC-41-DD-138)

INSTRUMENTS	NO. OF INSTRUMENTS
Foundation Piezometer (FP)	04
Pore Pressure Meter (PP)	04
Tilt Meter (TM)	06
Survey Targets (S.T.)	10
SDI	01
Automatic Data Acquisition System with Web Based Data Monitoring Service (WDMS)	01

6. HEAD RACE TUNNEL

(As per Drawing Number: T3-2BC-41-DD-036)

INSTRUMENT/ ARRAY OF INSTRUMENTS	LOCATION	ELEVATION (m)	NO. OF INSTRUMENTS
			MPBHX
Multi Point Bore Hole Extensometer (MPBX)	Head Race Tunnel Adit to HRT D/S of desilting Chamber Instrumentation at Location of Crossing with Flushing Tunnel	1527.35	1

7. POWER HOUSE COMPLEX :

(As per Drawing Number: T3-2BC-41-DD-133)

INSTRUMENT/ ARRAY OF INSTRUMENTS	LOCATION
Instrumented Rock Bolts Fixed with Reflector Type Targets	50 meter c/c length of Instrumented Rock Bolts

(As per Drawing Number: T3-2BC-41-DD-134)

INSTRUMENT/ ARRAY OF INSTRUMENTS	LOCATION	NO. OF INSTRUMENTS
Multi Point Bore Hole Extensometer (MPBX)	Instrumentation cum Drainage Gallery	20
Load Cell (LC)	Instrumentation cum Drainage Gallery	12
Pore Pressure Meter (PP)	Instrumentation cum Drainage Gallery	As Required
Convergence Points (PH-CP)	Instrumentation cum Drainage Gallery	19

~~400~~

(As per Drawing Number: T3-2BC-41-DD-134)

S.NO.	CONVERGENCE POINTS	R.D. (m)	ELEVATION
1	Convergence Point (PHCP-1)	21.60	795.75
2	Convergence Point (PHCP-2)	21.60	791.00
3	Convergence Point (PHCP-3)	21.60	784.927
4	Convergence Point (PHCP-4)	69.6	795.75
5	Convergence Point (PHCP-5)	69.6	791.00
6	Convergence Point (PHCP-6)	69.6	784.927
7	Convergence Point (PHCP-7)	69.6	776.399
8	Convergence Point (PHCP-1)	107.603	795.75
9	Convergence Point (PHCP-2)	107.603	791.00
10	Convergence Point (PHCP-3)	101.50	784.927
11	Convergence Point (PHCP-4)	101.50	776.399
12	Convergence Point (PHCP-5)	153.407	795.75
13	Convergence Point (PHCP-6)	153.407	791.00
14	Convergence Point (PHCP-7)	148.50	784.927
15	Convergence Point (PHCP-1)	148.50	776.399
16	Convergence Point (PHCP-2)	193.603	795.75
17	Convergence Point (PHCP-3)	193.603	791.00
18	Convergence Point (PHCP-4)	193.603	784.927
19	Convergence Point (PHCP-5)	193.603	776.399

(As per Drawing Number: T3-2BC-41-DD-165)

INSTRUMENT/ ARRAY OF INSTRUMENTS	LOCATION	NO. OF INSTRUMENTS
Multi Point Bore Hole Extensometer (MPBX)	Power House Cavern Instrumentation Transformer And GIS Cavern	7
Load Cell (LC)	Power House Cavern Instrumentation Transformer And GIS Cavern	As Required
Pore Pressure Meter (PP)	Power House Cavern Instrumentation Transformer And GIS Cavern	As Required
Convergence Points (PH-CP)	Power House Cavern Instrumentation Transformer And GIS Cavern	4x2=8

(As per Drawing Number: T3-2BC-41-DD-165)

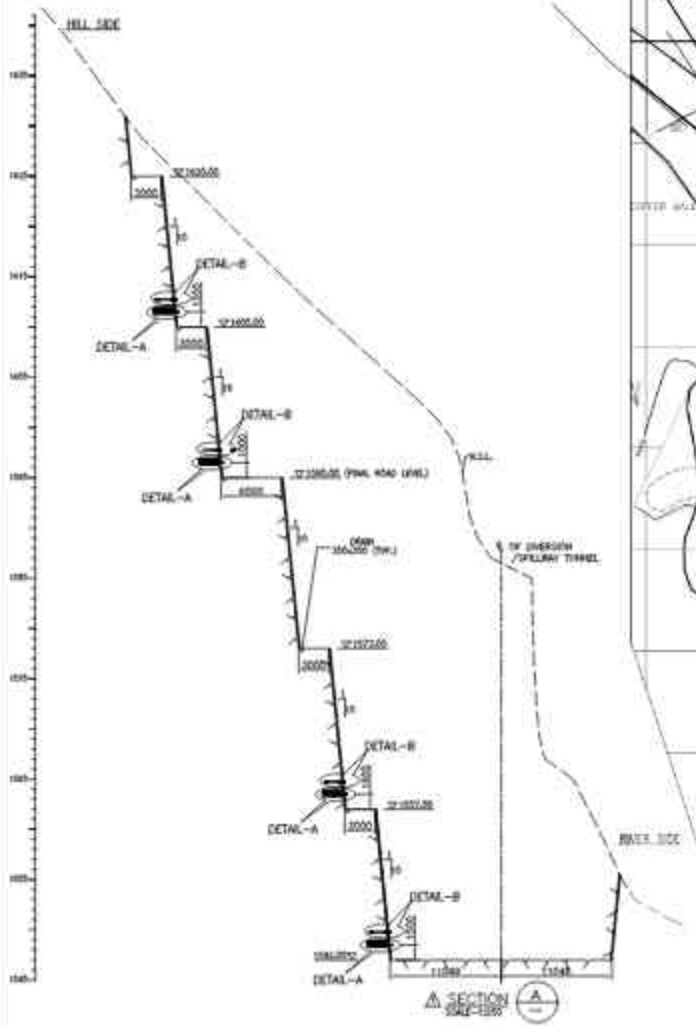
S.NO.	CONVERGENCE POINTS	R.D. (m)	ELEVATION
1	Convergence Point (PHCP-1)	134.659	790.30
2	Convergence Point (PHCP-2)	118.00	805.00
3	Convergence Point (PHCP-3)	118.00	790.30
4	Convergence Point (PHCP-4)	179.940	790.30

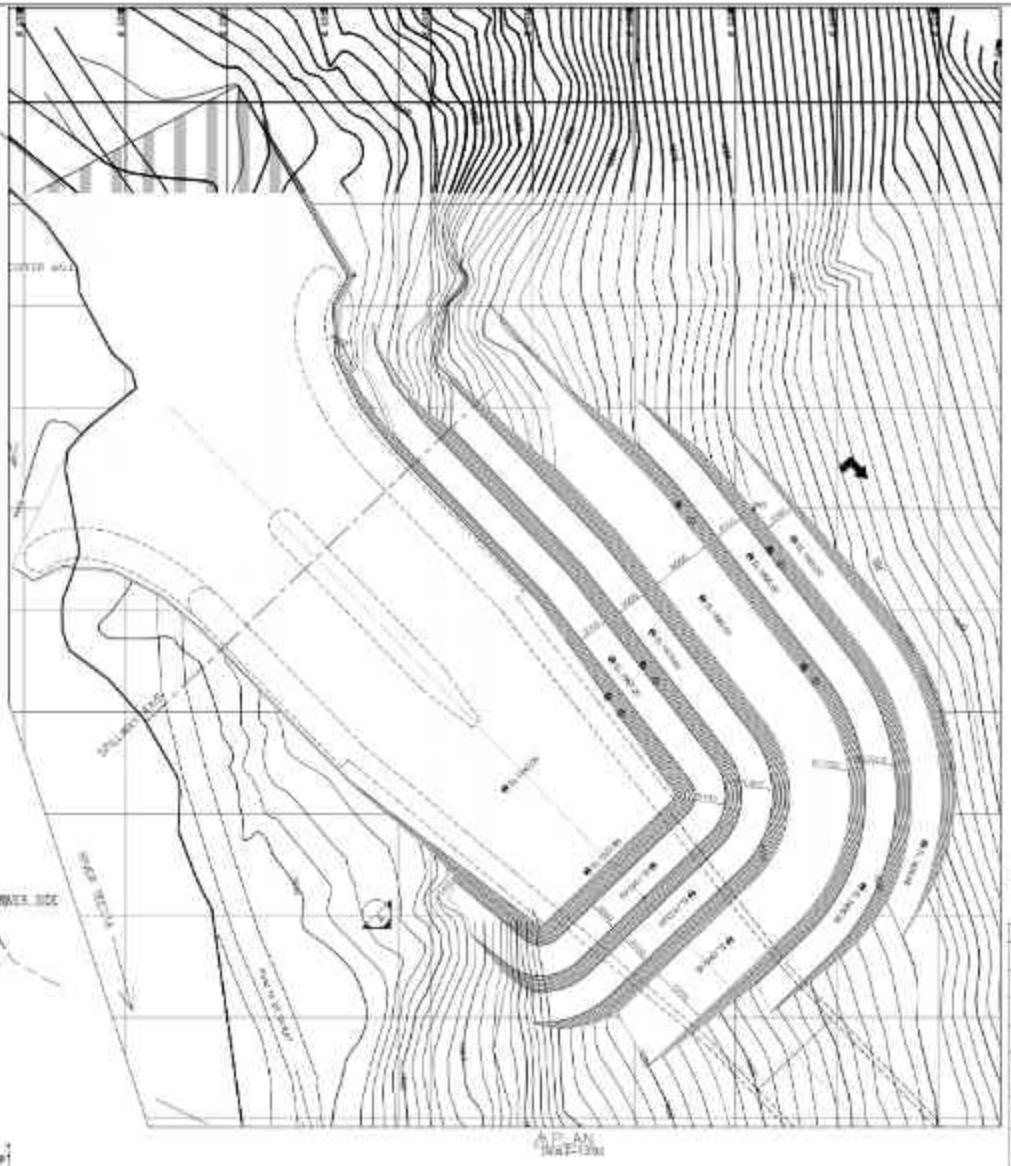
8. PRESSURE SHAFT:

(As per Drawing Number: T3-2BC-41-DD-169)

~~403~~

LOCATION	ELEVATION (m)	NO. OF INSTRUMENTS		
		Multi Point Bore Hole Extensometer MPBHX	Load Cell LC	Tape Convergence Stud TCS
P1	1513.75	1	1	-
P2		1	1	1
P3		-	-	1
P4		1	1	1
P5		-	-	1
P6	1513.00	1	1	1
P7	1509.00	-	-	1
P8	1509.00	-	-	1
P9	1509.00	-	-	1
P10	1509.00	-	-	1
P11		1	1	1
P12		-	-	1
P13	1509.00	-	-	1
P14	1512.00	1	1	1
P15		-	-	1
P16	1509.00	-	-	1
P17	1513.00	1	1	1
P18	1509.00	-	-	1
P19	1505.00	1	1	-
P20	1517.00	1	1	-
P21	1511.00	1	1	-
P22	1509.50	-	-	1
P23	1509.50	-	-	1
P24	1511.00	1	1	1
P25		-	-	1
P26		-	-	1
P27		-	-	1
P28		1	1	1
P29		1	1	1
P30		-	-	1
P31	1509.50	-	-	1
P32	1509.50	-	-	1
P33	1517.00	1	1	-
P34	1517.00	1	1	-





NOTES:-

1. ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATIONS ARE IN METRES UNLESS OTHERWISE SPECIFIED.
2. MPBXs AND LOAD CELLS AS SHOWN IN THE DRAWING SHALL BE INSTALLED AS PER MANUFACTURER'S REQUIREMENT AND AS SPECIFIED IN T.S.
3. MEASURING HEAD OF THE INSTRUMENTS MAY GET DAMAGED DUE TO BLASTING OR SHOTCRETE. THE SAME BE RECESSED INTO THE ROCK AND COVERED WITH A MILD STEEL PLATE, IF NECESSARY.
4. LOAD CELLS SHALL BE FIXED/CAST ON ROCK BOLT THE ROCK BOLT SHALL BE ONLY ANCHORED AND TENSIONED TO 5 TONNES AND SHALL NOT BE FULLY GROUTED.
5. LOCATION OF INSTRUMENTS MAY REQUIRE MODIFICATIONS BY THE ENGINEER-IN-CHARGE TO SUIT SITE CONDITION.
6. THE READING OF THE INSTRUMENTS SHALL BE STARTED DURING CONSTRUCTION AND DATA BE ANALYSED AND SUBMITTED TO THE ENGINEER-IN-CHARGE. FREQUENCY OF READINGS MAY BE DECREASED BY ENGINEER-IN-CHARGE ON ACHIEVING STABLE READINGS.
7. THE INSTRUMENTS DAMAGED DURING CONSTRUCTION SHALL BE REPLACED MANDATORY.

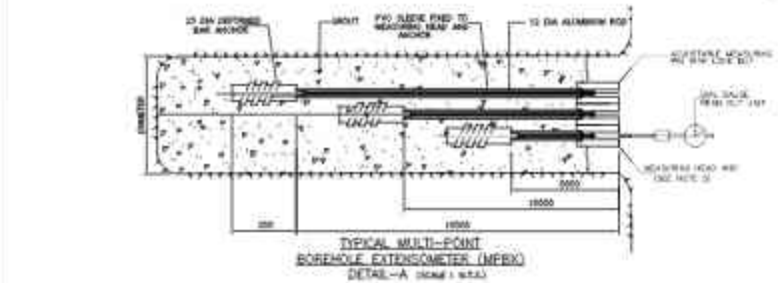
LEGEND :-

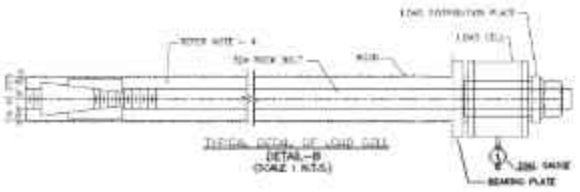
MPBX — MULTI POINT BOREHOLE EXTENSOMETER
LC — LOAD CELL

REFERENCE DRAWING :-

1. 33-280-41-00-109 DAM COMPLEX, LEFT SIDE DIVERSION TUNNEL / TUNNEL SPILLWAY FIRST STAGE EXCAVATION PLAN
2. 33-280-41-00-110 DAM COMPLEX, LEFT SIDE DIVERSION TUNNEL / TUNNEL SPILLWAY FIRST STAGE EXCAVATION SECTION

SCALE 1:250





NO.	BY	DATE	R.N.	RECOM.	APPD.	DATE	DESCRIPTION
1							REVISED & ISSUED AS Δ

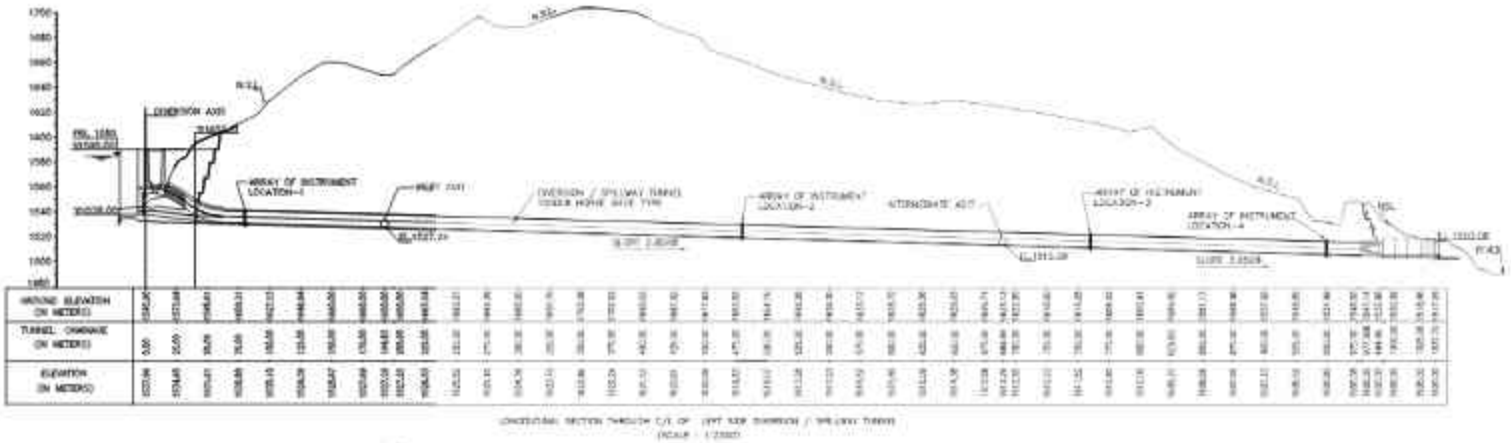
CLIENT : TEESTA URJA LIMITED

PROJECT : TEESTA STAGE-III H. E. PROJECT

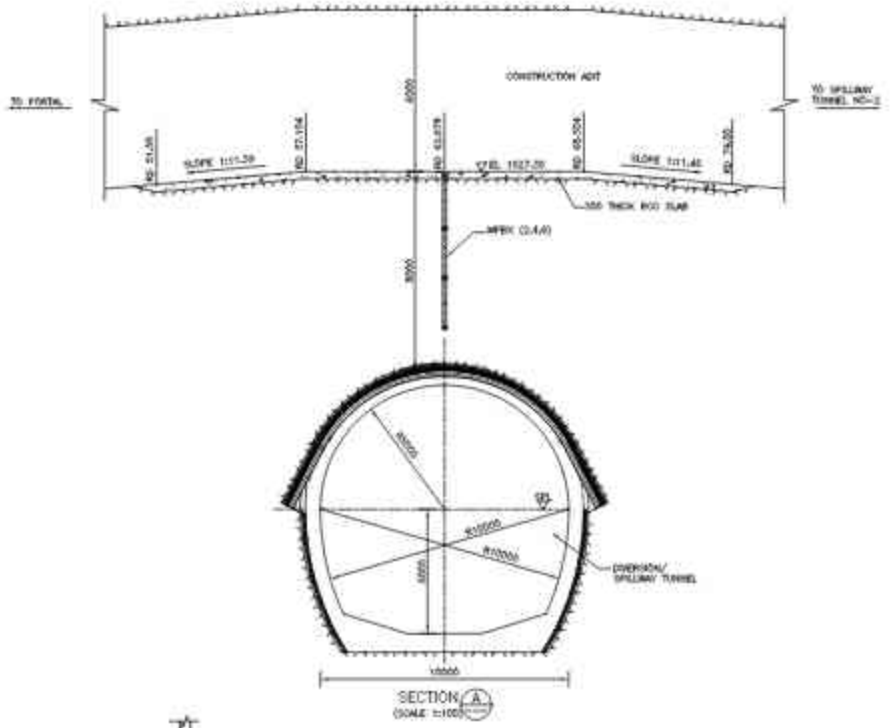
DESIGNER : ENERGY INFRATECH PRIVATE LTD.

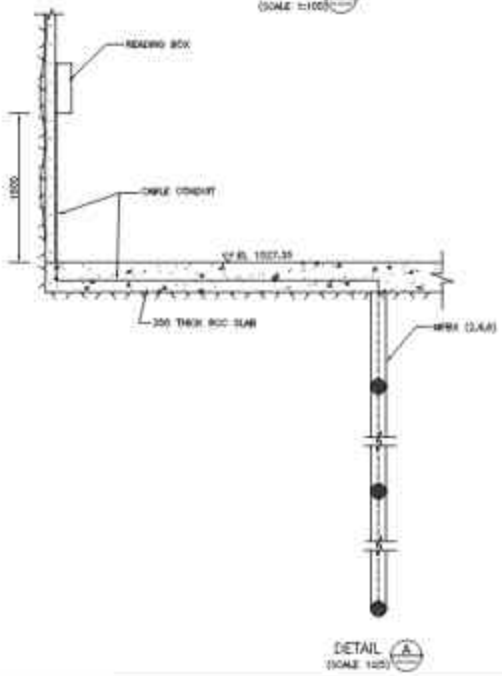
DRAWING : DAM COMPLEX
LEFT SIDE DIVERSION / SPILLWAY TUNNEL
INSTRUMENTATION
EXTENSOMETERS AND LOAD CELLS

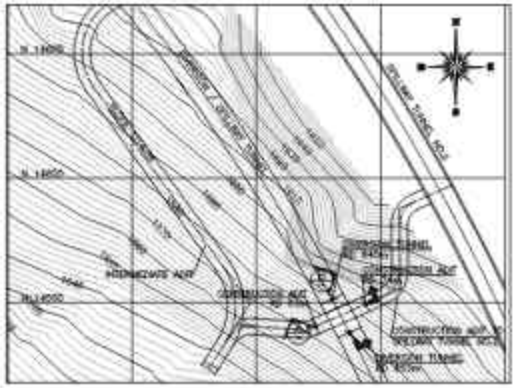
DRAWN	: V.CHAITANYA	SUBMITTED	: R.SETH
DESIGNED	: Y.M.R.	VETTED	: V.V.BADREENARAYANAN
CHECKED	: T.S.A.SHASTRY	APPROVED	: T.U.MAHARAJ
DRAWING NO	: 33-280-41-00-128	REV NO	: R1
DATE	: MAR. 2008	ORIGINAL PRINT SIZE	: A1

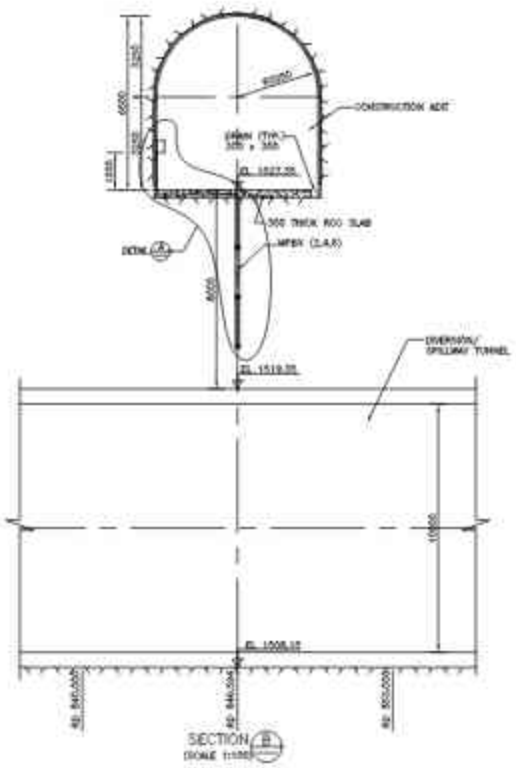


| | | |









NOTES :-

1. ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. MPBX AS SHOWN IN THE DRAWING SHALL BE INSTALLED AS PER MANUFACTURER'S REQUIREMENT AND AS SPECIFIED IN TECHNICAL SPECIFICATION.
3. LOCATION OF INSTRUMENT MAY REQUIRE MODIFICATIONS AT SITE ENGINEER-IN-CHARGE TO SUIT SITE CONDITIONS.
4. THE CHORD MAY BE PLACED IN THE CABLE CONDUIT THROUGH THE CONCRETE SLAB UPTO THE SIDE WALL AND EXTENDED UPTO THE APPROPRIATE DATA LOCATION TO THE NEARING SIDE.
5. THE READING OF THE INSTRUMENT SHALL BE OBSERVED DURING CONSTRUCTION AND DATA BE ANALYSED AND SUBMITTED TO THE ENGINEER-IN-CHARGE.
6. NECESSARY PRECAUTIONS SHALL BE TAKEN DURING AND AFTER TUNNEL EXCAVATION TO ENSURE THAT INSTALLED INSTRUMENT DO NOT GET DAMAGED.
7. THE INSTRUMENT DAMAGED DURING CONSTRUCTION SHALL BE REPLACED IMMEDIATELY.

LEGENDS :-

MPBX (2,4,6) - MULTI POINT BOREHOLE EXTENSOMETER (TM/MA/YM)

REFERENCE DRAWING :-

1. T3-DBC-41-00-102 DAM COMPLEX LEFT SIDE DIVERSION/SPILLWAY TUNNEL L-SECTION
2. T3-DBC-41-00-201 DAM COMPLEX SPILLWAY TUNNEL-2 CONSTRUCTION ADIT PLAN
3. T3-DBC-41-00-202 DAM COMPLEX SPILLWAY TUNNEL-2 CONSTRUCTION ADIT L-SECTION
4. T3-DBC-41-00-203 DAM COMPLEX CONSTRUCTION ADIT TO SPILLWAY TUNNEL NO.-2 ADDITIONAL DETAILS MONUMENT AT CROSSING WITH DIVERSION TUNNEL

FOR CONSTRUCTION

SCALE 1:1000

SCALE 1:100

SCALE 1:25

REV	DRN	DES.	REVISED	SUB	APPD	DATE	DESCRIPTION

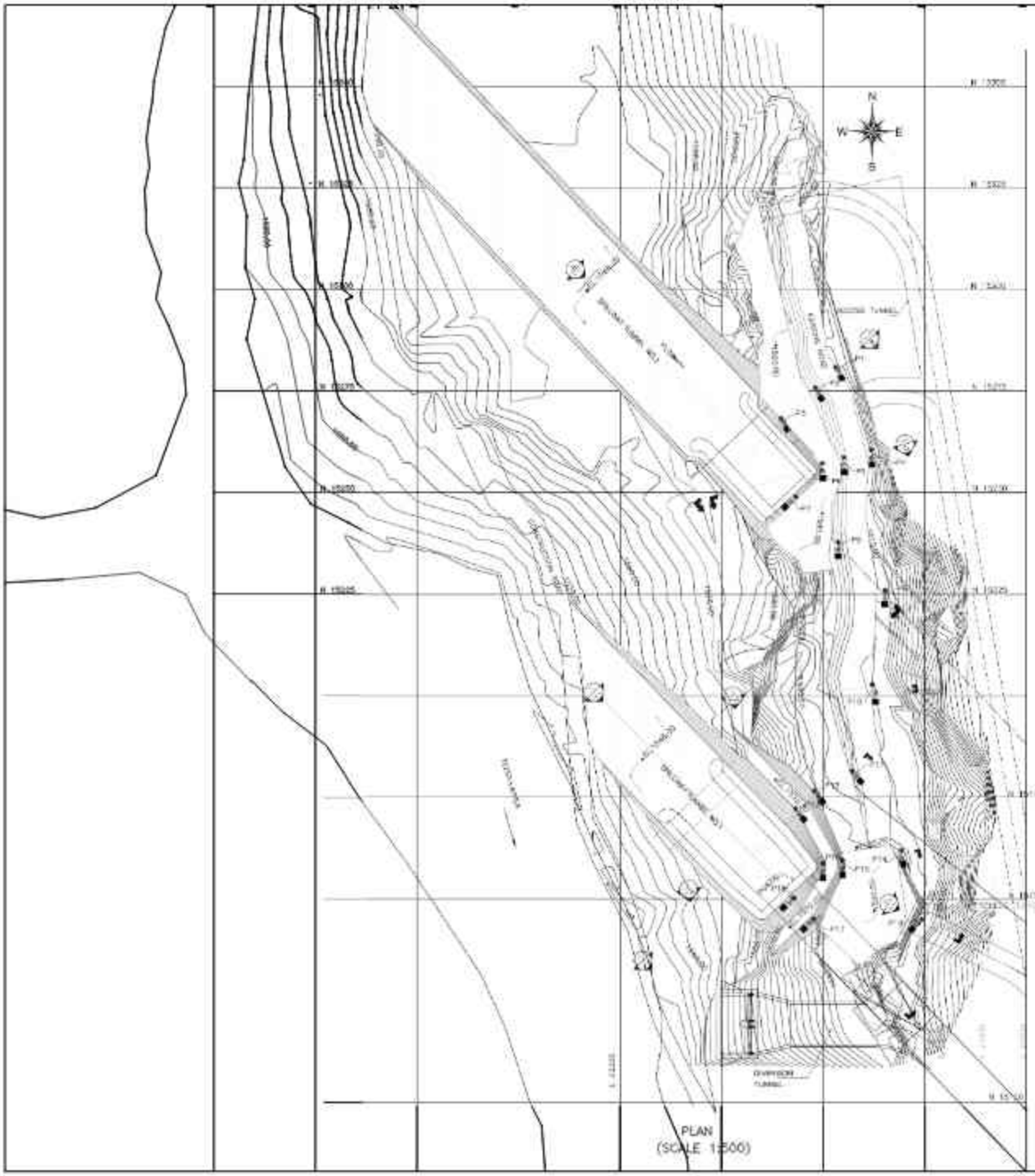
CLIENT : TEESTA URJA LIMITED

PROJECT : TEESTA STAGE-III H. E. PROJECT

DESIGNER : ENERGY INFRATECH PRIVATE LTD.

DRAWING : DAM COMPLEX
CONSTRUCTION ADIT TO SPILLWAY TUNNEL NO. 2
INSTRUMENTATION AT LOCATION OF CROSSING WITH DIVERSION TUNNEL

DRAWN :		CHECKED :	S. MURMU
DESIGNED :	M.K. GUPTA	APPROVED :	K. SETHI
DRAWING NO :	T3- DBC- 41- 00- 204	REV NO :	R0
DATE :	JUNE, 2009	ORIGINAL PRINT SIZE :	A1



COORDINATES AND ELEVATIONS (IN METER)

S.NO.	POINT NO.	EASTING COORDINATES	NORTHING COORDINATES	LEVELS
1	P1	23368.6	15280.0	1615.00
2	P2	23348.6	15275.1	1560.00
3	P3	23340.7	15267.5	1560.00
4	P4	23361.8	15258.5	1601.00
5	P5	23354.7	15257.8	1561.00
6	P6	23346.5	15255.1	1560.00
7	P7	23340.4	15246.1	1560.00
8	P8	23363.7	15235.9	1560.00
9	P9	23360.2	15225.5	1700.00
10	P10	23362.3	15250.0	1607.00
11	P11	23357.7	15180.7	1562.00
12	P12	23346.2	15175.8	1560.00
13	P13	23348.7	15171.4	1560.00
14	P14	23368.2	15161.2	1560.00
15	P15	23354.9	15158.8	1560.00
16	P16	23360.1	15157.9	1560.00
17	P17	23347.2	15144.4	1570.00
18	P18	23362.2	15149.8	1560.00
19	P19	23373.8	15142.2	1609.00

DETAILS OF INSTRUMENTS

S.NO.	POINT NO.	MPBX	LC	ST
1	P1	1	1	1
2	P2	1	1	1
3	P3	1	1	1
4	P4	1	1	1
5	P5	1	1	1
6	P6	1	1	1
7	P7	1	1	1
8	P8	1	1	1
9	P9	1	1	1
10	P10	1	1	1
11	P11	1	1	1
12	P12	1	1	1
13	P13	1	1	1
14	P14	1	1	1
15	P15	1	1	1
16	P16	1	1	1
17	P17	1	1	1
18	P18	1	1	1
19	P19	1	1	1
	TOTAL	19	19	19

NOTES :-

1. ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATIONS ARE IN METRES UNLESS OTHERWISE SPECIFIED.
2. MPBXs AND LOAD CELLS AS SHOWN IN THE DRAWING SHALL BE INSTALLED AS PER MANUFACTURER'S RECOMMENDATIONS AND AS APPROVED BY I.C.
3. MEASURING HEAD OF THE INSTRUMENTS MAY BE CHANGED DUE TO BLASTING OR DISTORTION THE SAME BE RETESTED AND THE HOLE AND COUPLED WITH A MILD STEEL PLATE, IF NECESSARY.
4. LOAD CELLS SHALL BE FASTENED ON ROCK BOLT THE BOLT SHALL BE ONLY TIGHTENED AND TENSIONED TO A TORQUE AND SHALL NOT BE PRE-STRESSED.
5. LOCATION OF INSTRUMENTS AND MINOR MODIFICATIONS BY THE ENGINEER-IN-CHARGE TO SUIT SITE CONDITION
6. THE READING OF THE INSTRUMENTS SHALL BE OBSERVED DURING CONSTRUCTION AND DATA BE ANALYSED AND SUBMITTED TO THE ENGINEER-IN-CHARGE. FREQUENCY OF READING NOT BE DECREASED BY ENGINEER-IN-CHARGE IN ACHIEVING TARGET ACCURACY.
7. NECESSARY PRECAUTIONS SHALL BE TAKEN DURING AND AFTER TUNNEL EXCAVATION TO ENSURE THAT INSTALLED INSTRUMENTS DO NOT GET DAMAGED.
8. DAMAGED INSTRUMENTS DURING CONSTRUCTION SHALL BE REPLACED IMMEDIATELY.

REFERENCE DRAWING :-

1. T3-280-01-00-001 — DAM COMPLEX-LEFT BANK DIVERSION/ SPILLWAY TUNNEL, SPILLWAY INLET EXCAVATION PLAN FROM EL 1596.00 TO 1580.00
2. T3-280-41-00-020 — DAM COMPLEX-LEFT SIDE DIVERSION/ SPILLWAY TUNNEL SPILLWAY INLET EXCAVATION SECTIONS FROM EL 1596.00 TO 1580.00
3. T3-280-41-00-021 — DAM COMPLEX - SPILLWAY TUNNEL NO-1 SPILLWAY INLET EXCAVATION PLAN FROM EL 1580.00 TO EL 1560.00
4. T3-280-41-00-035 — DAM COMPLEX - SPILLWAY TUNNEL NO-2 SPILLWAY INLET EXCAVATION SECTIONS FROM EL 1580.00 TO EL 1560.00

LEGENDS :-

- MPBX — MULTI POINT BOREHOLE EXTENSOMETER
- LC — LOAD CELL
- ST — SURVEY TARGETS

FOR CONSTRUCTION

SCALE 1:500

NO.	DRN	DESIGNED	REVIEWED	APPD	DATE	DESCRIPTION

CLIENT : TEESTA URJA LIMITED

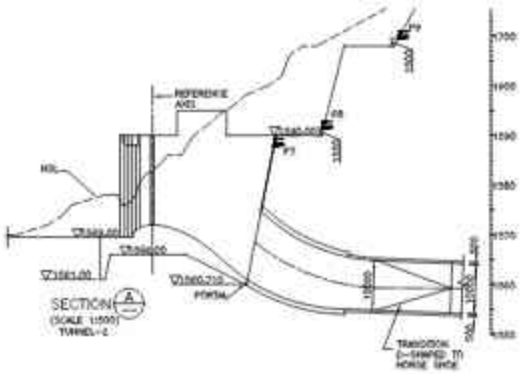
PROJECT : TEESTA STAGE-III H. E. PROJECT

DESIGNER : ENERGY INFRATECH PRIVATE LTD.

DRAWING : DAM COMPLEX
INSTRUMENTATION AT LEFT BANK
LEFT BANK SPILLWAY TUNNELS
SURFACE EXCAVATION

SHEET 1 of 2

DRAWN : AARIHANT	REVIEWED : P.K.BANSAL
DESIGNED : REENA BARIA / MANOJ GUPTA	APPROVED : RAJEEV SETHI
DRAWING NO. : T3-280-41-00-037	REV NO. : R0
DATE : JULY, 2010	ORIGINAL PRINT SIZE : A1



NOTES:-

1. ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. MPBX AND LOAD CELLS AS SHOWN IN THE DRAWING SHALL BE INSTALLED AS PER MANUFACTURER'S RECOMMENDATION AND AS DIRECTED BY I.E.
3. MEASURING HEAD OF THE INSTRUMENTS MAY GET DAMAGED DUE TO BLASTING OR DISTORTED. THE SAME BE EXPOSED INTO THE ROCK AND COVERED WITH A MILD STEEL PLATE IF NECESSARY.
4. LOAD CELLS SHALL BE FIXED ON ROCK BOLT. THE BOLT SHALL BE GRIT BLASTED AND TENSIONED TO 6 TONNES AND SHALL NOT BE PULL OUTED.
5. LOCATION OF INSTRUMENTS MAY REQUIRE MODIFICATIONS BY THE OWNER/ IN- CHARGE TO SUIT SITE CONDITION.
6. THE READING OF THE INSTRUMENTS SHALL BE OBSERVED DURING CONSTRUCTION AND DATA BE ANALYSED AND SUBMITTED TO THE OWNER/ IN-CHARGE. FREQUENCY OF READING MAY BE INCREASED BY OWNER/ IN- CHARGE IN ADVERSE STRESS REGIONS.
7. NECESSARY PRECAUTIONS SHALL BE TAKEN DURING AND AFTER TUNNEL EXCAVATION TO ENSURE THAT INSTALLED INSTRUMENTS DO NOT GET DAMAGED.
8. THE INSTRUMENTS DAMAGED DURING CONSTRUCTION SHALL BE REPLACED IMMEDIATELY.

REFERENCE DRAWING:-

1. T3-000-41-DD-001 DAM COMPLEX-LAYOUT DUE DIVERSION/ SPILLWAY TUNNEL SPILLWAY INLET EXCAVATION SECTIONS FROM EL.1548.00 TO 1590.00
2. T3-380-41-DD-002 DAM COMPLEX-LAYOUT DUE DIVERSION/ SPILLWAY TUNNEL SPILLWAY INLET EXCAVATION SECTIONS FROM EL.1548.00 TO 1590.00
3. T3-380-41-DD-027 DAM COMPLEX- SPILLWAY TUNNEL NO-2 SPILLWAY INLET EXCAVATION PLAN FROM EL. 1568.00 TO EL.1590.00
4. T3-380-41-DD-028 DAM COMPLEX- SPILLWAY TUNNEL NO-2 SPILLWAY INLET EXCAVATION SECTIONS FROM EL. 1568.00 TO EL.1590.00

FOR CONSTRUCTION

SCALE 1:500

REV	DATE	DESIGNED	REVISED	APPD.	DATE	DESCRIPTION

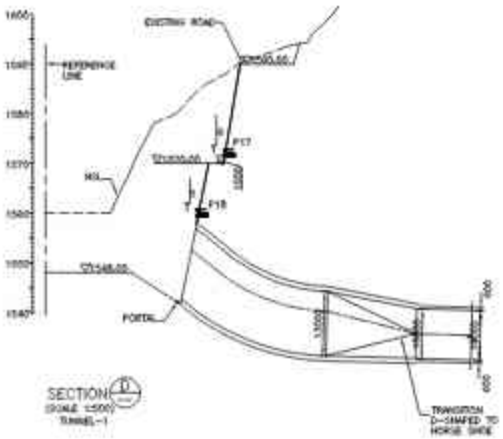
CLIENT : TEESTA URJA LIMITED

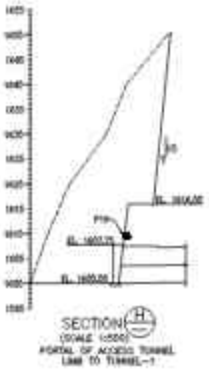
PROJECT : TEESTA STAGE-III H. E. PROJECT

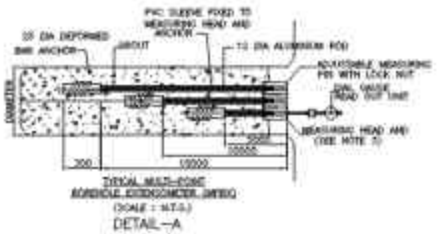
DESIGNED : ENERGY INFRATECH PRIVATE LTD.

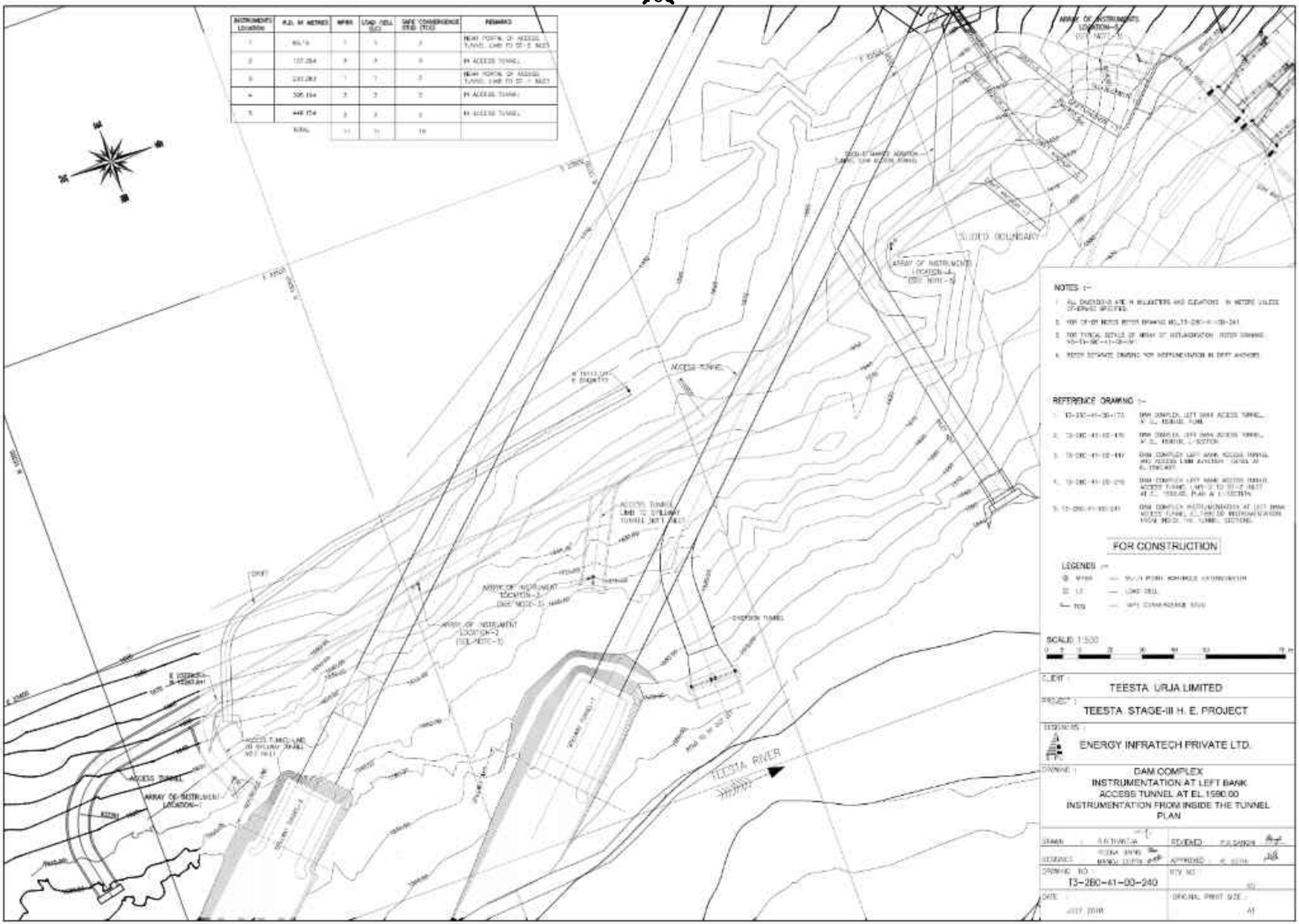
DRAWING : DAM COMPLEX
INSTRUMENTATION AT LEFT BANK
LEFT BANK SPILLWAY TUNNELS
SURFACE EXCAVATION
SHEET-01

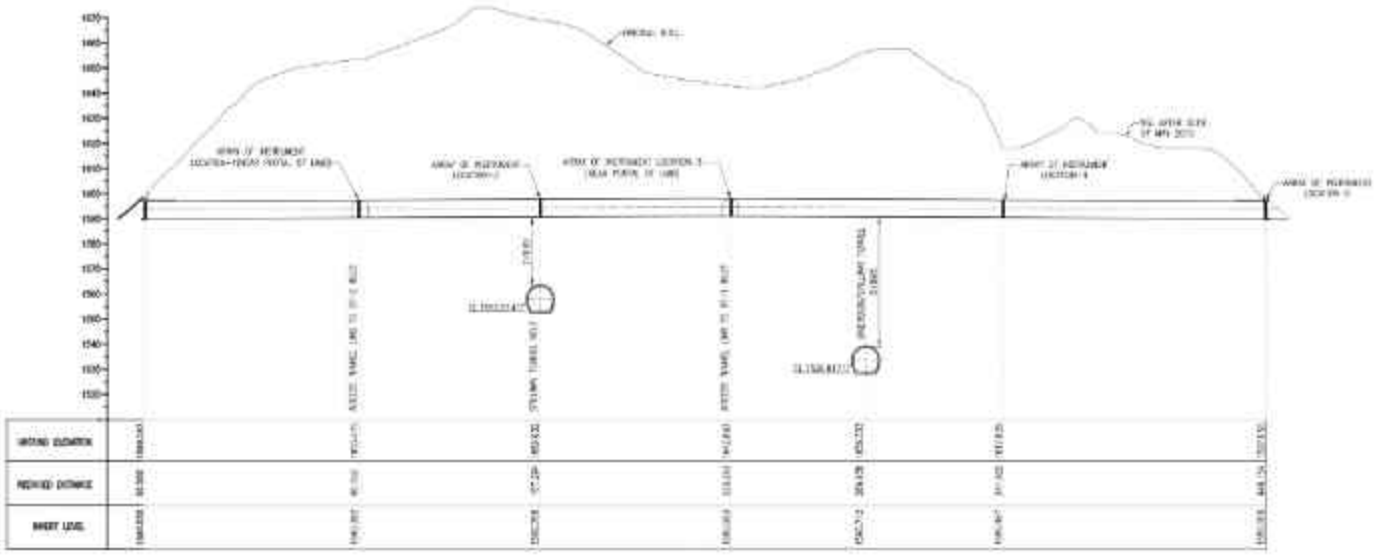
DRAWN :	KANANYA	REVIEWED :	P.K.BARUAH
DESIGNED :	MEENA MAINA / MANOJ GUPTA	APPROVED :	TAJETO SETIA
DRAWING NO. :	T3-380-41-DD-027	REV NO. :	00
DATE :	JULY, 2010	ORIGINAL PRINT SIZE :	A1








ACCESS TUNNEL
ACCESS TUNNEL AND DIVERSION TUNNEL
DIVERSION TUNNEL
ARRAY OF INSTRUMENT LOCATION-1
ARRAY OF INSTRUMENT LOCATION-2
ARRAY OF INSTRUMENT LOCATION-3
ARRAY OF INSTRUMENTS LOCATION-4
ARRAY OF INSTRUMENTS LOCATION-5
SLOPED BOUNDARY
TEESTA RIVER
NOTES :-
REFERENCE DRAWING :-
FOR CONSTRUCTION
LEGENDS :-
SCALE 1:500
CLIENT : TEESTA URJA LIMITED
PROJECT : TEESTA STAGE-III H. E. PROJECT
DESIGNER : ENERGY INFRATECH PRIVATE LTD.
DRAWING : DAM COMPLEX INSTRUMENTATION AT LEFT BANK ACCESS TUNNEL AT EL 1590.00 INSTRUMENTATION FROM INSIDE THE TUNNEL PLAN
DRAWN : S.R.TAMANG
DESIGNED : P.K.SARKAR
CHECKED : MANOJ GUPTA
APPROVED : K. SETH
DRAWING NO : T3-280-41-00-240
REV NO :
DATE : JULY 2018
ORIGINAL PRINT SIZE : A1



L-SECTION ALONG ACCESS TUNNEL

NOTES:-

1. ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATIONS ARE IN METRES UNLESS OTHERWISE SPECIFIED.
2. SPRING AND LOAD CELLS AS SHOWN IN THE DRAWING SHALL BE INSTALLED AS PER MANUFACTURER'S RECOMMENDATION AND AS SPECIFIED IN T.S.
3. UNDERSIZED HOLE OF THE INSTRUMENTS MAY GET DAMAGED DUE TO BLASTING OR SHOTCRETE THIS SHALL BE AVOIDED AND THE ROCK HAS COATED WITH 5 MLD STEEL PLATE, IF NECESSARY.
4. ANY DRILLS SHALL BE PROVIDED TO ROCK BOLT THE BOLT SHALL BE GREY ANCHORED AND TENSIONED IN 5 TONNES AND SHALL NOT BE FULLY GROUTED.
5. LOCATION OF INSTRUMENTS MAY REQUIRE MODIFICATIONS BY THE ENGINEER-IN-CHARGE DEPENDING ON SITE CONDITION.
6. THE READING OF THE INSTRUMENTS SHALL BE OBSERVED DURING CONSTRUCTION AND DATA BE ANALYSED AND SUBMITTED TO THE ENGINEER-IN-CHARGE. FREQUENCY OF READING MAY BE DECREASED BY ENGINEER-IN-CHARGE AS PER SCHEDULE SHALL FOLLOWING.
7. NECESSARY PRECAUTIONS SHALL BE TAKEN DURING AND AFTER TUNNEL EXCAVATION TO ISOLATE THE INSTALLED INSTRUMENTS SO AS NOT GET DAMAGED.
8. THE INSTRUMENTS DAMAGED DURING CONSTRUCTION SHALL BE REPLACED IMMEDIATELY.
9. ACCESSIBILITY MEASURES TO TAKE THE READING OF INSTRUMENTS AT ALL LOCATIONS SHALL BE PROVIDED.
10. REFER LATEST REVISIONS OF REFERENCE DRAWING.

REFERENCE DRAWING :-

1. T3-000-A-00-175 DAM COMPLEX, LEFT BANK ACCESS TUNNEL, PLAN.
2. T3-DAC-41-00-176 DAM COMPLEX, LEFT BANK ACCESS TUNNEL, L-SECTION.
3. T3-DAC-41-00-177 DAM COMPLEX, LEFT BANK ACCESS TUNNEL AND ACCESS LINE JUNCTION LEVEL AT EL 1590.00
4. T3-DAC-41-00-178 DAM COMPLEX, LEFT BANK ACCESS TUNNEL ACCESS TUNNEL LINE-1 TO [illegible]
5. T3-DAC-41-00-216 DAM COMPLEX INSTRUMENTATION AT LEFT BANK ACCESS TUNNEL EL 1590.00 INSTRUMENTATION FROM INSIDE THE TUNNEL PLAN.

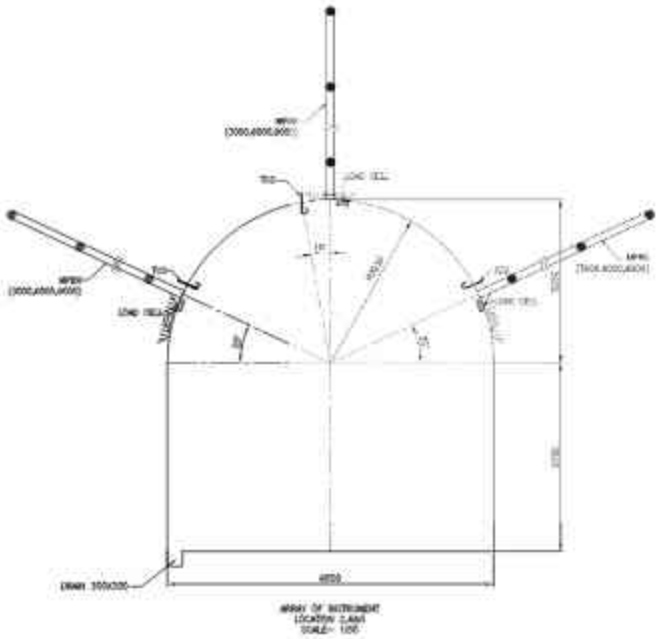
FOR CONSTRUCTION

LEGENDS :-

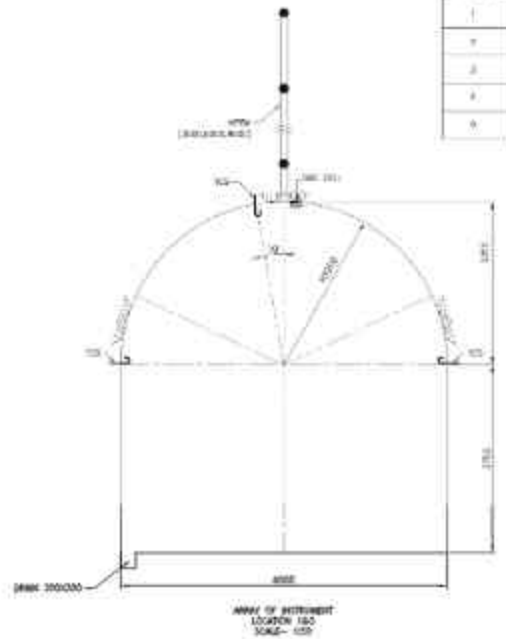
- MPBX — MULTI POINT BOREHOLE EXTENSOMETER
- LC — LOAD CELL
- TPC — TAPE CONVERGENCE STUD

SCALE 1:1000

SCALE 1:50



ARRAY OF INSTRUMENT LOCATION CLARA SCALE:- 1:50



ARRAY OF INSTRUMENT LOCATION 180 SCALE:- 1:50

INSTRUMENTS LOCATION	R.D. IN METRES	MPBX	LOAD CELL (LC)	TAPE CONVERGENCE (TPC) STUD	REMARKS
1	85.15	1	1	3	NEAR PORTAL OF ACCESS TUNNEL LINE TO [illegible]
2	117.284	2	2	3	IN ACCESS TUNNEL
3	273.043	1	1	3	NEAR PORTAL OF ACCESS TUNNEL LINE TO [illegible]
4	308.354	2	2	3	IN ACCESS TUNNEL
5	344.332	2	2	3	IN ACCESS TUNNEL
	TOTAL	10	10	15	

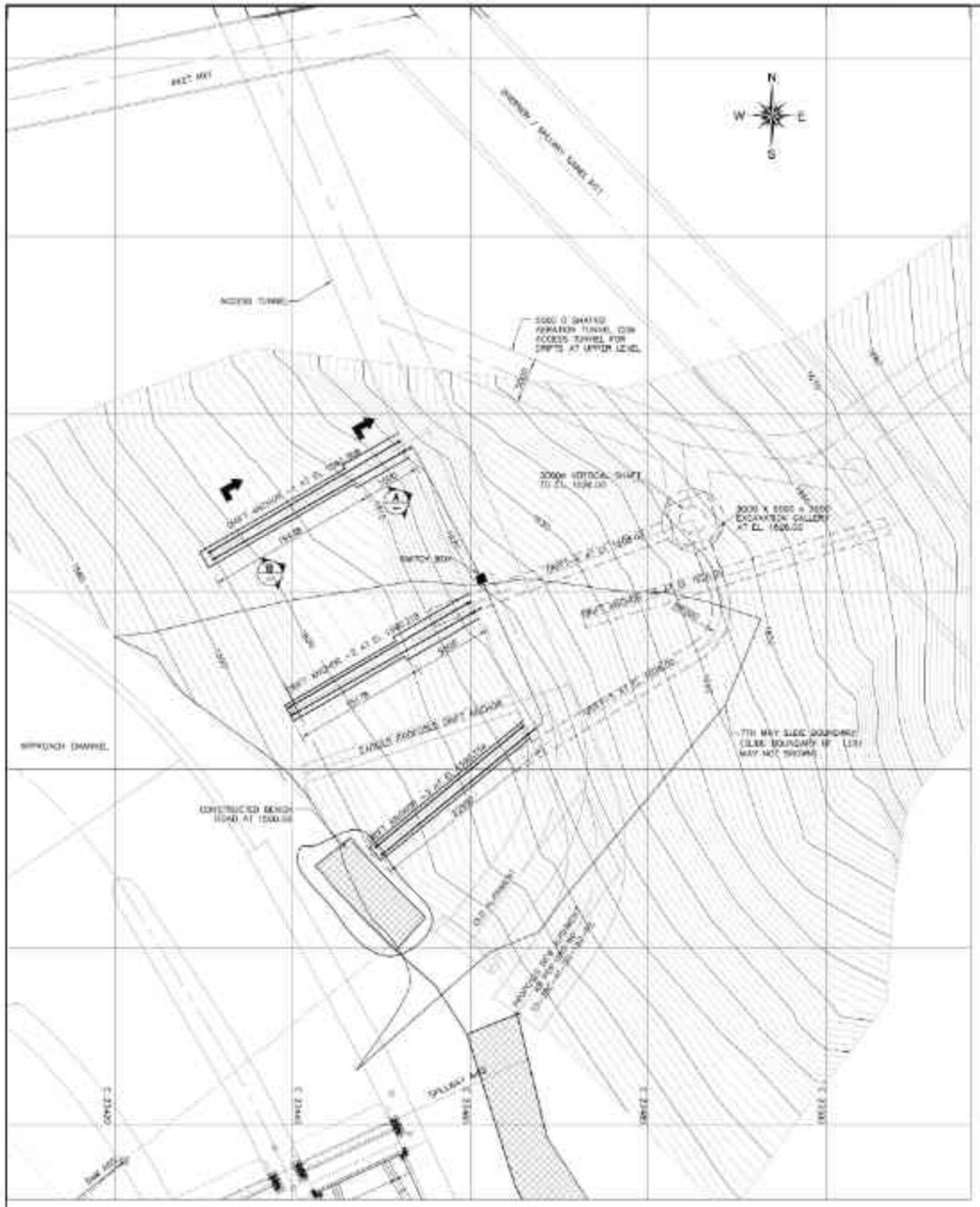
CLIENT : TEESTA URJA LIMITED

PROJECT : TEESTA STAGE-III H. E. PROJECT

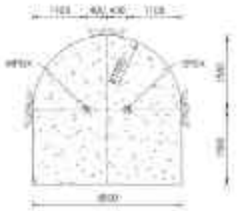
CONSULTANTS : ENERGY INFRATECH PRIVATE LTD.

DRAWING : DAM COMPLEX
INSTRUMENTATION AT LEFT BANK
ACCESS TUNNEL AT EL 1590.00
INSTRUMENTATION FROM INSIDE THE TUNNEL
SECTIONS

DRAWN : R.K.THAPLIYA	REVIEWED : P.K.SAHOO
DESIGNED : REKHA BAWRI, MANTU GUPTA	APPROVED : K. SETHI
DRAWING NO. : T3-28C-41-00-241	REV NO. : 00
DATE : JULY 2010	ORIGINAL PRINT SIZE : A1



SECTIONAL PLAN AT EL 1590.00
(SCALE 1:250)

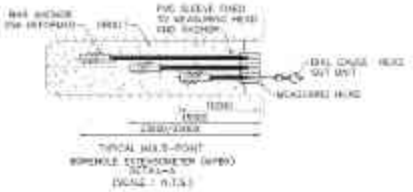


TYPICAL SECTION A
(DRIFT ANCHORS - 1.5)
(SCALE - 1:50)

TYPICAL SECTION B
(DRIFT ANCHORS - 2.5)
(SCALE - 1:50)

LOCATION, NUMBER, APPX. ELEVATION AND DESCRIPTION OF INSTRUMENTS

LOCATION	NO. OF MPBX	NO. OF SPBX	ELEVATION (APPX.)	DESCRIPTION
DRIFT NO.(1B-1)	1	1	1590.0	MPBX-1(7.5M,15M,30M) SPBX-1(2.5M)
DRIFT NO.(1B-2)	1	1	1591.0	MPBX-1(7.5M,15M,30M) SPBX-1(2.5M)
DRIFT NO.(2K-1)	1	1	1591.0	MPBX-1(7.5M,15M,30M) SPBX-1(2.5M)



NOTES:-

1. THIS DRAWING IS VALID FOR INSTRUMENTATION IN DRIFT ANCHOR AT EL 1590.
2. ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.
3. MPBX AND SPBX SHALL BE PROVIDED AT SHOWN FURTHEST DETAIL SHALL BE DEVELOPED BY INSTRUMENT SUPPLIER/CONTRACTOR.
4. MEASURING HEAD OF ALL INSTRUMENTS MAY BE DAMAGED DUE TO CONSTRUCTION ACTIVITY, ALL SAME SHALL BE PROTECTED WITH ROCK AND COVERED WITH A MILD STEEL PIPE, IF REQUIRED.
5. THE READING OF THE INSTRUMENTS SHALL BE OBSERVED DURING CONSTRUCTION AND DATA BE ANALYZED AND SUBMITTED TO THE ENGINEER-IN-CHARGE. FREQUENCY OF READINGS MAY BE DECREASED BY ENGINEER-IN-CHARGE OR KEEPING STABLE READINGS.
6. REFER LATEST REVISION FOR REFERENCE DRAWING.

REFERENCE DRAWING :-

1.13-000-41-00-140	DAM COMPLEX-INSTRUMENTATION AT LEFT BANK - LEFT BANK ACCESS TUNNEL AT EL.1590 - INSTRUMENTATION FROM INSIDE THE TUNNEL - PLAN.
2.13-000-41-00-141	DAM COMPLEX- INSTRUMENTATION AT LEFT BANK - LEFT BANK ACCESS TUNNEL AT EL.1590 - INSTRUMENTATION FROM INSIDE THE TUNNEL - SECTION.
3.13-000-41-00-302	DAM COMPLEX-LAND SLIDE TREATMENT NEAR CHUTE SPILLWAY APPROACH CHANNEL-DRIFT ANCHORS @ VERTICAL SHAFT-EXCAVATION & ROCK SUPPORT-TYPICAL DETAILS
4.13-000-41-00-303	DAM COMPLEX-LAND SLIDE TREATMENT NEAR CHUTE SPILLWAY APPROACH CHANNEL-DRIFT ANCHORS-GENERAL ARRANGEMENT- PLAN AT EL.1590.00
5.13-000-41-00-307	DAM COMPLEX-LAND SLIDE TREATMENT NEAR CHUTE SPILLWAY APPROACH CHANNEL-DRIFT ANCHORS-GENERAL ARRANGEMENT- PLAN AT EL.1626.00
6.13-000-41-00-308	DAM COMPLEX-LAND SLIDE TREATMENT NEAR CHUTE SPILLWAY APPROACH CHANNEL-DRIFT ANCHORS-GENERAL ARRANGEMENT- PLAN AT EL.1600.00
7.13-000-41-00-309	DAM COMPLEX-LAND SLIDE TREATMENT NEAR CHUTE SPILLWAY APPROACH CHANNEL-DRIFT ANCHORS-GENERAL ARRANGEMENT- SECTIONS.
8.13-000-41-00-310	DAM COMPLEX-LAND SLIDE TREATMENT NEAR CHUTE SPILLWAY APPROACH CHANNEL-DRIFT ANCHORS-1 & 2 REINFORCEMENT DETAILS.

FOR CONSTRUCTION

SCALE: 1:250
0 2.5 5 7.5 10 12.5 25 37.5 m

SCALE: 1:50
0 0.5 1 1.5 2 2.5 5 7.5 m

CLIENT :
TEESTA URJA LIMITED

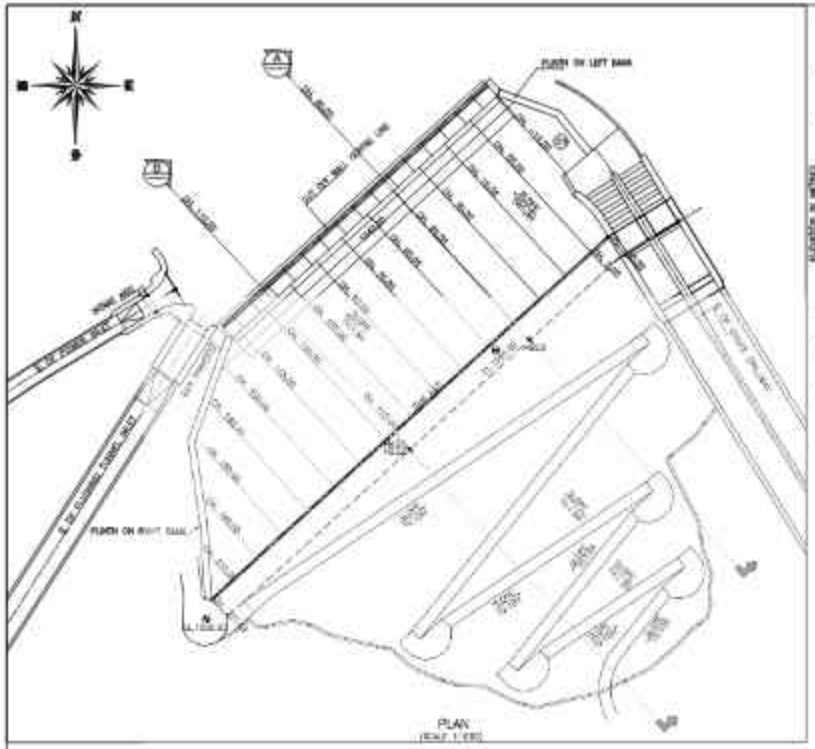
PROJECT :
TEESTA STAGE-III H. E. PROJECT

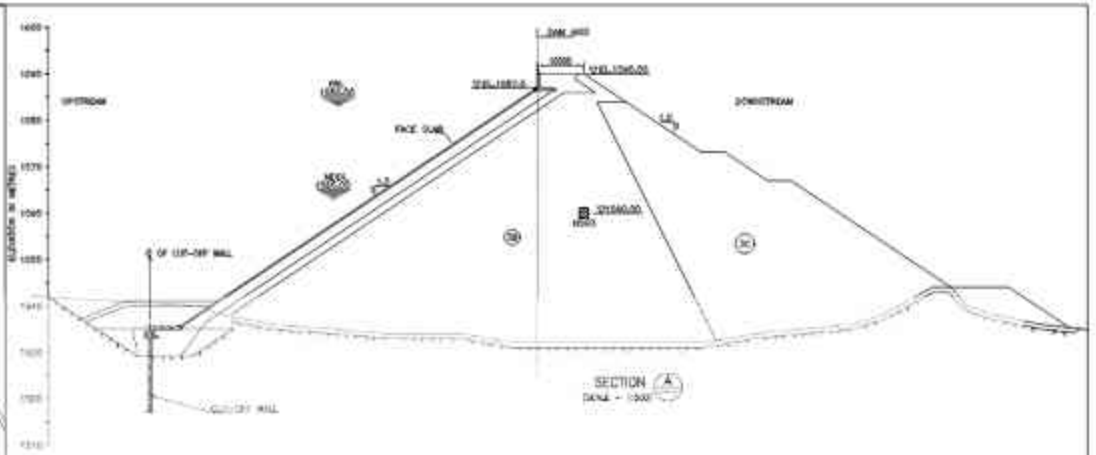
DESIGNERS :
ENERGY INFRATECH PRIVATE LTD.

DRAWING :
DAM COMPLEX
INSTRUMENTATION AT LEFT BANK
LEFT BANK SLIDE TREATMENT
DRIFT ANCHORS AT EL.1590.

DRAWN :	...SINGH	REVIEWED :	P.K.SAHOO
DESIGNED :	REENA SAHU, M.K.GUPTA	APPROVED :	R. SETH
DRAWING NO :	T3-280-41-00-312	REV NO :	R1
DATE :	AUG 2010	ORIGINAL PRINT SIZE :	A1

~~AR2~~





NOTES :-

1. ALL DIMENSIONS ARE IN MILLIMETERS & ELEVATIONS IN METERS UNLESS OTHERWISE SPECIFIED.
2. THIS DRAWING IS VALID FOR INSTRUMENTATION SCHEME OF HYDRAULIC SETTLEMENT GAUGE.
3. INSTALLATION DETAILS OF HYDRAULIC SETTLEMENT GAUGES FROM THE MANUFACTURER/SUPPLIER SHALL BE SUBMITTED TO ENGINEER-IN-CHARGE FOR APPROVAL.
4. BENCH MARK/DATUM IS THE LOCATION OF INSTRUMENTS SHOWN BUT IS NOT IN SITE INSTALLATION.
5. MONITORING FREQUENCY SHALL BE CONSULTED BY THE ENGINEER-IN-CHARGE.
6. FULL DETAILS OF THE TESTING PROCEDURE IN CASE ANY TECHNICAL DIFFICULTIES SHALL BE PROVIDED BY MANUFACTURER / CONTRACTOR AND SHALL BE SUBJECTED TO ENGINEER-IN-CHARGE'S APPROVAL.
7. FOR LOCATION OF INSTRUMENTS REQUIRED TO MONITOR DAM CONSTRUCTION, ELEVATION OF THE DAM SUCH AS JOINT MOVED , PIEZOMETER AND OVERALL SETTLEMENT POINTS SEPARATE DRAWINGS SHALL BE REFERRED.
8. REFER LATEST REVISION FOR REFERENCE DRAWINGS.

REFERENCE DRAWING :-

1. [illegible] DAM COMPLEX, CONCRETE FACE ROCK FILL DAM, GENERAL ARRANGEMENT, PLAN.
2. [illegible] DAM COMPLEX, CONCRETE FACE ROCK FILL DAM, GENERAL ARRANGEMENT, SECTION ON CHAINAGE [illegible]
3. [illegible] DAM COMPLEX, CONCRETE FACE ROCK FILL DAM, GENERAL ARRANGEMENT, L-SECTION.

FOR CONSTRUCTION

SCALE 1:1000

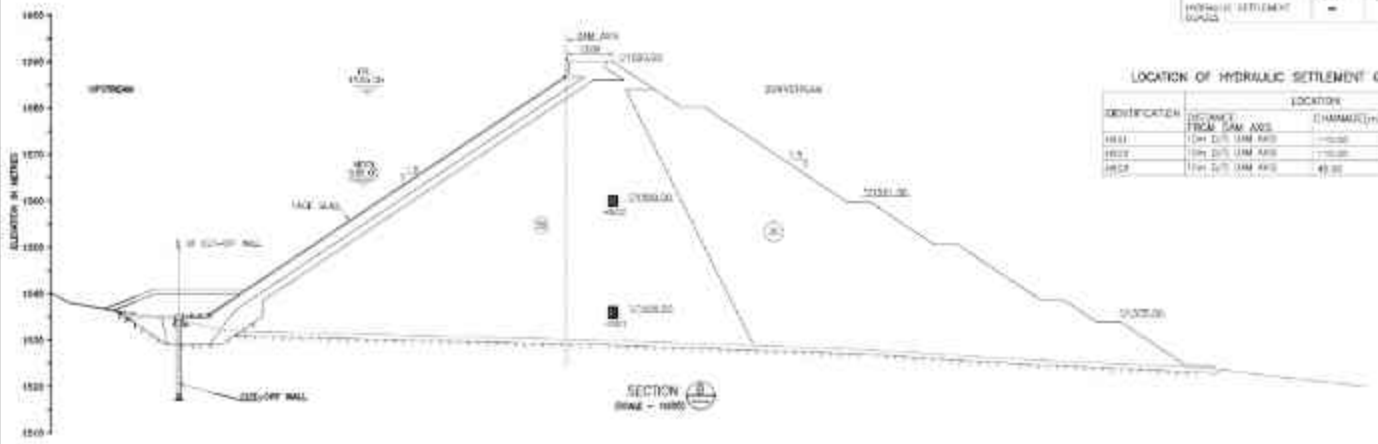
SCALE 1:1000

LEGEND:-

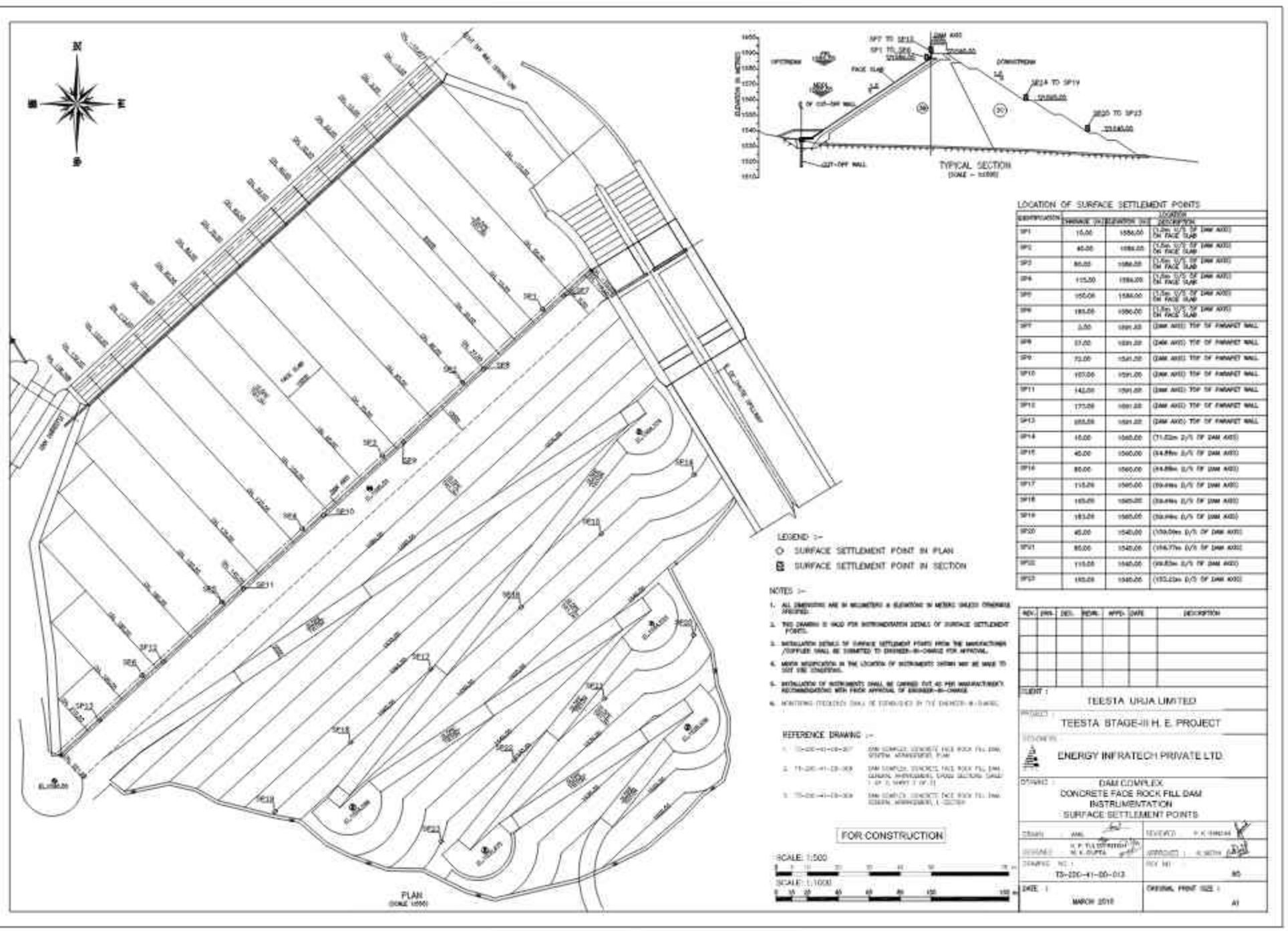
INSTRUMENT	SYMBOL PLAN	SYMBOL SECTION
HYDRAULIC SETTLEMENT GAUGE	⊕	■

LOCATION OF HYDRAULIC SETTLEMENT GUAGES

IDENTIFICATION	LOCATION DISTANCE FROM DAM AXIS	CHAINAGE(m)	ELEVATION(m)
HSG1	15m D/S DAM AXIS	[illegible]	[illegible]
HSG2	15m D/S DAM AXIS	[illegible]	[illegible]
HSG3	15m D/S DAM AXIS	45.00	[illegible]



CLIENT :	TEESTA URJA LIMITED
PROJECT :	TEESTA STAGE-III H. E. PROJECT
CONSULTANTS :	ENERGY INFRATECH PRIVATE LTD.
DRAWING :	DAM COMPLEX CONCRETE FACE ROCK FILL DAM INSTRUMENTATION HYDRAULIC SETTLEMENT GAUGE
DRAWN : [illegible]	REVIEWED : [illegible]
CHECKED : [illegible]	APPROVED : [illegible]
DRAWING NO : TD-200-41-00-012	REV NO : 1 R0
DATE : MARCH 2010	ORIGINAL PRINT SIZE : A1



LOCATION OF SURFACE SETTLEMENT POINTS

IDENTIFICATION	CHAINAGE (m)	ELEVATION (m)	LOCATION DESCRIPTION
SP1	15.00	1556.00	(1.2m U/S OF DAM AXIS) ON FACE SLAB
SP2	40.00	1556.00	(1.2m U/S OF DAM AXIS) ON FACE SLAB
SP3	80.00	1556.00	(1.2m U/S OF DAM AXIS) ON FACE SLAB
SP4	115.00	1556.00	(1.2m U/S OF DAM AXIS) ON FACE SLAB
SP5	150.00	1556.00	(1.2m U/S OF DAM AXIS) ON FACE SLAB
SP6	185.00	1556.00	(1.2m U/S OF DAM AXIS) ON FACE SLAB
SP7	3.50	1591.00	(DAM AXIS) TOP OF PARAPET WALL
SP8	37.00	1591.00	(DAM AXIS) TOP OF PARAPET WALL
SP9	72.00	1591.00	(DAM AXIS) TOP OF PARAPET WALL
SP10	107.00	1591.00	(DAM AXIS) TOP OF PARAPET WALL
SP11	142.00	1591.00	(DAM AXIS) TOP OF PARAPET WALL
SP12	177.00	1591.00	(DAM AXIS) TOP OF PARAPET WALL
SP13	205.00	1591.00	(DAM AXIS) TOP OF PARAPET WALL
SP14	15.00	1565.00	(71.02m D/S OF DAM AXIS)
SP15	45.00	1560.00	(54.89m D/S OF DAM AXIS)
SP16	80.00	1560.00	(44.89m D/S OF DAM AXIS)
SP17	115.00	1565.00	(59.44m D/S OF DAM AXIS)
SP18	165.00	1565.00	(59.44m D/S OF DAM AXIS)
SP19	183.00	1565.00	(59.44m D/S OF DAM AXIS)
SP20	45.00	1540.00	(109.09m D/S OF DAM AXIS)
SP21	85.00	1540.00	(104.77m D/S OF DAM AXIS)
SP22	115.00	1540.00	(99.83m D/S OF DAM AXIS)
SP23	165.00	1540.00	(103.23m D/S OF DAM AXIS)

REV.	BY	DES.	REVW.	APPD.	DATE	DESCRIPTION

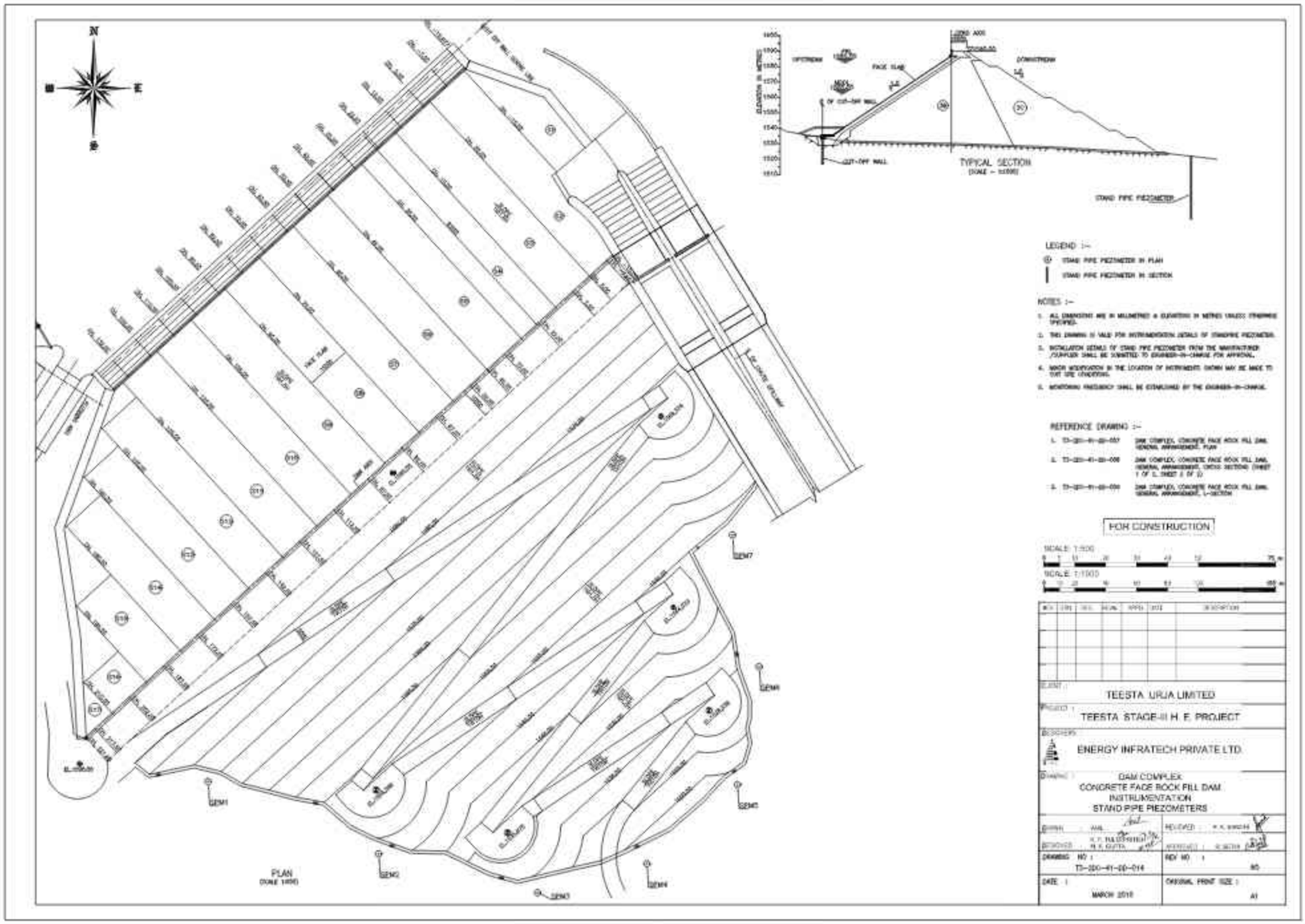
CLIENT : TEESTA URJA LIMITED

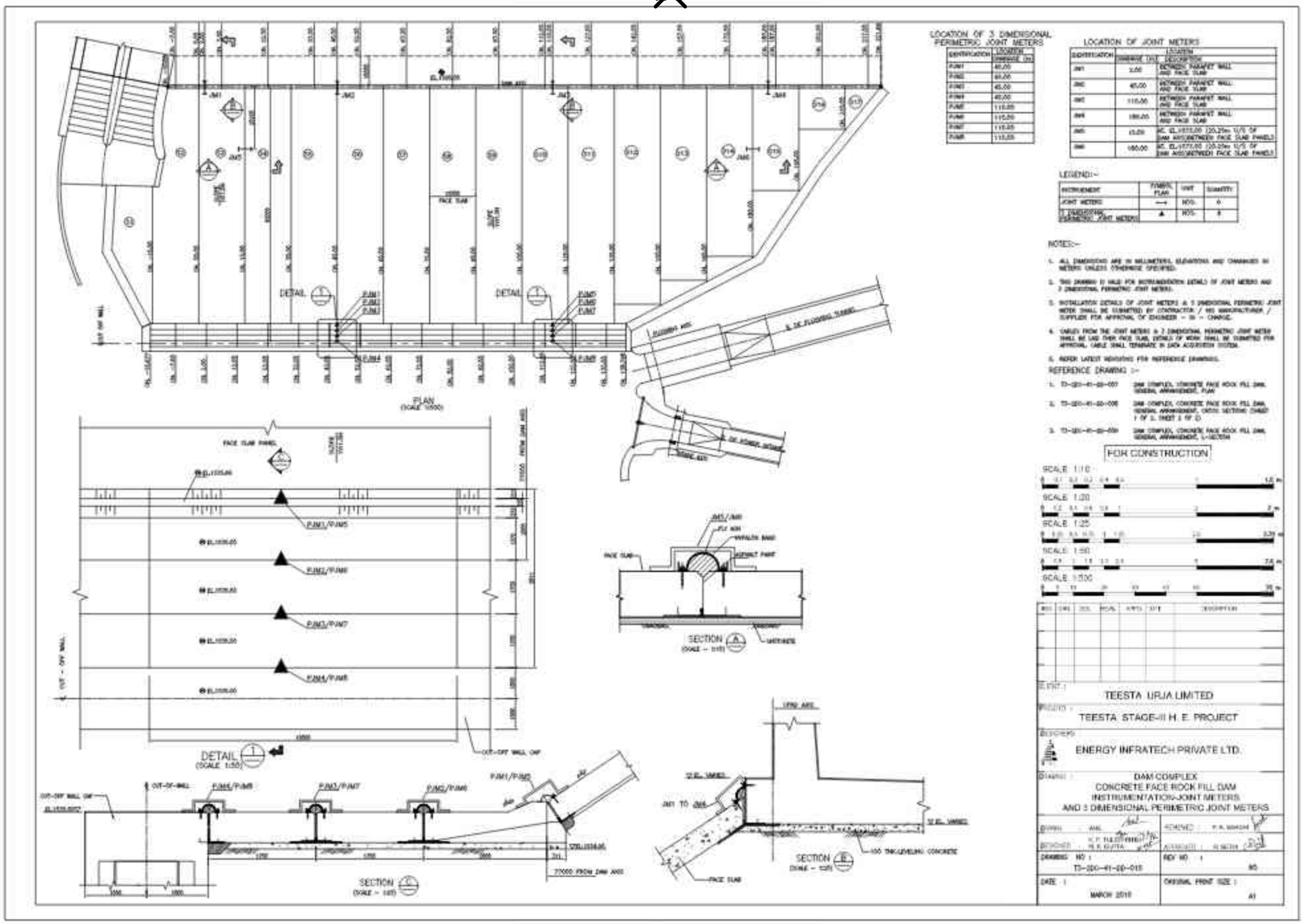
PROJECT : TEESTA STAGE-III H. E. PROJECT

CONSULTANT : ENERGY INFRATECH PRIVATE LTD.

DRAWING : DAM COMPLEX
CONCRETE FACE ROCK FILL DAM
INSTRUMENTATION
SURFACE SETTLEMENT POINTS

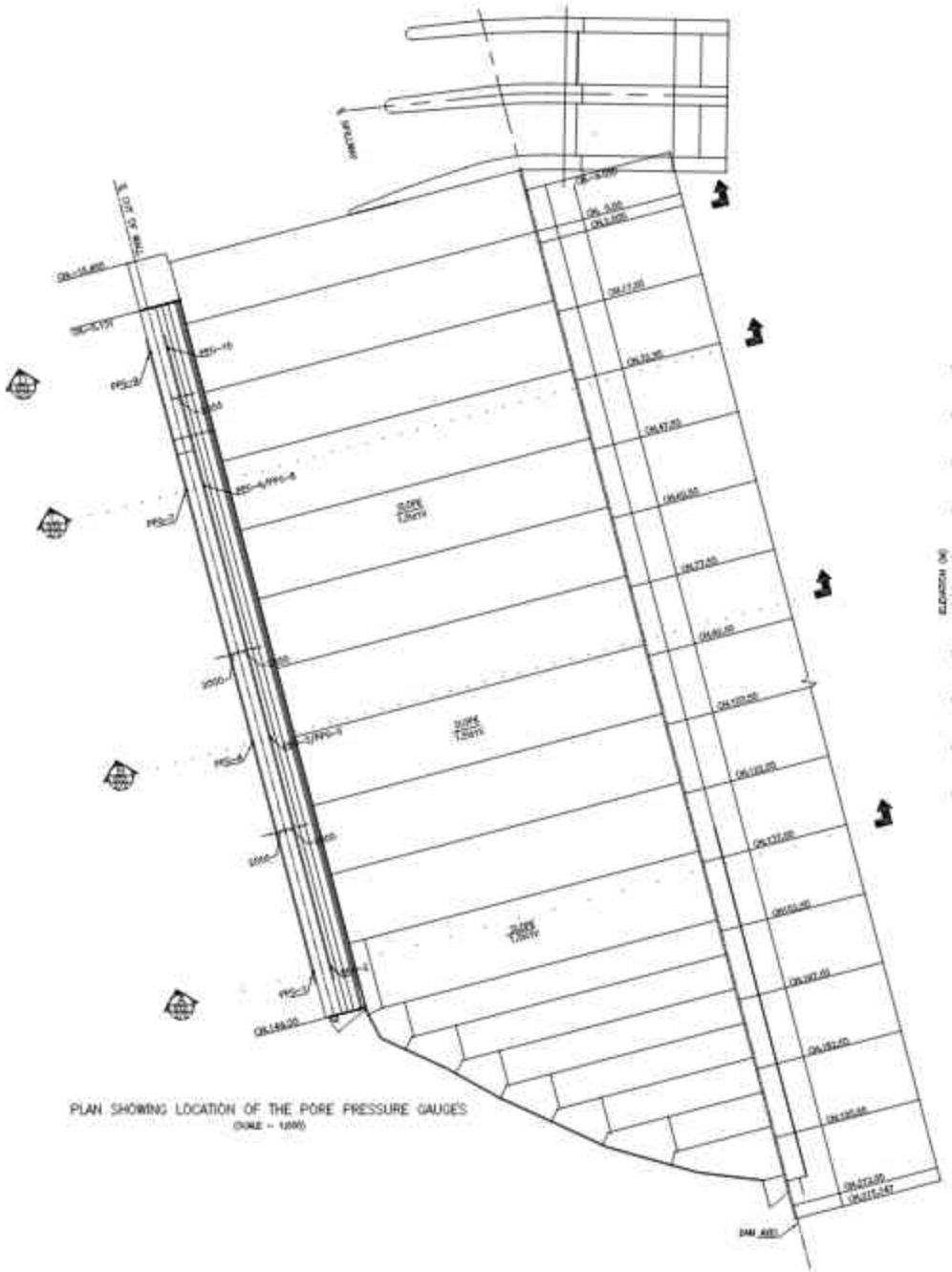
DRAWN :	ANIL	REVIEWED :	P. K. HARDIA
DESIGNED :	S. P. TULSYAN / M. K. GUPTA	APPROVED :	K. SETHI
DRAWING NO. :	TS-220-41-DD-013	REV. NO. :	R0
DATE :	MARCH 2010	ORIGINAL PRINT SIZE :	A1


N
W
E
S
PLAN
(SCALE 1:500)
TYPICAL SECTION
(SCALE – 1:1000)
CUT-OFF WALL
STAND PIPE PIEZOMETER
LEGEND :-
STAND PIPE PIEZOMETER IN PLAN
STAND PIPE PIEZOMETER IN SECTION
NOTES :-
1. ALL DIMENSIONS ARE IN MILLIMETRES & ELEVATIONS IN METRES UNLESS OTHERWISE SPECIFIED.
2. THIS DRAWING IS VALID FOR INSTRUMENTATION DETAILS OF STANDPIPE PIEZOMETER.
3. INSTALLATION DETAILS OF STAND PIPE PIEZOMETER FROM THE MANUFACTURER /SUPPLIER SHALL BE SUBMITTED TO ENGINEER-IN-CHARGE FOR APPROVAL.
4. MINOR MODIFICATION IN THE LOCATION OF INSTRUMENTS SHOWN MAY BE MADE TO SUIT SITE CONDITIONS.
5. MONITORING FREQUENCY SHALL BE ESTABLISHED BY THE ENGINEER-IN-CHARGE.
REFERENCE DRAWING :-
1. T3-000-41-00-007 DAM COMPLEX, CONCRETE FACE ROCK FILL DAM, GENERAL ARRANGEMENT, PLAN
2. T3-000-41-00-008 DAM COMPLEX, CONCRETE FACE ROCK FILL DAM, GENERAL ARRANGEMENT, CROSS SECTIONS (SHEET 1 OF 2, SHEET 2 OF 2)
3. T3-000-41-00-009 DAM COMPLEX, CONCRETE FACE ROCK FILL DAM, GENERAL ARRANGEMENT, L-SECTION
FOR CONSTRUCTION
SCALE 1:500
SCALE 1:1000
CLIENT :
TEESTA URJA LIMITED
PROJECT :
TEESTA STAGE-III H. E. PROJECT
ENGINEERS :
ENERGY INFRATECH PRIVATE LTD.
DRAWING :
DAM COMPLEX
CONCRETE FACE ROCK FILL DAM
INSTRUMENTATION
STAND PIPE PIEZOMETERS
DRAWN : AML
REVIEWED : R. K. SINGH
APPROVED : R. K. GUPTA
RECOMMENDED : K. SEN
DRAWING NO : T3-000-41-00-014
REV NO : R0
DATE : MARCH 2010
ORIGINAL PRINT SIZE : A1

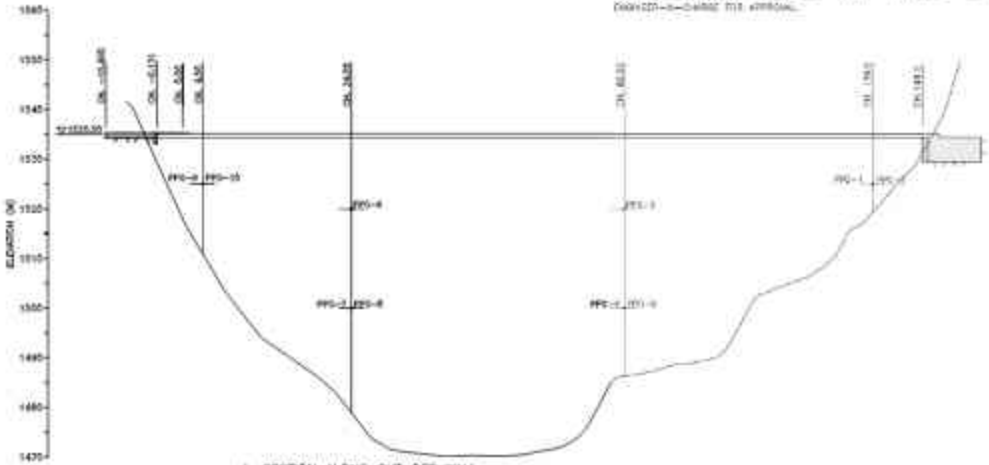

LOCATION OF 3 DIMENSIONAL PERIMETRIC JOINT METERS
LOCATION OF JOINT METERS
LEGEND:-
NOTES:-
1. ALL DIMENSIONS ARE IN MILLIMETERS, ELEVATIONS AND CHAINAGES IN METERS UNLESS OTHERWISE SPECIFIED.
2. THIS DRAWING IS VALID FOR INSTRUMENTATION DETAILS OF JOINT METERS AND 3 DIMENSIONAL PERIMETRIC JOINT METERS.
3. INSTALLATION DETAILS OF JOINT METERS & 3 DIMENSIONAL PERIMETRIC JOINT METER SHALL BE SUBMITTED BY CONTRACTOR / ME MANUFACTURER / SUPPLIER FOR APPROVAL OF ENGINEER - IN - CHARGE.
4. CABLES FROM THE JOINT METERS & 3 DIMENSIONAL PERIMETRIC JOINT METER SHALL BE LAID OVER FACE SLAB, DETAILS OF WORK SHALL BE SUBMITTED FOR APPROVAL. CABLE SHALL TERMINATE IN DATA ACQUISITION SYSTEM.
5. REFER LATEST REVISIONS FOR REFERENCE DRAWINGS.
REFERENCE DRAWING :-
FOR CONSTRUCTION
SCALE 1:10
SCALE 1:20
SCALE 1:25
SCALE 1:50
SCALE 1:500
PLAN
(SCALE 1:500)
DETAIL
(SCALE 1:50)
SECTION
(SCALE - 1:10)
SECTION
(SCALE - 1:20)
SECTION
(SCALE - 1:25)
TEESTA URJA LIMITED
TEESTA STAGE-III H. E. PROJECT
ENERGY INFRATECH PRIVATE LTD.
DAM COMPLEX
CONCRETE FACE ROCK FILL DAM
INSTRUMENTATION-JOINT METERS
AND 3 DIMENSIONAL PERIMETRIC JOINT METERS
DRAWING NO :
T3-DDO-41-DD-015
REV NO :
DATE :
MARCH 2010
ORIGINAL PRINT SIZE :
A1

NOTES :-

1. ALL CHAINAGES ARE IN KILOMETERS AND ELEVATIONS ARE IN METERS.
2. THIS DRAWING IS VALID FOR INSTRUMENTATION DETAILS AT CUT-OFF WALL.
3. PORE PRESSURE GAUGES SHALL BE INSTALLED AFTER PLASTIC CONCRETE IN CUT OFF WALL HAS BEEN POURED BUT BEFORE INSTALLATION OF CUT OFF CAP.
4. CABLES FOR ALL PORE PRESSURE GAUGES SHALL BE TAKEN UP TO DAM TOP TO DATA ACQUISITION SYSTEM.
5. CABLES FOR PORE PRESSURE GAUGES PPS1,PPS3,PPS7 AND PPS9 SHALL BE LAID OVER FACE SLABS/TOE OF WHICH SHALL BE WORKED OUT BY CONTRACTOR IN CONSULTATION WITH INSTRUMENTS SUPPLIER FOR ENGINEER-IN-CHARGE'S APPROVAL.
6. CABLE FOR PORE PRESSURE GAUGES PPS2,PPS5,PPS6,PPS8,PPS10 AND PPS11 SHALL BE TAKEN UPTO DAM TOP THROUGH ZONE 2 MATERIAL DETAILS OF SUCH FABRICATION AND ALSO ITS CROSSING BELOW THE PLINTH PANEL AND SEQUENCE OF LAYING OF CABLE ETC SHALL BE WORKED OUT BY CONTRACTOR IN CONSULTATION WITH INSTRUMENTS SUPPLIER AND SHALL BE SUBMITTED TO EIC FOR APPROVAL.
7. ALL OTHER INSTALLATION DETAILS SHALL BE WORKED OUT BY THE CONTRACTOR/INSTRUMENTS SUPPLIER AND SUBMITTED TO ENGINEER-IN-CHARGE FOR APPROVAL.



PLAN SHOWING LOCATION OF THE PORE PRESSURE GAUGES
(SCALE - 1:500)



L-SECTION ALONG CUT OFF WALL
(SCALE - 1:500)

FOR CONSTRUCTION PURPOSE

SCALE 1:500

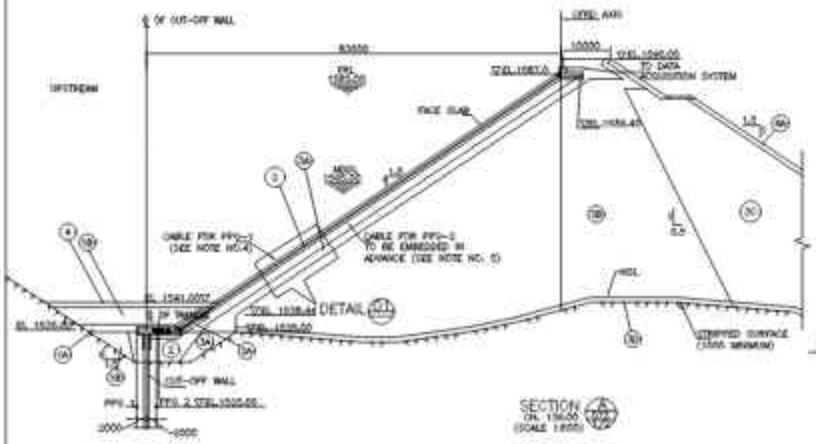
CLIENT : TEESTA URJA LIMITED

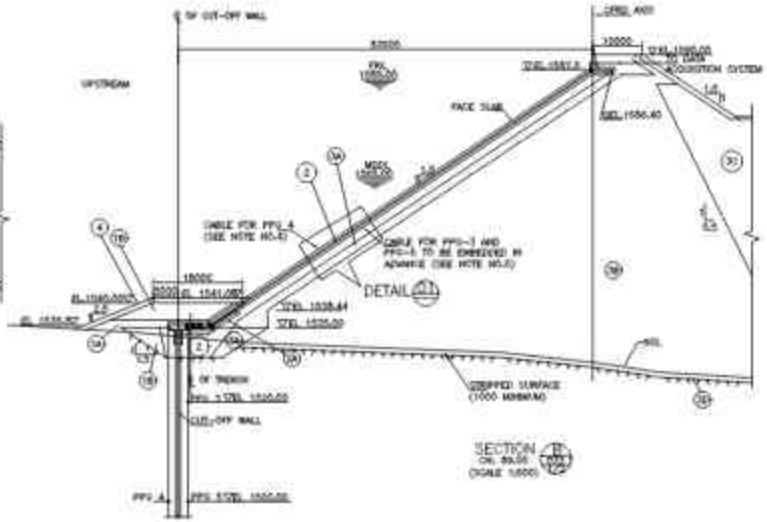
PROJECT : TEESTA STAGE-III H. E. PROJECT

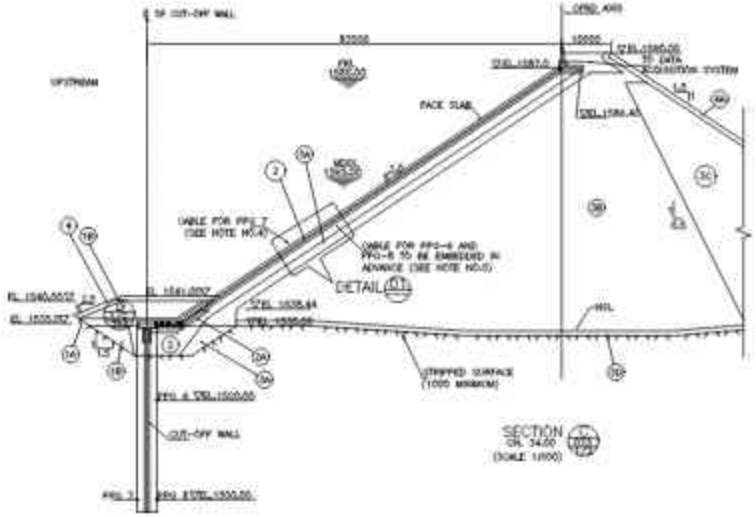
DESIGNER : ENERGY INFRATECH PRIVATE LTD.

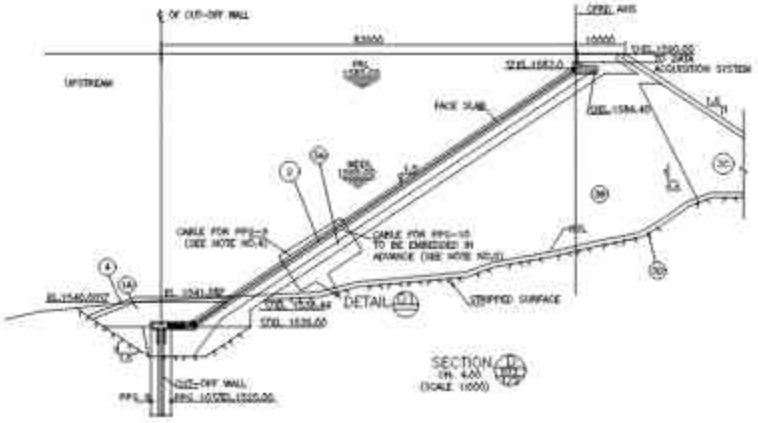
DRAWING : DAM COMPLEX
CONCRETE FACE ROCK FILL DAM
CUT-OFF - INSTRUMENTATION
PORE PRESSURE GUAGES
(SHEET 1 OF 3)

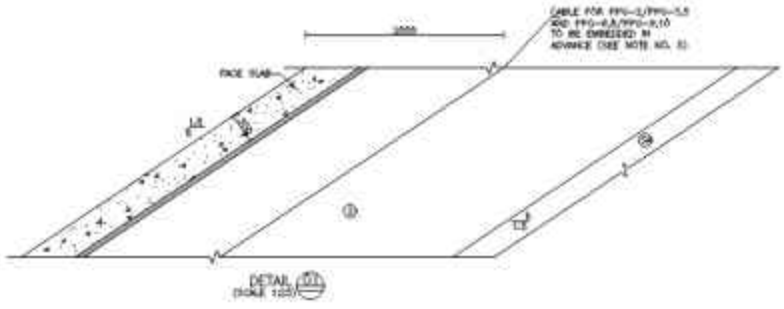
DRAWN :	MOHIT JAIN / KALPANA RANA	CHECKED :	R. K. SINGH
DESIGNED :	K. P. TULSI / M. K. GUPTA	APPROVED :	RAJEEV MEHTA
DRAWING NO. :	T3-SDC-41-00-073	REV NO. :	00
DATE :	NOV, 2011	ORIGINAL PRINT SIZE :	A0

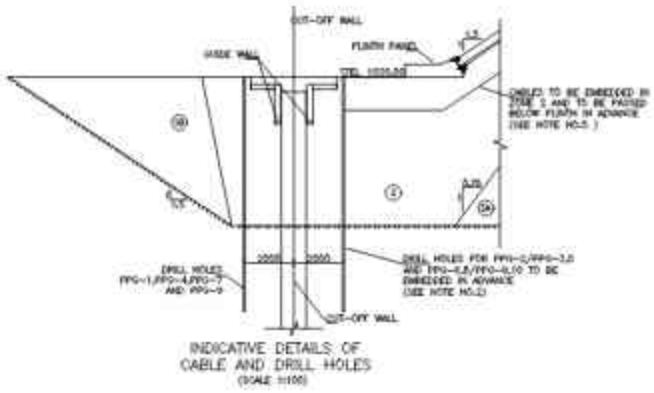












NOTES :-

1. ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATIONS ARE IN METERS.
2. PORE PRESSURE GAUGES SHALL BE INSTALLED AFTER PLASTIC CONCRETE IN CUT OFF WALL HAS BEEN PLACED AND BEFORE INSTALLATION OF CUT OFF CAP.
3. CABLES FOR ALL PORE PRESSURE GAUGES SHALL BE TAKEN UP TO DAM TOP TO DATA ACQUISITION SYSTEM.
4. CABLES FOR PORE PRESSURE GAUGES PPG-1/PPG-4/PPG-7 AND PPG-9 SHALL BE LAID UNDER FACE SLAB DETAILS OF WHICH SHALL BE FURNISHED BY CONTRACTOR IN CONSULTATION WITH SUBVENDORS SUPPLIER FOR ENGINEER-IN-CHARGE'S APPROVAL.
5. CABLES FOR PORE PRESSURE GAUGES PPG-2/PPG-3/PPG-5/PPG-6/PPG-8/PPG-10 AND PPG-11 SHALL BE TAKEN UPTO DAM TOP THROUGH ZONE 3 MATERIAL OUTSIDE OF SLOPE PROTECTION AND ALSO ITS CROSSING ALLOW THE PIPING AND WELDING IS LATER BE TAKEN OUT BY CONTRACTOR IN CONSULTATION WITH HEL INSTRUMENTS SUPPLIER AND SHALL BE SUBMITTED TO EIC FOR APPROVAL.
6. ALL OTHER INSTALLATION DETAILS SHALL BE WORKED OUT BY THE CONTRACTOR/INSTRUMENTS SUPPLIER AND SUBMITTED TO ENGINEER-IN-CHARGE FOR APPROVAL.
7. THIS DRAWING IS VALID FOR INSTALLATION UPTO EL. 1577 OF CUT-OFF WALL.

FOR CONSTRUCTION PURPOSE

SCALE: 1:500

SCALE: 1:100

SCALE: 1:25

REV.	DRN.	DES.	RVWR.	APPR.	DATE	DESCRIPTION

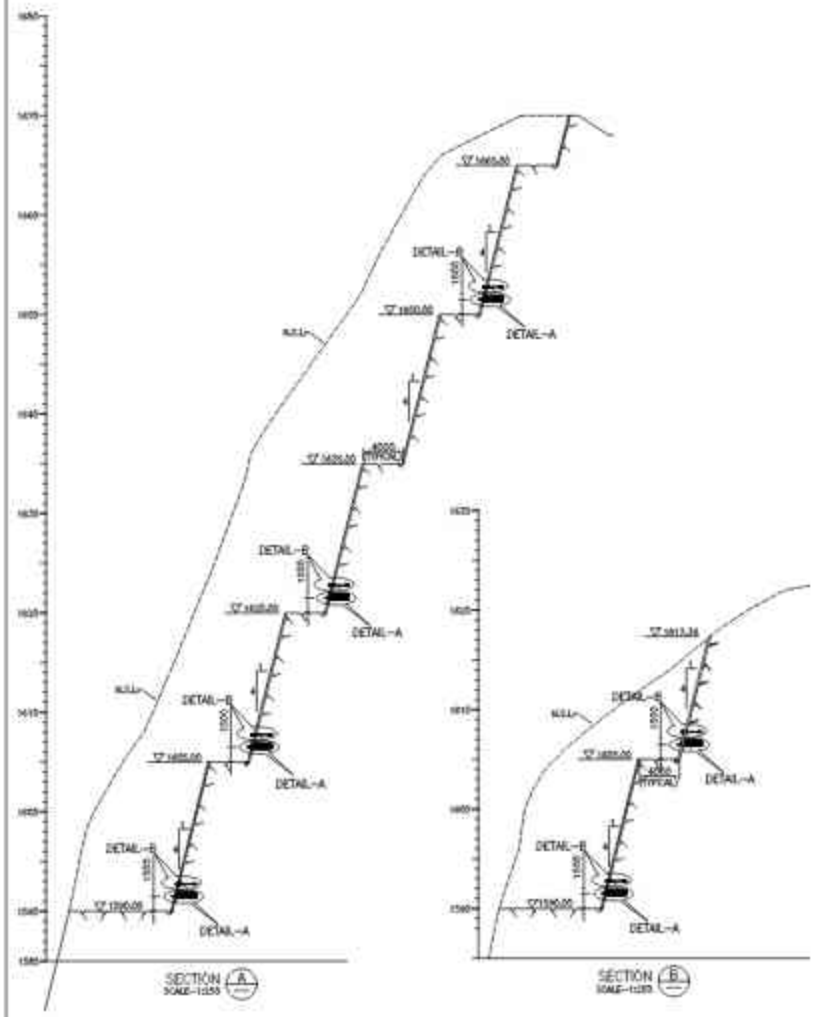
CLIENT : TEESTA URJA LIMITED

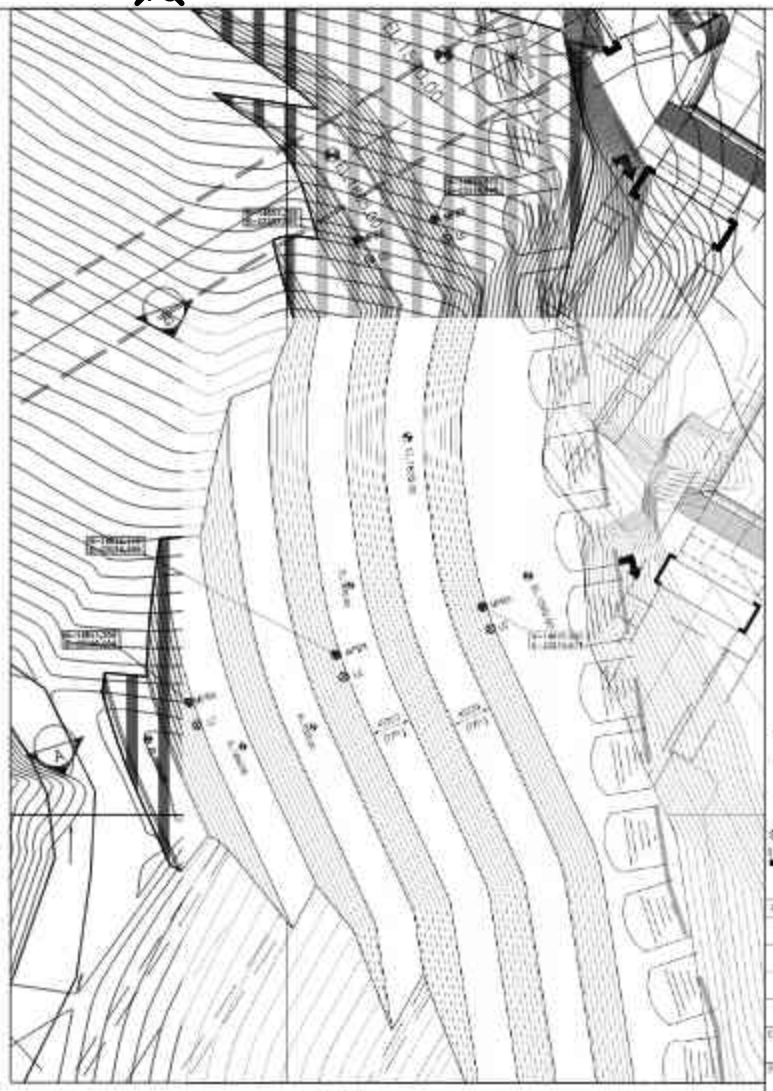
PROJECT : TEESTA STAGE-III H. E. PROJECT

DESIGNERS : ENERGY INFRATECH PRIVATE LTD.

DRAWING : DAM COMPLEX
CONCRETE FACE ROCK FILL DAM
CUT-OFF WALL - INSTRUMENTATION
PORE PRESSURE GUAGES

DRAWN :	BIDYUT / KALPANA RANA	CHECKED :	R.K. SINGH
DESIGNED :	K. P. TULSI / R.K. GUPTA	APPROVED :	RAJEEV SETHI
DRAWING NO :	T3-SDC-41-00-073	REV NO :	00
DATE :	NOV 2011	ORIGINAL PRINT SIZE :	A0





NOTES:-

1. ALL DIMENSIONS ARE IN MILLIMETRES & ELEVATIONS IN METRES UNLESS OTHERWISE SPECIFIED.
2. MPBX AND LOAD CELLS AS SHOWN IN THE DRAWING SHALL BE INSTALLED AS PER MANUFACTURER'S REQUIREMENT AND AS SPECIFIED IN T.S.
3. MEASURING HEAD FOR THE INSTRUMENT MAY GET DAMAGED DUE TO BLASTING OR SHOTCRETE. THE SAME BE RECESSED INTO THE ROCK AND COVERED WITH A MILD STEEL PLATE IF NECESSARY.
4. LOAD CELLS SHALL BE PROVIDED ON ROCK BOLT. THE BOLT SHALL BE ONLY ANCHORED AND TENSIONED TO 5 TONNES AND SHALL NOT TO BE FILL GROUTED.
5. LOCATION OF INSTRUMENTS MAY REQUIRE MODIFICATIONS BY THE ENGINEER-IN-CHARGE TO SUIT SITE CONDITIONS.
6. THE READING OF THE INSTRUMENTS SHALL BE OBSERVED DURING CONSTRUCTION AND DATA BE ANALYSED AND SUBMITTED TO THE ENGINEER-IN-CHARGE. FREQUENCY OF READING MAY BE DECREASED BY ENGINEER-IN-CHARGE ON ACHIEVING STABLE READINGS.
7. NECESSARY PRECAUTIONS SHALL BE TAKEN DURING AND AFTER EXCAVATION TO ENSURE THAT ISTALLED INSTRUMENTS DO NOT GET DAMAGED.
8. THE INSTRUMENTS DAMAGE DURING CONSTRUCTION SHALL BE REPLACED IMMEDIATELY.
9. ACCESSIBILITY ARRANGED TO TAKE THE READING OF INSTRUMENTS AT ALL LOCATIONS SHALL BE PROVIDED.

LEGENDS :-

REFERENCE DRAWING :-

1. T3-200-41-DD-007 DAM COMPLEX, POWER INTAKE, EXCAVATION PLAN ABOVE EL.1590.00
2. T3-200-41-DD-008 DAM COMPLEX, POWER INTAKE, EXCAVATION SECTIONS ABOVE EL.1590.00

SCALE: 1:250

REV.	BY	CHKD.	SUB.	APPR.	DATE	DESCRIPTION

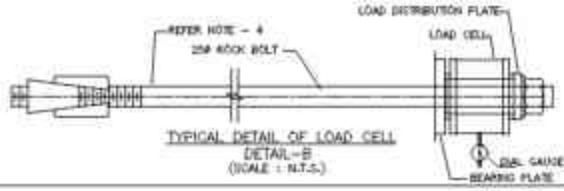
CLIENT :
TEESTA URJA LIMITED

PROJECT :
TEESTA STAGE-III H. E. PROJECT

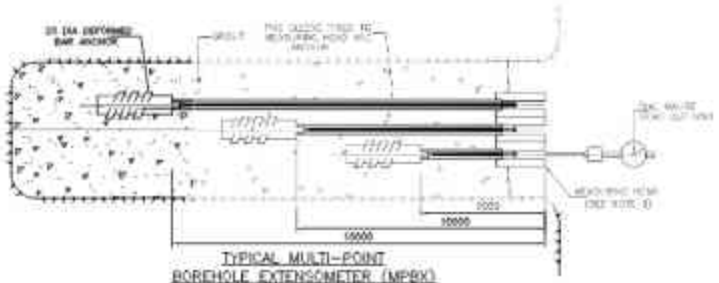
CONSULTANT :
ENERGY INFRATECH PRIVATE LTD.

DRAWING :
DAM COMPLEX
POWER INTAKE
EXCAVATION ABOVE EL. 1590.00
INSTRUMENTATION

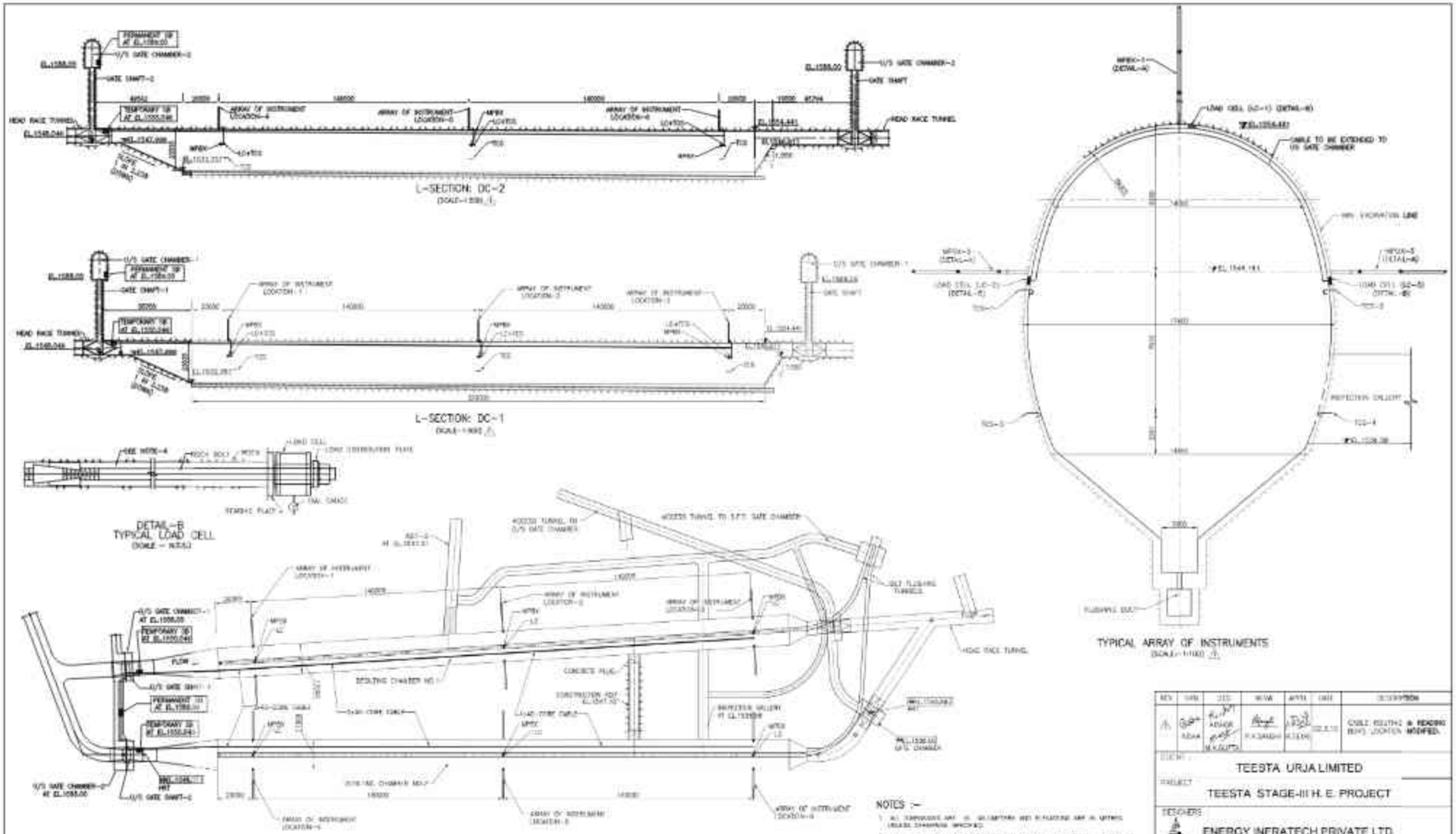
DESIGN :	PRAMA DHAR	RECOMMENDED :	R. SETH
DESIGNED :	REENA RANA	APPROVED :	V.V. BASAREKAR/A.P.
CHECKED :	M. K. GUPTA		
DRAWING NO. :	T3-200-41-DD-009	REV NO. :	R0
DATE :	JAN. 2009	ORIGINAL PRINT SIZE :	A1

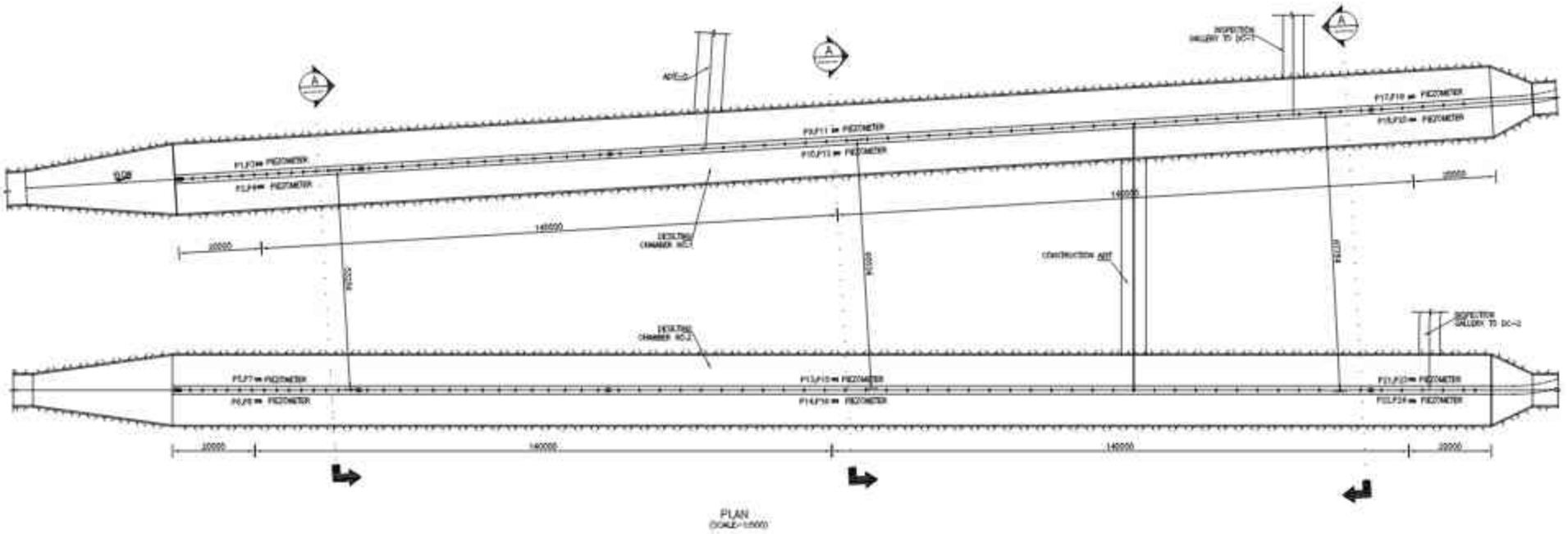


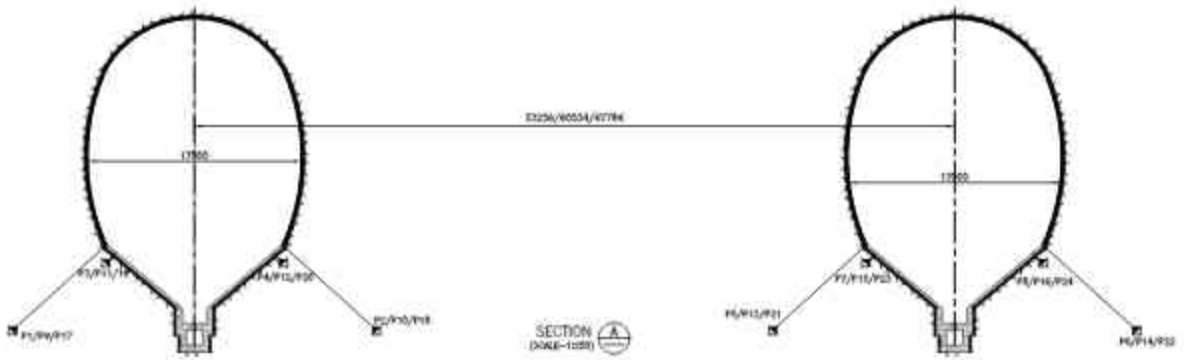
TYPICAL DETAIL OF LOAD CELL
DETAIL-B
(SCALE : N.T.S.)



TYPICAL MULTI-POINT
BOREHOLE EXTENSOMETER (MPBX)
DETAIL-A (SCALE : N.T.S.)


L-SECTION: DC-2
L-SECTION: DC-1
TYPICAL ARRAY OF INSTRUMENTS
DETAIL-B
TYPICAL LOAD CELL
PLAN
DETAIL-A
TYPICAL MULTI-POINT
BOREHOLE EXTENSOMETER (MPBX)
REFERENCE DRAWING :-
NOTES :-
TEESTA URJA LIMITED
TEESTA STAGE-III H. E. PROJECT
ENERGY INFRATECH PRIVATE LTD.
DESILTING CHAMBER (DC) COMPLEX
INSTRUMENTATION IN CENTRAL BASINS
(PLAN & L-SECTION)
NOV.2009





NOTES :-

1. ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATIONS IN METERS.
2. READING OF INSTRUMENT SHALL BE TAKEN FROM THE APPROACHABLE LOCATION DURING OPERATION PHASE AS DIRECTED BY MANUFACTURE & ENGINEERING IN CHARGE.

REFERENCE DRAWING :-

1. T3-DHC-41-DD-001 DESILTING CHAMBER COMPLEX LAYOUT PLAN
2. T3-DHC-41-DD-002 DESILTING CHAMBER COMPLEX PLAN & L-SECTION
3. T3-DHC-41-DD-003 DESILTING CHAMBER COMPLEX CROSS SECTION
4. T3-DHC-41-DD-029 DESILTING CHAMBER COMPLEX INSTRUMENTATION IN CENTRAL BAYING (PLAN & SECTION).

LEGEND :-

PIEZOMETER

FOR CONSTRUCTION

SCALE 1:500

SCALE 1:200

DISTANCE FROM END OF U/S TRANSITION (METER)	DESILTING CHAMBER	NO. OF PIEZOMETER	REMARKS
20	DC-1	2+2=4	P1 & P2 EACH AT 10M DEPTH BENEATH THE CONCRETE FACE P3 & P4 EACH AT 1M DEPTH BENEATH THE CONCRETE FACE
	DC-2	2+2=4	P5 & P6 EACH AT 10M DEPTH BENEATH THE CONCRETE FACE P7 & P8 EACH AT 1M DEPTH BENEATH THE CONCRETE FACE
160	DC-1	2+2=4	P9 & P10 EACH AT 10M DEPTH BENEATH THE CONCRETE FACE P11 & P12 EACH AT 1M DEPTH BENEATH THE CONCRETE FACE
	DC-2	2+2=4	P13 & P14 EACH AT 10M DEPTH BENEATH THE CONCRETE FACE P15 & P16 EACH AT 1M DEPTH BENEATH THE CONCRETE FACE
300	DC-1	2+2=4	P17 & P18 EACH AT 10M DEPTH BENEATH THE CONCRETE FACE P19 & P20 EACH AT 1M DEPTH BENEATH THE CONCRETE FACE
	DC-2	2+2=4	P21 & P22 EACH AT 10M DEPTH BENEATH THE CONCRETE FACE P23 & P24 EACH AT 1M DEPTH BENEATH THE CONCRETE FACE
TOTAL NO.= 24			

CLIENT : TEESTA URJA LIMITED

PROJECT : TEESTA STAGE-III H. E. PROJECT

DESIGNERS : ENERGY INFRATECH PRIVATE LTD.

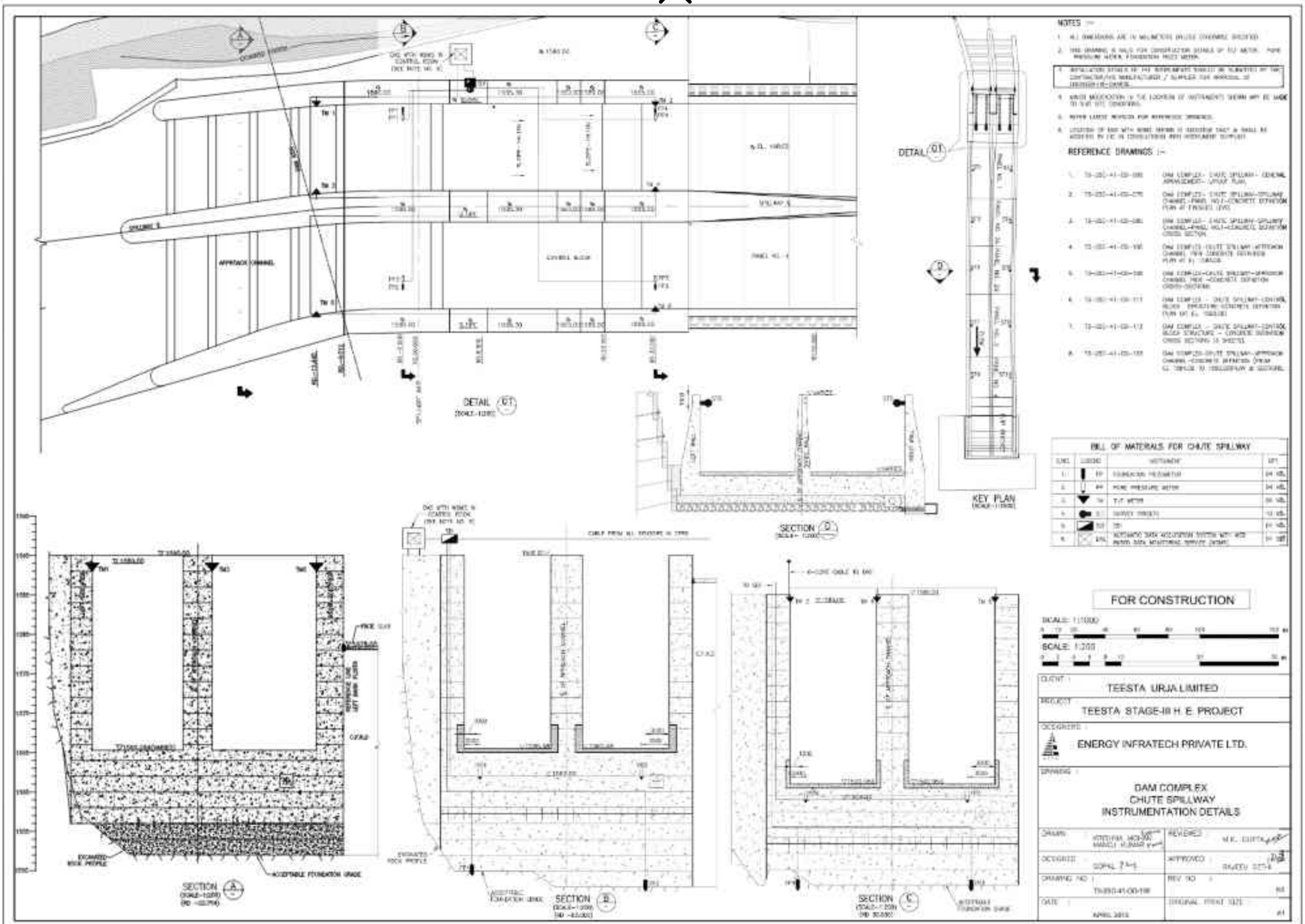
DRAWING : DESILTING CHAMBER COMPLEX
ADDITIONAL INSTRUMENTATION PIEZOMETER
PLAN AND SECTION

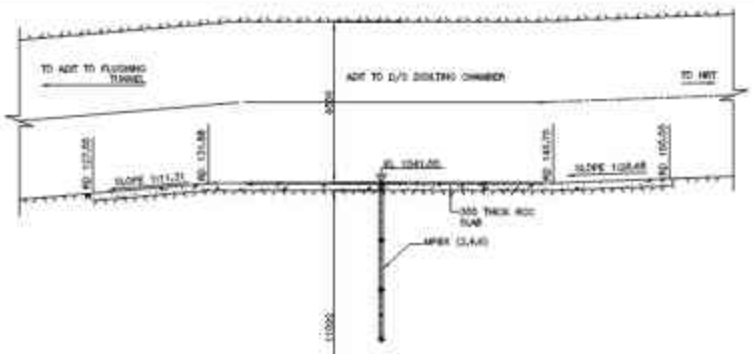
DRAWN : CHECKED/REVIEWED : M.K. GUPTA

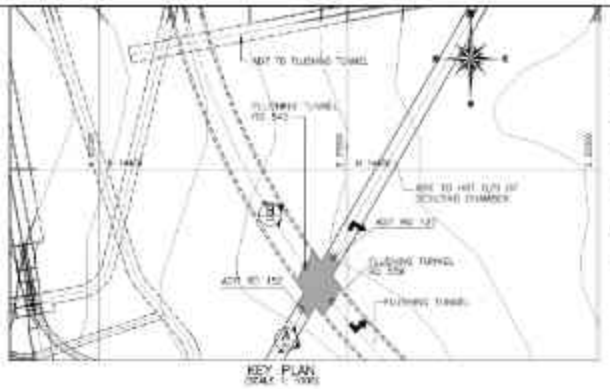
DESIGNED : APPROVED :

DRAWING NO. : T3-DHC-41-DD-003 REV. NO. : 00

DATE : JUNE,2012 ORIGINAL PRINT SIZE : A1

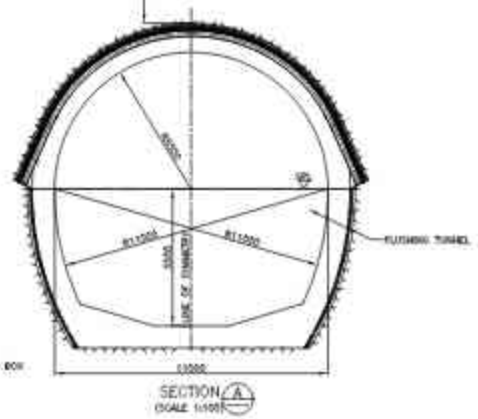

NOTES :-
REFERENCE DRAWINGS :-
DETAIL (D1)
KEY PLAN
SECTION (D)
SECTION (A)
SECTION (B)
SECTION (C)
BILL OF MATERIALS FOR CHUTE SPILLWAY
FOR CONSTRUCTION
SCALE: 1:1000
SCALE: 1:200
CLIENT :
TEESTA URJA LIMITED
PROJECT :
TEESTA STAGE-III H. E. PROJECT
DESIGNER :
ENERGY INFRATECH PRIVATE LTD.
DRAWING :
DAM COMPLEX
CHUTE SPILLWAY
INSTRUMENTATION DETAILS
DRAWN :
DESIGNED :
DRAWING NO. :
TS/DS1-41-00-108
REV NO. :
DATE :
APRIL 2013
REVIEWED :
APPROVED :
ORIGINAL PRINT SIZE :
A1

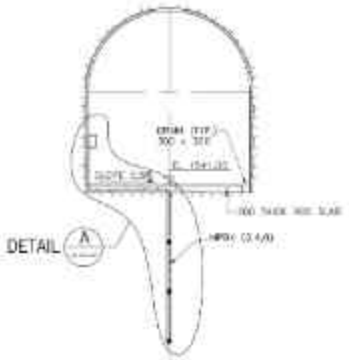




NOTES :-

1. ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATIONS ARE IN METRES UNLESS OTHERWISE SPECIFIED.
2. MPBX AS SHOWN IN THE DRAWING SHALL BE INSTALLED AS PER MANUFACTURER'S REQUIREMENT AND AS SPECIFIED IN TECHNICAL SPECIFICATION.
3. LOCATION OF INSTRUMENT MAY REQUIRE MODIFICATIONS BY THE ENGINEER-IN-CHARGE TO SUIT SITE CONDITIONS.
4. THE CHORD MAY BE PLACED IN THE CABLE CONDUIT THROUGH THE SPANDREL SLAB UPTO THE SIDE WALL AND CATENOIDE UPTO THE APPROPRIATE GAS LOCATION TO THE READING BOX.
5. THE READING OF THE INSTRUMENT SHALL BE OBTAINED DURING CONSTRUCTION AND DATA BE ANALYSED AND SUBMITTED TO THE ENGINEER-IN-CHARGE.
6. NECESSARY PRECAUTION SHALL BE TAKEN DURING AND AFTER TUNNEL EXCAVATION TO ENSURE THAT INSTALLED INSTRUMENT DO NOT GET DAMAGED.
7. THE INSTRUMENT DAMAGED DURING CONSTRUCTION SHALL BE REPLACED IMMEDIATELY.





LEGENDS :-

MPBX (3,4,6) = MULTI POINT BOREHOLE EXTENSOMETER (3/4/6 NOS)

REFERENCE DRAWING :-

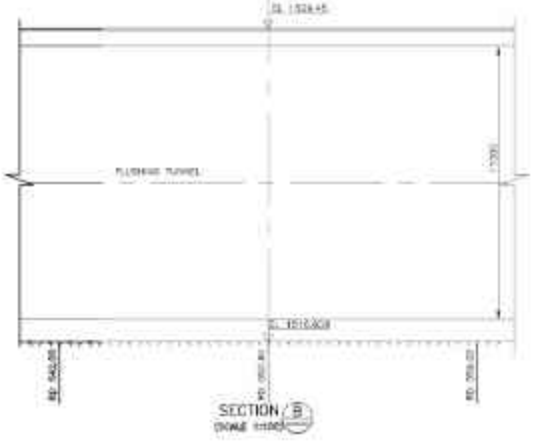
1	T3-345-41-GA-001	DAM COMPLEX RIGHT SIDE FLUSHING/SPILLWAY TUNNEL LAYOUT PLAN
2	T3-345-41-01-002	DAM COMPLEX RIGHT SIDE DIVERSION/SPILLWAY TUNNEL L-SECTION
3	T3-380-41-AD-003	HEAD RACE TUNNEL ADIT TO D/S OF DESILTING CHAMBERS PLAN
4	T3-380-41-AD-004	HEAD RACE TUNNEL ADIT TO D/S OF DESILTING CHAMBERS SECTION
5	T3-380-41-AD-035	DAM COMPLEX ADIT TO D/S DESILTING CHAMBER ADDITIONAL CUTOFF MEASURE AT CROSSING WITH FLUSHING TUNNEL

FOR CONSTRUCTION

SCALE 1:1000

SCALE 1:100

SCALE 1:25



NO.	BRN.	SYS	REVIS.	APPD.	DATE	DESCRIPTION

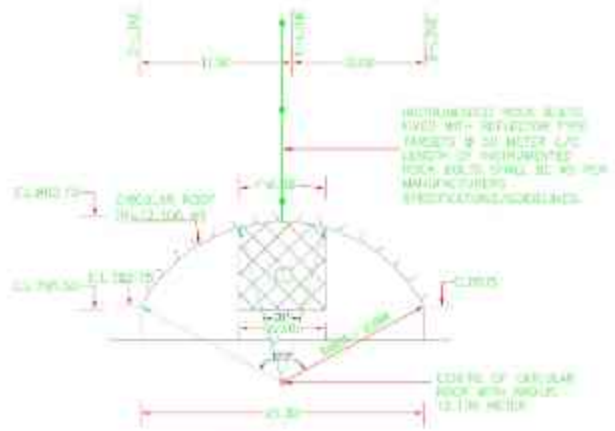
CLIENT : TEESTA URJA LIMITED

PROJECT : TEESTA STAGE-III H. E. PROJECT

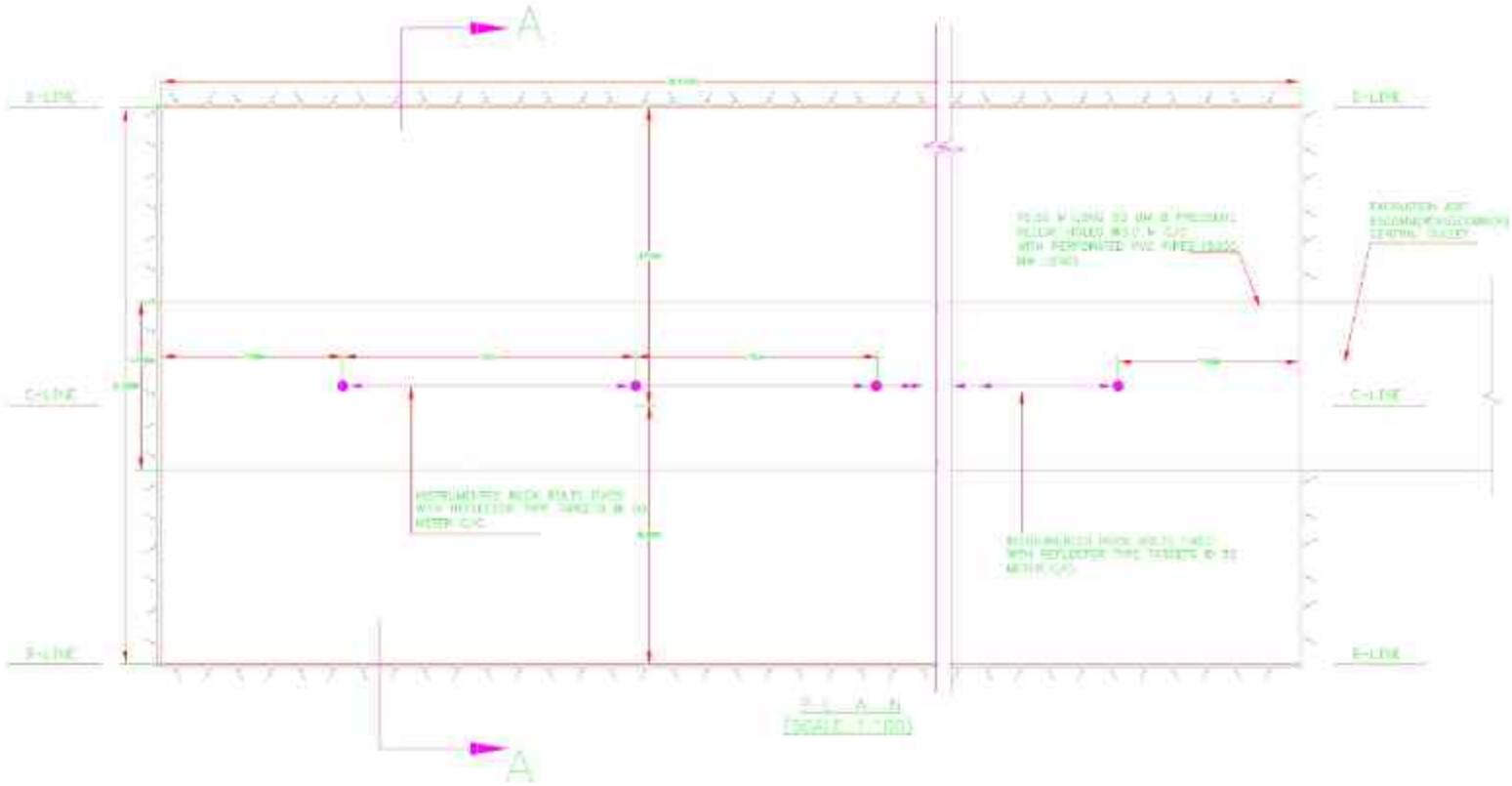
DESIGNERS : ENERGY INFRATECH PRIVATE LTD.

DRAWING : HEAD RACE TUNNEL
ADIT TO HRT D/S OF DESILTING CHAMBER
INSTRUMENTATION AT LOCATION OF
CROSSING WITH FLUSHING TUNNEL

DRAWN :	PANKAJ SINGH / REENA BAINS	REVIEWED :	S. JAVED WASHMI
DESIGNED :	L. C. GUPTA (HOD) E.	APPROVED :	RAJEEV SETIA
DRAWING NO :	T3-380-41-GD-036	REV NO :	R0
DATE :	JULY 2009	ORIGINAL PRINT SIZE :	A1



SECTION A–A
STAGE – I
SCALE 1:200



PLAN A-A
SCALE 1:100

REFERENCE DRAWINGS

Sr.	NUMBER	SUBJECT

ISSUED FOR CONSTRUCTION

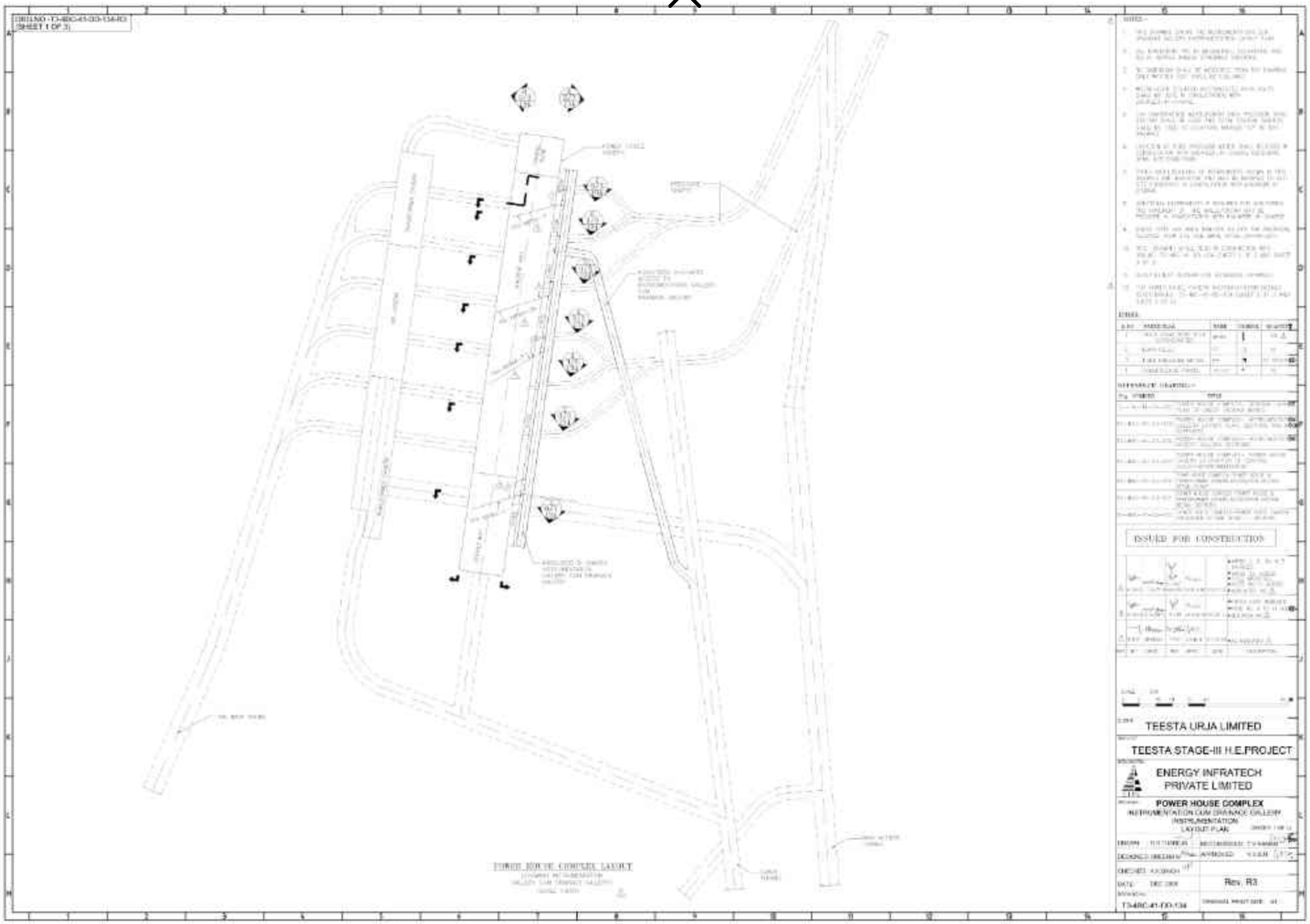
TEESTA URJA LIMITED

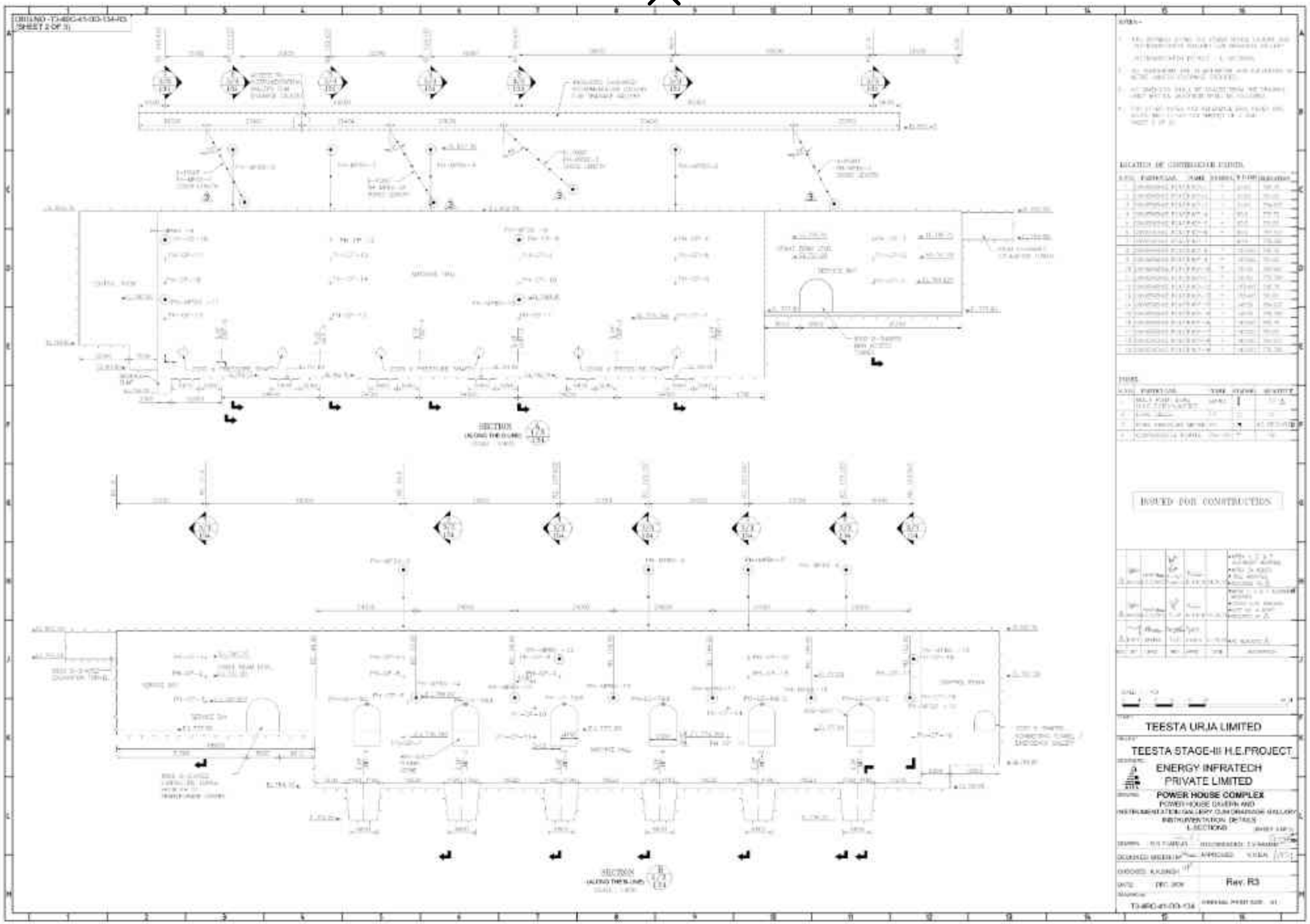
TEESTA STAGE-III H.E. PROJECT

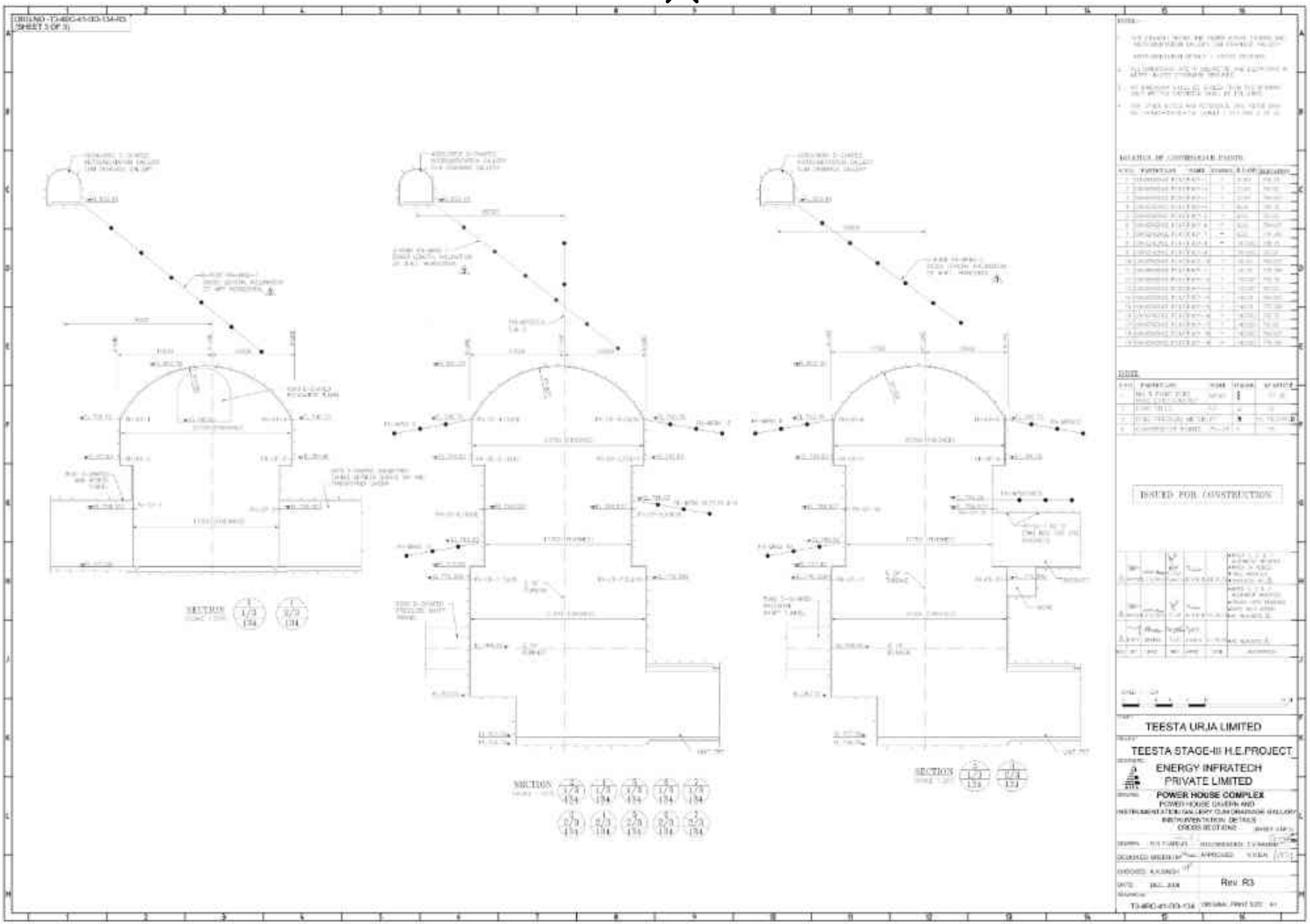
ENERGY INFRATECH PRIVATE LIMITED

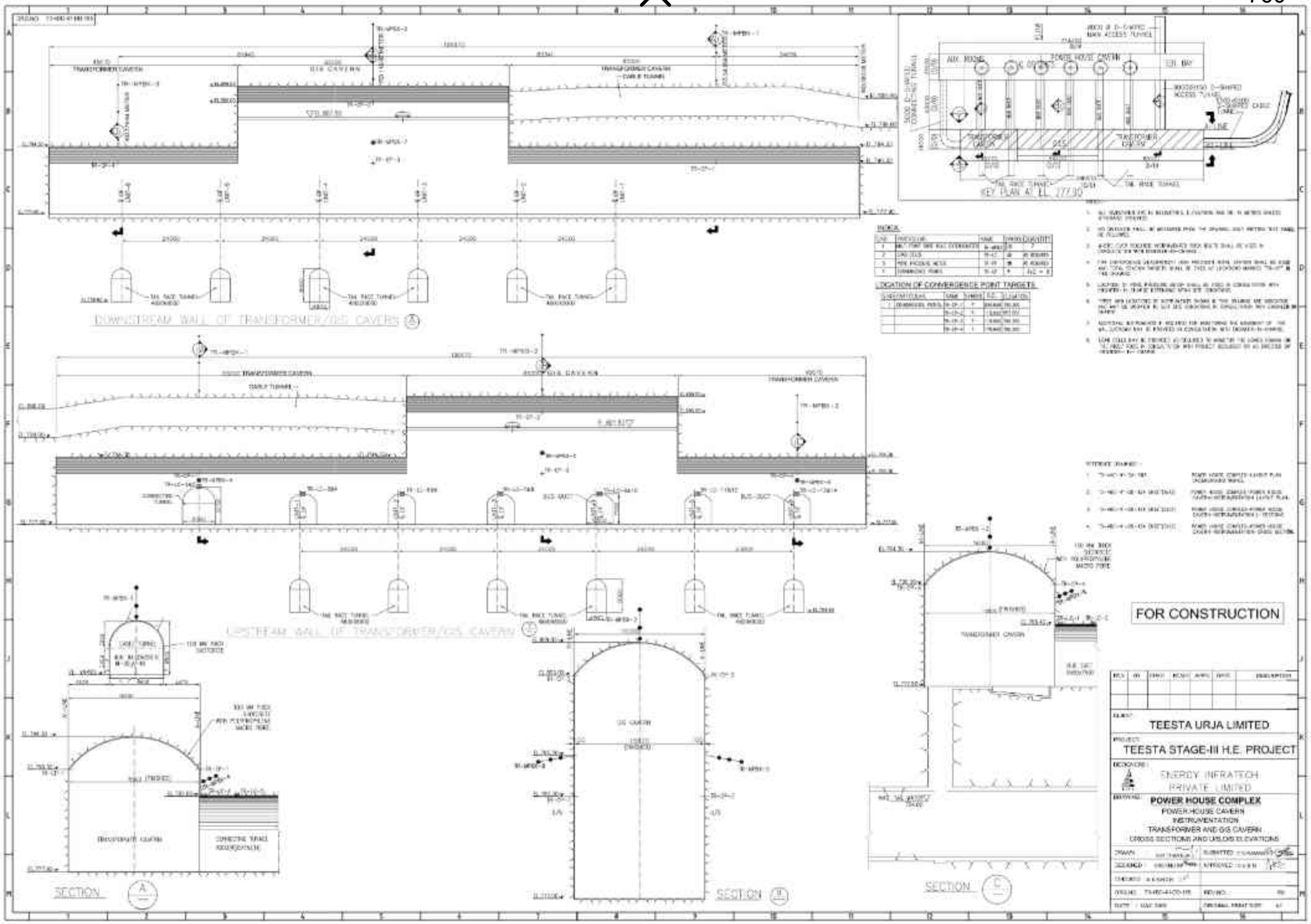
POWER HOUSE COMPLEX
POWER HOUSE CAVERN EXCAVATION OF CENTRAL GULLET-INSTRUMENTATION

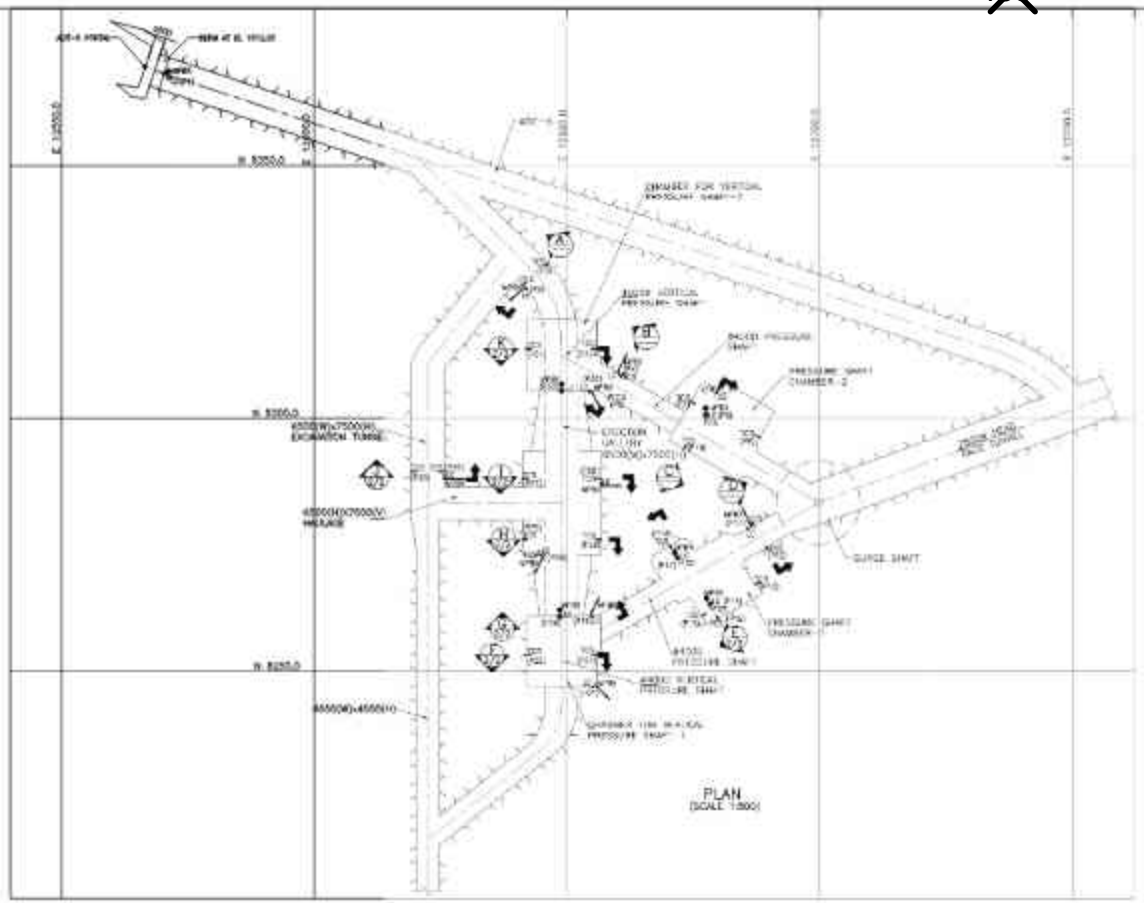
~~404~~


ISSUED FOR CONSTRUCTION
TEESTA URJA LIMITED
TEESTA STAGE-III H.E.PROJECT
ENERGY INFRATECH PRIVATE LIMITED
POWER HOUSE COMPLEX
INSTRUMENTATION CUM DRAINAGE GALLERY
INSTRUMENTATION LAYOUT PLAN
Rev. R3
T3-ABC-41-DD-134


ISSUED FOR CONSTRUCTION
TEESTA URJA LIMITED
TEESTA STAGE-III H.E.PROJECT
ENERGY INFRATECH PRIVATE LIMITED
POWER HOUSE COMPLEX
Rev. R3


ISSUED FOR CONSTRUCTION
TEESTA URJA LIMITED
TEESTA STAGE-III H.E.PROJECT
ENERGY INFRATECH PRIVATE LIMITED
POWER HOUSE COMPLEX
Rev. R3


DOWNSTREAM WALL OF TRANSFORMER/GIS CAVERN
UPSTREAM WALL OF TRANSFORMER/GIS CAVERN
SECTION
SECTION
SECTION
KEY PLAN AT EL. 777.00
FOR CONSTRUCTION
TEESTA URJA LIMITED
TEESTA STAGE-III H.E. PROJECT
ENERGY INFRATECH PRIVATE LIMITED
POWER HOUSE COMPLEX
POWER HOUSE CAVERN
INSTRUMENTATION
TRANSFORMER AND GIS CAVERN
CROSS SECTIONS AND U/S,D/S ELEVATIONS



LOCATION NO. AND ELEVATION OF INSTRUMENTS

LOCATION	NO. OF METER	NO. OF [illegible]	NO. OF [illegible]	ELEVATION (APPX.)
P1	1	1	-	1513.00
P2	1	1	1	
P3	-	-	1	
P4	1	1	1	
P5	-	-	-	
P6	1	1	1	1513.00
P7	-	-	1	1508.00
P8	-	-	1	1504.00
P9	-	-	1	1498.00
P10	-	-	1	1503.00
P11	1	1	1	
P12	-	-	1	
P13	-	-	1	1528.00
P14	1	1	1	1517.00
P15	-	-	-	
P16	-	-	1	1503.00
P17	1	1	1	1513.00
P18	-	-	1	1508.00
P19	1	1	-	1503.00
P20	1	1	-	1517.00
P21	1	1	-	1511.00
P22	-	-	1	1503.00
P23	-	-	1	1528.00
P24	1	1	1	1511.00
P25	-	-	1	
P26	-	-	-	
P27	-	-	1	
P28	1	1	1	
P29	1	1	1	
P30	-	-	-	
P31	-	-	1	1508.00
P32	-	-	1	1504.00
P33	1	1	1	1511.00
P34	1	1	-	1517.00
TOTAL	15	15	28	

NOTES:-

1. ALL DIMENSIONS ARE IN MILLIMETERS AND ELEVATIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. MODEL AND LOAD CELLS AS SHOWN IN THE DRAWING SHALL BE INSTALLED AS PER MANUFACTURER'S REQUIREMENT AND AS SPECIFIED IN T.S.
3. INSTALLED HEAD OF THE INSTRUMENTS MAY GET DAMAGED DUE TO BLASTING OR SIMILARLY THE SAME BE RECESSED INTO THE ROCK AND COVERED WITH 6 MM.S STEEL PLATE, IF NECESSARY.
4. LOAD CELLS SHALL BE PROVIDED ON ROCK BOLT. THE BOLT SHALL BE SHOT ANCHORED AND GROUTED TO S. DRAWING AND SHALL NOT BE FIXED DIRECTLY.
5. LOCATION OF INSTRUMENTS MAY REQUIRE MODIFICATIONS BY THE ENGINEER-IN-CHARGE TO SUIT SITE CONDITION.
6. THE READING OF THE INSTRUMENTS SHALL BE CHECKED DURING CONSTRUCTION AND DATA SO ASSESSED AND SUBMITTED TO THE ENGINEER-IN-CHARGE. FREQUENCY OF READING MAY BE MODIFIED BY ENGINEER-IN-CHARGE DEPENDING UPON ACTUAL RESULTS.
7. NECESSARY PRECAUTIONS SHALL BE TAKEN DURING AND AFTER EXCAVATION TO ENSURE THAT INSTALLED INSTRUMENTS DO NOT GET DAMAGED.
8. THE INSTRUMENTS DAMAGED DURING CONSTRUCTION SHALL BE REPLACED IMMEDIATELY.
9. ADEQUATE PROVISIONS TO TAKE THE READING OF INSTRUMENTS AT ALL LOCATIONS SHALL BE PROVIDED.
10. THIS DRAWING IS VALID FOR INSTRUMENTATION ONLY. THE DIMENSIONS SHOWN ARE INDICATIVE. THE DRAWING SHALL NOT BE USED FOR EXCAVATION PURPOSE.

LEGENDS :-

FOR CONSTRUCTION

SCALE: 1:500

SCALE: 1:75

REV.	DRN.	DESIGN REVIEW	APPD.	DATE	DESCRIPTION

CLIENT : TEESTA URJA LIMITED

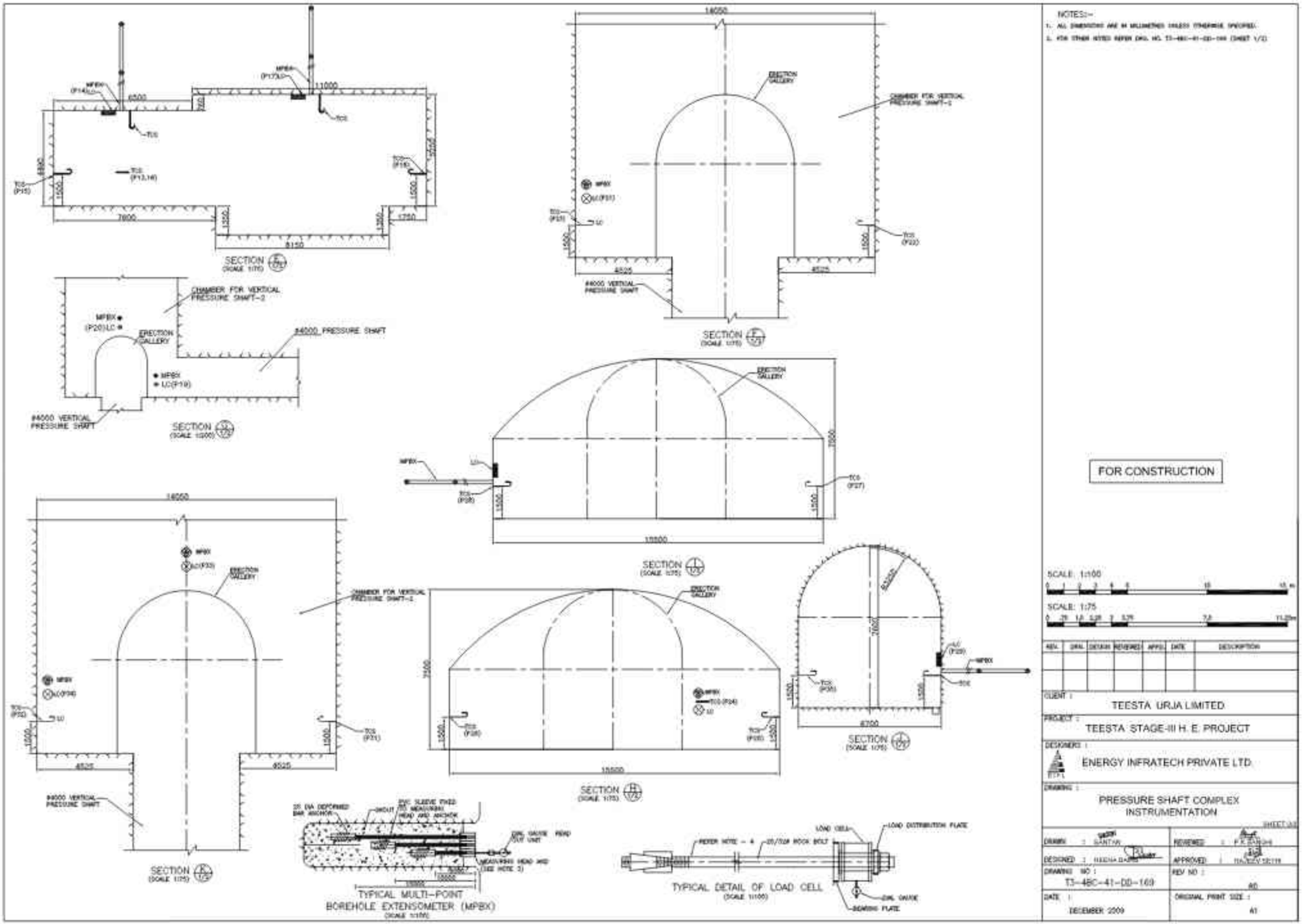
PROJECT : TEESTA STAGE-III H. E. PROJECT

DESIGNERS : ENERGY INFRATECH PRIVATE LTD.

DRAWING : PRESSURE SHAFT COMPLEX INSTRUMENTATION

SHEET NO.

DRAWN : SANTAN	REVIEWED : PUSHADEB
DESIGNED : REKHA KARKI	APPROVED : HARIEV SETHI
DRAWING NO. : T3-4BC-41-DD-169	REV NO. : R0
DATE : DECEMBER 2009	ORIGINAL PRINT SIZE : A1


SECTION
SECTION
SECTION
SECTION
SECTION
SECTION
SECTION
TYPICAL MULTI-POINT BOREHOLE EXTENSOMETER (MPBX)
TYPICAL DETAIL OF LOAD CELL
NOTES:-
FOR CONSTRUCTION
SCALE: 1:100
SCALE: 1:75
CLIENT : TEESTA URJA LIMITED
PROJECT : TEESTA STAGE-III H. E. PROJECT
DESIGNERS : ENERGY INFRATECH PRIVATE LTD.
DRAWING : PRESSURE SHAFT COMPLEX INSTRUMENTATION
DRAWN : SANTAN
DESIGNED : REKHA
DRAWING NO : T3-48C-41-DD-169
DATE : DECEMBER 2009
REVIEWED : P.K.SARKAR
APPROVED : RAKESH SETHI
REV NO : R0
ORIGINAL PRINT SIZE : A1

~~490~~

Annexure-6

~~491~~

GOVERNMENT OF INDIA
MINISTRY OF WATER RESOURCES
CENTRAL WATER COMMISSION
DAM SAFETY ORGANISATION

REPORT

ON

DAM SAFETY PROCEDURES

BHATSA DAM

NEW DELHI

~~492~~

Government of India
Central Water Commission

Sewa Bhavan, R.K.Puram,
New Delhi 110066

Dated the 10th July 1986

To

The Hon'ble Minister,
Ministry of Water Resources,
Government of India,
Shram Shakti Bhavan,
Rafi Marg,
New Delhi 110001

Subject: Report of Standing committee to review the existing and to evolve unified procedure of the dam safety for all the dams in India.

Sir,

The Government of India vide their Office Memorandum No.18/18/80-I.T. dated the 17th August 1982 constituted a Standing Committee to review the existing practices of inspection / maintenance of dams and allied structures in various States and to evolve standard guidelines for the same. In pursuance of the above memorandum, the Standing Committee went through the task assigned to it and I have now the pleasure to submit its report on "Dam Safety Procedure" for the country.

The procedures outlined in this report have been suggested after taking into account the experience available in the dam safety7 activities in India as well as abroad. The recommendations of the Committee on Dam Safety of the International Commission on Large Dams have also been kept in view.

The Committee had a very difficult task while framing the criteria for safety, because it had to steer clear of what

is ideal against what is practicable in the context of existing conditions in the country. The Committee has suggested that the criteria for evaluating the safety of the existing dams may not necessarily be in conformity with the current provisions for designs of new dams so long as the basic safety is not being sacrificed. Safety status of each existing dam will have to be decided separately on its own merits.

'Dam Engineering' is a discipline subject to rapid evolution. Consequently, the safety procedures will have also to be reviewed regularly by the Standing Committee. It has been suggested in the report to reconstitute the Standing Committee to make it broad based.

While submitting this report, I would also like to place on record the very pioneering work done by Shri G.S. Narayana, Chief Engineer (DSO), Central Water Commission, in his capacity as Member-Secretary of the Standing Committee. He was assisted by Shri K.D. Thite, Director(Dam Safety Service), Central Water Commission and Shri S.K. Das, the young Deputy Director from Central Water Commission. But for their devotion and hard work, the Committee would not have been able to finalise the report in time as planned.

With kind regards,

Yours faithfully,

(M.A. Chitale)
Chairman,
Central Water Commission &
Ex-Officio Secretary to
Government of India.

REPORT ON DAM SAFETY PROCEDURES

CONTENTS

Letter of Transmittal			
Preamble			1
Chapter I	-	Introduction	5
Chapter II	-	Existing procedures of dam safety in various States	11
Chapter III	-	Evaluation of existing procedures	47
Chapter IV	-	Suggested administrative set up for the dam safety cell in the State, its functions and prioritization for safety review.	59
Chapter V	-	Guidelines for determining hydrological safety of existing dams.	69
Chapter VI	-	Structural review	75
Chapter VII	-	Guidelines for inspection, operation and maintenance.	85
Chapter VIII	-	Emergency preparedness	93
Chapter IX	-	Need for legislation	103
Chapter X	-	Summary of action points	115
Acknowledgement			
Appendix I	-	Government of India's Office Memorandum constituting the Standing Committee	123
Appendix II	-	Important references and codes for investigations.	125
Appendix III	-	Important references and codes for design.	127
Appendix IV	-	Periodical inspection of dams.	131
Appendix V	-	Staff strength in the State Dam Safety Cells.	132

~~495~~

PREAMBLE

The growth of civilization is inextricably woven around the availability of water the world over. Dams are human device for exploitation of water for irrigation, flood control and hydro-power development etc, and thus occupy a pivotal role in the development activities of the human race. Dams, however, are not unmixed blessings. They do pose a major hazard in the unlikely event of a failure.

There have been about 200 notable reservoir failures in 20th century in the world so far. It is estimated that more than 8000 people lost their lives in these disasters. The following tabulation published by ICOLD indicates the number of major dam failures in the historical period through 1965:

Year	Approximate No.of significant failure
Period to 1900	38
1900 to 1909	15
1910 to 1919	25
1920 to 1929	33
1930 to 1939	15
1940 to 1949	11
1950 to 1959	30
1960 to 1965	10
Date unknown	25
	202

The toll of human lives resulting from some of the major disasters throughout the world has been estimated as follows:

Sl. No.	Dam	Country	Year of disasters	Lives lost
1	Machuu II (Gujarat : 26 m masonry & earthfill)	India	1979	2000+
2	Vaiont (265 m : world's highest thin arch)	Italy	1963	2600
3	South Fork (Johnstown) (21.9 m : earthfill)	USA	1889	2209
4	Teton	USA	1976	11
5	Tailings	Italy	1985	200
6	Malpasset	France	1959	421
7	Kantle	Sri Lanka	1986	100

Failures have not only occurred in dams built without application of engineering principles; but also in dams built to accepted state of art of "dam engineering." The failure of Malpasset dam is an example. In this connection, the observations of Karl Terzaghi in a letter addressed by him to Andr Coyne immediately after the failure of Malpasset dam are relevant.

"In situations of this kind it is at the outset impossible to divorce the technical aspects of the event from the human tragedies involved. Yet every fair-minded engineer will remember that failures of this kind are, unfortunately, essential and inevitable links in the chain of progress in the realm of engineering, because there are no other means for detecting the limit to the validity of our concepts and procedures."

"Having known you well for many years, I feel confident that the failure was not a consequence of an error in your design. Therefore, it will serve the vital purpose of disclosing a factor which in the past has not received the attention which it requires. The fact that its implications became manifest on one of your jobs is not your fault, because the occurrence of failures at the borderline of our knowledge is governed by the laws of statistics, and these laws hit at random. None of us is immune. You as an individual, and the equally innocent victims of the failure have paid one of the many fees which nature has stipulated for the advancement in the real of dam construction."

The International Congress on Large Dams has been the pioneer in projecting various aspects of dam engineering since its inception to ensure proper design and construction of safe dams. However, it was during the International Conference on Large Dams in New Delhi in 1979 a more direct and forceful action by the international body in the field of dam safety was suggested. In 1980 an adhoc committee was established. The adhoc committee recommended in the executive committee meeting during 1982 at Rio De Janeiro a new technical committee on dam safety for the following reasons:

Several dam incidents with severe consequences during recent years had given rise to general concern about the safety of dams, and indicate the necessity for the introduction of a formal safety approach.

The height of new dams and the volume of new reservoirs are increasing, while more older dams are approaching an age at which material deterioration and decreasing operational reliability may dictate some repair and upgrading. Certainly both the growing dimensions of new dams and the aging of older dams suggest a somewhat more rigid approach to safety aspects.

~~447~~

An ever increasing number of dams are being built in countries with little or no tradition and experience in dam engineering. The formalization of safety considerations and the issuance of summarized safety requirements would be part of the necessary transfer of technological know-how to these countries.

There was an International Conference of Safety of Dams at Portugal, Coimbra in April 1984 to highlight the importance of dam safety. Dam safety has enjoyed varying degree of attention in inverse proportion to the time and distance from the most recent catastrophic event. Engineers have been understanding and continue to understand the hazards associated with dam safety.

Dam building activity got impetus and first priority after India became independent. The total number of dams already constructed / under construction upto 1986 is of the order of 2123.

The dams built in the country by and large have performed well, but there have been a few failures. The notable ones are:

Sl. No.	Name of the dam	Height Metres	Year of completion	Year of failure
1	Kaddam	22.5	1957	1958
2	Panshet	53.0	1961	1961
3	Khadakwasla	20.0	1875	1961
4	Chikkhole	36.7	1968	1972
5	Machhu II	24.1	1975	1979

The Machhu II disaster took a toll of more than 2000 lives.

Realizing the importance of dam safety, many countries in the world have initiated action to review the safety of dams in their countries and United States of America can be considered a pioneer in this field. The review conducted recently by US Army Crops of Engineers revealed that out of 8819 review inspection completed, 2925 dams were evaluated as unsafe. Of the various causes, inadequate spillway capacity was the primary deficiency found in 81% of the unsafe dams.

Keeping in view the importance of dam safety in our country, a Dam Safety Organization was established in May 1979 in Central Water Commission to assist the State Governments in various activities in dam safety. The Dam Safety Organization also initiated action for reviewing the existing procedures of dam safety in the country and also evolves appropriate dam safety practices.

~~458~~

Chapter I

INTRODUCTION

1.1 Background

1.1.1 The safety of dams in our country is the principal concern of the State agencies that are involved in the various aspects of their investigation, planning, design, construction, operation and maintenance. While most of the dams have performed well, there have been a few failures. These failures, either partial or complete, highlight the need to review the procedures and the criteria that are being adopted by the various States with the object of establishing the best assurance of dam safety within the limitation of the present state-of-art.

1.1.2 All State agencies who own the dams and have responsibility or are involved with any of the aspects of the project, carry-out the maintenance of the structures in some prescribed manner of their own. The practices of dam safety-operation-maintenance and surveillance, etc., being adopted by the various agencies differ from State to State and also from agency to agency within the State.

1.1.3 The broad objective is to provide a comprehensive review and to recommend means of assuring the effectiveness of existing State agencies, their practices and procedures affecting various aspects of dam safety.

1.1.4 The ultimate objective of this review would be to assure that the dam safety is given proper consideration by the State agencies in the discharge of their responsibilities, providing the greatest possible dam safety consistent with the current state of knowledge available. A unified practice would then be evolved based on what is best available at present.

1.2 Formation of Standing Committee

The Government of India, Ministry of Irrigation constituted a Standing Committee to review the existing practices and to evolve unified procedures of dam safety for all dams in India, under the chairmanship of the Chairman, Central Water Commission, vide Government of India, Ministry of Irrigation Office Memo No.18/18/80-I.T. dated 17th August 1982. A copy of the same is enclosed as Appendix I.

1.3 Terms of Reference

1.3.1 As mentioned in the Office Memorandum of the Government of India constituting this Standing Committee, the Standing Committee is to review the existing practices of inspection / maintenance of dam and allied structure in various States and to evolve standard guidelines for the same. The terms of reference to the Committee are as under:

(a) Review practices of various agencies in the country responsible for or involved with site selection, design, construction, regulation, inspection, maintenance and operation, repairs and ultimate disposition of dams which could affect the safety and integrity of the structures.

(b) To suggest means of improving the effectiveness of each agency, engaged in its dam safety efforts.

The Committee as constituted comprised of:

- Chairman, Central Water Commission .. Chairman
- Member (D&R), Central Water Commission .. Member
- Member (WR), Central Water Commission .. Member
- Commissioner for Indus Waters, Ministry of Irrigation .. Member
- Director General, Geological Survey of India (or his representative) .. Member
- Director General, India Meteorological Department (or his representative) .. Member
- Member (Irrigation), Bhakra Beas Management Board, Chandigarh .. Member
- * Shri J.F.Mistry, Chief Engineer, Irrigation Department, Government of Gujarat .. Member
- Chief Engineer (DSO), Central Water Commission Member Secretary

* now Secretary (Irrigation), Government of Gujarat

The term (a) can be grouped into two parts.

1.3.2 The first part relating to review of practices of site selection, design construction and regulation are essentially connected with new dams which have yet to come up through information on this aspect of old dams would also be relevant.

1.3.3 The other part consisting of review of operation, maintenance, inspection and surveillance practices essentially relate to existing dams.

1.3.4 This term of reference highlights the fact that safety of the dam has to be tackled at all stages from the stage of investigation till the concept is translated to reality and subsequently during its life time. There are various Indian Standards and procedures which deal with the first part quite exhaustively. The main object of the Committee is to fill in the gap in the procedure adopted for surveillance of existing dams and, therefore, the Committee would address itself to this aspect in greater detail though incidentally; it may touch upon other aspects connected with dam building.

1.4 Stages in dam building

1.4.1 New dams can be made safe; if at all stages mentioned below, the existing guidelines, procedures and IS Codes are followed:

1.4.2 Investigation stage

1.4.2.1 The quality of data collected from field investigation would determine the adequacy of the design provisions made in the structure. Detailed geological and foundation investigations are a vital input in design.

1.4.2.2 The correct assessment of design inflow flood is one of the basic factors that would decide the safety of the structure. Here again, the hydrological data collected should be true and correct. There are various publications by Central Water Commission IS Codes providing necessary guidelines for ensuring accurate and detailed investigation that would form the basis for project preparation. A list of guidelines and IS Codes that are relevant for investigation stage is given in Appendix II.

1.4.3 Design stage

Provision for ensuring safety made in the design would depend upon the correctness of the data in respect of geological, hydrological, construction materials and foundation investigation,

etc. Designs of dams (masonry / earth) are governed by ISI criteria in the country. The various IS Codes relevant for design of masonry / concrete and earth core rockfill dam are given in Appendix III.

1.4.4 Construction stage

The safety of the dam would depend very much on the engineer at site who has to get the geological conditions of the foundation, the competency of reservoir rim, construction material and their properties properly evaluated vis-à-vis the design assumptions and send in time, related data back to the designers, should there be any variation in respect of the properties noticed during construction vis-à-vis design assumptions; to effect modification called for in designs.

1.4.5 Post-construction stage

The Committee would address themselves for formulating guidelines for the following:

- Administrative set up for the dam safety cell in the State and its functions.
- Fixing priorities for review of dams.
- Hydrological safety of existing dams.
- Structural review.
- Seismological review.
- Assessment of seepage in dams.
- Operation & maintenance.
- Inspection.
- Emergency preparedness plans.
- Need for legislation.

~~502~~

Chapter II

EXISTING PROCEDURES OF DAM SAFETY IN VARIOUS States

2.1 General

2.1.1 The Standing Committee in their first meeting decided that in order to review the present practices of various agencies involved in site selection, design, construction, regulation, inspection, maintenance and operations, repairs, etc., of dams, the relevant information has to be obtained from all concerned.

2.1.2 The Committee evolved a questionnaire and the same was sent to sixteen States, Bhakra Beas Management Board (BBMB) and Damodar Valley Corporation.

2.1.3 Replies to the questionnaire have been received from Gujarat, Maharashtra, Tamil Nadu, Uttar Pradesh, Orissa, Bhakra Beas Management Board, Damodar Valley Corporation, Kerala Irrigation Department & Kerala State Electricity Board. The information received from Karnataka is incomplete and pertains to one project only.

2.1.4 The information received from the following States / Agencies has been summarized:

(a) Gujarat
(b) Maharashtra
(c) Uttar Pradesh
(d) Kerala (Irrigation Department)
(e) Kerala (State Electricity Board)
(f) Orissa
(g) Tamil Nadu (Irrigation Department)
(h) Damodar Valley Corporation
(i) Bhakra Beas Management Board
(j) West Bengal
(k) Karnataka Power Corporation
(l) Karnataka (Irrigation)

2.2 Gujarat

2.2.1 Organization

2.2.1.1 All dams in the State are owned by the State Government and are maintained by the staff kept for operation. A separate Dam Safety

Organization is functioning in the State since September 1981 and has been attached to the Central Design Organization, Gandhi Nagar. The entire Central Design Organization is under the control of the Chief Engineer and Director, Gujarat Engineering Research Institute (GERI), Vadodra, who in turn report to the Special Secretary and Chief Engineer (Irrigation Project), Sachivalaya, Gandhi Nagar.

2.2.1.2 A Superintending Engineer (Dam Safety & Gates), along with two Executive Engineers (Civil) and one Executive Engineer (Mech) and five Deputy Executive Engineers carry out the main functions of documentation, monitoring and also inspection of dams and appurtenant structures.

2.2.1.3 A Superintending Engineer (Hydrology) with two Executive Engineers and other supporting staff review the design floods for the existing and on-going projects and suggest suitable modifications. This Cell can also be considered to be a part of the Dam Safety Organization.

2.2.2 Periodic Inspection Programme

2.2.2.1 Pre-monsoon and post-monsoon inspections are conducted by the project officers as per instructions issued in this regard. In 1981 the Government have issued detailed instructions which also include checks to be exercised during the inspections.

2.2.2.2 The inspection reports are sent to higher officers and presently also to the Dam Safety Organization.

2.2.3 Dam Safety Inspections

2.2.3.1 One of the functions of the Dam Safety Organization is to carry out phased inspection of head works of major and medium schemes and seven dams of Gujarat Water Supply and Sewerage Board (GWSSB) and to point out deficiencies noticed during the inspections, to suggest remedial measures and to watch for timely action.

2.2.3.2 The inspections of the dams is carried out as per "Checklists" and the "Guidelines for Safety Inspection of Dams" prepared by the Dam Safety Organization of the Central Water Commission.

2.2.3.3 The activities of Dam Safety Organization are restricted to major and medium dams, catering to irrigation of more than 10000 and

2000 hectares respectively, irrespective of height of dam or its storage.

2.2.3.4 Phase I inspections of all the completed major and medium dams has been done.

2.2.3.5 Training the officers in charge of dams and their inspection is imparted by Staff Training College, Gandhi Nagar and by conducting seminars on relevant subjects.

2.2.4 Geological Aspects

2.2.4.1 There is a Superintending Engineer (Geology) attached to the CDO, Gandhi Nagar. Under his guidance, the Engineering Geology Divisions under Irrigation Department of the State Government are carrying out geological investigations and subsurface exploration. Moreover, certain projects are also referred to Geological Survey of India.

2.2.5 Hydrological Aspects

2.2.5.1 At present the flood estimation is done by the unit hydrograph method and as outlined in the publication of CWC (1972) "Estimation of Design Flood – Recommended Procedures." The PMP and design storm details are obtained from India Meteorological Department.

2.2.5.2 For the purpose of deciding the spillway capacity, the dams are classified as major and medium according to their gross storage capacities. The schemes having their gross storage capacity exceeding 50000 acre ft. (6250 ha.m.) are termed as major schemes and those having their gross capacities less than 50000 acre ft. (6250 ha.m.) are termed as medium schemes. The spillway capacities for medium schemes are provided for Standard Project Flood (SPF) and that for major schemes are provided for Maximum Probable Flood (PMF).

2.2.5.3 Hydrological reviews are generally made when either observed flood surpasses the previous highest observed flood or one day/two day storm depth occurring over the basin is more severe than the design storm depth considered earlier.

2.2.6 Emergency Action Plan

2.2.6.1 There is no regular practice to prepare a dam failure inundation map for each dam.

2.2.6.2 However, during June 1983 floods in Saurashtra region, emergency preparedness plans were prepared for certain dams. The State also issues flood memorandum for various rivers every year. Setting up of flood fighting units on regional levels has been contemplated. The "Guidelines for Emergency Action Plans" as prepared by the Dam Safety Organization of the Central Water Commission is presently being adopted.

2.2.7 Quality Control

2.2.7.1 For major and medium dams under construction normally there is a quality control sub-division placed under an Executive Engineer who is not in charge of construction. The Executive Engineer or the Deputy Executive Engineer in charge of quality control reports directly to the Superintending Engineer. The quality control sub-division ensures that work is carried out according to specifications and they are empowered to stop the work if specifications are not adhered to and get the sub standard work removed.

2.2.7.2 The quality control sub-division acts as an independent agency. They collect sample from the field and test them either at the project laboratory or the samples are sent to GERI for carrying out control tests.

2.2.7.3 Training courses are frequently held at project site, at GERI, at the Staff Training College for the quality control staff to bring them up to date with the latest technological advances and practices.

2.2.8 Instrumentation

2.2.8.1 Usually instruments are provided in important earth dams having height more than 15 metres and on concrete and masonry dams more than 30 metres in height.

2.2.8.2 In earth dam hydraulic type and mechanical type, devices are provided to measure pore pressures and settlements.

2.2.8.3 In masonry and concrete dams the following instruments of the vibrating wire type are provided:

- Strain Transmitter
- Thermometers
- Stress meters
- Uplift Pressure
- Inclination Transmitter

In general, instruments provided in earth dams are functioning satisfactorily with scattered mortality. In case of masonry and concrete dams, the instruments provided in Ukai dam are reported to be functioning. The CDO and GERI analyse the observations and make use of the results for taking remedial measures, if necessary. Designs are also reviewed, if required.

2.2.9 Operation and Maintenance

The officers in charge of the various dams are required to inspect the head works from time to time and guide the resident staff in properly operating and maintaining the works. Procedures have also been laid down for detailed pre-monsoon inspection of the head works. One constraint in proper operation and maintenance appears to be the lack of adequate financial provision. Though these provisions are being increased from time to time, it appears that they are required to be substantially increased to ensure safe and proper maintenance of the project. For careful operation and maintenance during the rainy season, the State makes necessary arrangements to set up flood control cells and install wireless and warning stations, etc., at the dam sites, and the catchment areas and in the vulnerable areas downstream of the reservoir as well as at the administrative headquarters. It is, however, often noticed that general lines of communications like power, telephones & roads, etc., get disrupted during high floods or storms and it appears that a much more comprehensive arrangement is required in this respect and the State is making necessary arrangements.

2.3 Maharashtra

2.3.1 Organization

2.3.1.1 There are about 1200 large dams in Maharashtra State including 940 completed large dams and 260 dams under construction. Most of the dams in Maharashtra State are under the jurisdiction of the Irrigation Department of the State. There are some dams owned by Semi Government and private bodies like Environmental Engineering Board, Maharashtra State Electricity Board, Maharashtra Industrial Development Corporation, Bombay Municipal Corporation and Tata Hydro Electric Company. All such dams are expected to be under the State supervision of the Irrigation Department for safety aspects. The pre- and post-monsoon inspections of dams owned by Tata Hydro Electric Company are already being conducted by the officers of Irrigation Department since their commissioning.

2.3.1.2 A separate Dam Safety Organization is functioning in the State since 20th October 1980. Since 1st May 1985, the set up of the Organization has been modified and it consists of a circle level unit headed by a Superintending Engineer, with three Dam Safety Divisions as under:

(a) Dam Safety Division No.1, Nasik with five cells (including one mathematical cell)

(b) Dam Safety Division No.2, Nasik with four cells

(c) Dam Safety Division No.3, Nasik with four cells.

2.3.1.3 The Dam Safety Organization and its Divisions are working as an integral part of the CDO, Nasik and are located in the same premises.

2.3.1.4 The Dam Safety Organization in Maharashtra does not have any independent hydrology unit for flood studies for the work of review of spillway capacities of existing dams in the State. However, the Government has constituted a Committee comprising the Superintending Engineer, Dam Safety Organization, Nasik, as the Chairman and six Executive Engineers from Water Resources Investigation Divisions and Irrigation Projects Investigations, including the Executive Engineer, Water Planning, CDO, Nasik, as members. One Meteorologist from India Meteorological Department is also a member of this Committee.

2.3.2 Periodic Inspection Programme

2.3.2.1 There is a schedule for regular inspection of all dams in the State which indicates the different types of dams and the categories into which they could be classified and also the levels of officers at which close vigilance is maintained by camping at the dam site and the levels at which periodic inspections are done and inspection reports sent to higher authorities. This schedule is given in Appendix IV.

2.3.2.2 For inspection reports, there are various proforma and even for inspection of minor irrigation dams, specific proforma have been evolved. The inspections are carried out as pre-monsoon and post-monsoon inspection. Special inspections are carried out during and after heavy floods, earthquake and if any signs of peculiar behaviour are noted.

2.3.2.3 The pre- and post-monsoon inspection reports are submitted to the concerned Superintending Engineer, the Regional Chief Engineers and also to the Superintending Engineer, DSO. The inspection reports are scrutinized in the DSO and a periodical status report (Health Report) of the dams is prepared and submitted to the Government in August and February for pre- and post-monsoon inspections respectively. Copies of these status reports are also sent to the Regional Chief Engineers and the concerned Superintending Engineers. Further compliance about the deficiencies reported and the remedial measures is watched in the DSO.

2.3.2.4 The DSO has now prepared a revised checklist for inspection of dams which is brought in use on trial basis on some selected projects. The State Government has also prescribed a proforma for watching progress and position in respect of completion of installation and operation capabilities of gates and control structures on outlets and spillways in dams. This information is also required to be sent to the Superintending Engineer, DSO along with the pre- and post-monsoon inspection reports.

2.3.2.5 The DSO has also taken up the preparation of a Dam Safety Manual. Chapter No.7 on Flood Forecasting, Reservoir Operation and Gate Operation and Chapter No.8 on Preparedness for Dealing with Emergency Situation in Dams are already published.

2.3.2.6 Administrative and technical methods pertaining to Dam Safety are also being reviewed for improving their effectiveness.

2.3.2.7 With a view to train the field officers in dam safety aspects, seminar-cum-training courses are conducted by the Engineering Staff College, Nasik-4. It is also proposed to have regular region-wise programmes of short term workshops for training the field staff working on dams on maintenance and safety aspects of dams and reservoirs.

2.3.3 Status Reports on Health of Dams

2.3.3.1 The Dam Safety Organization oversees the timely completion of pre- and post-monsoon inspections of all large dams in the State by the concerned field officers. The inspection reports received by the DSO are scrutinized and a periodic status report of health of dams based on these inspections is prepared and submitted to State Government in August and February, each year. The report consists of:

(i) Statement – I: Large dams having capacity more than 60 mm^3 whose health and performance is required to be carefully observed.

(ii) Statement – II: Dams with major deficiencies (storage capacity less than 60 mm^3)

(iii) Statement – III: Dams with minor rectifiable defects (storage capacity less than 60 mm^3)

(iv) Statement – IV: Dams reported to be without signs of deficient performance.

(v) Statement – V: List of the dams having capacity 60 mm^3 and more for which pre- and post-monsoon inspection reports are not received in the DSO.

2.3.4 Geological Aspects

There is a geological unit under the Superintending Engineer (Masonry Dams), CDO, Nasik. This unit, along with the Engineering Geology Division of Geological Survey of India (GSI), Nagpur, advises on the initial geological investigations and interpretation of the results. The geological reports prepared by the GSI and the State Geologists are examined in the CDO, Nasik for preparing detailed designs about foundation treatment, etc.

2.3.5 Emergency Action Plan

2.3.5.1 In Maharashtra State there is a practice to prepare a probable dam failure inundation map for each dam. Emergency preparedness plans in appropriate details are prepared at the time of first filling.

2.3.5.2 Government of Maharashtra have issued Code of Instructions about precautions to be taken in case of imminent danger to dams as early as 1965. Even prior to this there were instructions on the subject.

2.3.5.3 The Code of Instructions mainly for earth dams, specified preparation of maps showing approximate flood level downside of the dam on the assumption that the dam may breach at the most vulnerable location. This map showing the likely flood zone as well as inhabited localities, public properties and special installations coming in the flood zone is supplied to the collector of the District, Commissioner of the Division, the officers of the various concerned

departments and District Superintendent of Police in addition to the Department officers.

2.3.5.4 It also specified formation of flood committees, fixing the safe places by the Mamlatdar in consultation with villages and local bodies, communication arrangements and even listing of 100 able bodied persons from nearby villages, for rescue operations.

2.3.5.5 The Code also provides instructions and formats of 'Alert Signal', 'Action Warning' & 'De-alert Signal' and actions to be taken by the police and administrative authorities on receiving the 'Alert Signals.'

2.3.5.6 The Government of Maharashtra have taken up the preparation of a Dam Safety Manual and the Chapter 8 of this Manual titled 'Preparedness for dealing with emergency situations on dams' which has already been prepared is quite exhaustive. This Manual specified that it is obligatory on the part of every agency that owns a dam which is under construction or operation to fulfill the following requirements.

2.3.5.7 "To formulate and implement an Emergency Action Plan for each dam to minimize to the greatest extent possible the probable loss of life and damage to the property in the event of failure of the dams."

Some other aspects covered in the Manual are:

(a) The Regional Chief Engineers and Superintending Engineers must also ensure that the Emergency Action Plan of the dam is completed before permission of gorge filling work is granted for creation of any storage.

(b) Guidelines for inundation map under dam-break floods.

(c) Constitution of Emergency Action Committees.

(d) Actions in dealing with problems of public safety during emergency on dams.

(e) Preparation of zoning maps and land use regulation for dam-break flood zones.

2.3.6 <u>Technical Aspects</u>

The State has got independent organization for investigation, designs, research, quality control, staff training and dam safety. These organizations are expected to provide specialized services to

the Irrigation Department in their respective fields as per the latest state-of-art.

2.3.7 Hydrological Aspects

2.3.7.1 At present the flood estimate is done by unit hydrograph method. The design storm and relevant data for design flood are being obtained from the India Meteorological Department (IMD).

2.3.7.2 Review of spillway capacity of all existing dams has been taken up by the DSO and 33 dams have been identified for such a review. The adequacy of spillway capacity is checked tentatively for 12 dams. Latest designs flood criteria based on PMP and PMF or SPF and the up-to-date hydrological data is being followed for such reviews.

2.3.8 Structural Aspects

For actual designs, various IS Codes are followed. Wherever necessary, the USBR and US Army Crops of Engineers practice is also referred to.

2.3.9 Quality Control

2.3.9.1 Field laboratories are established at all major projects for testing the construction materials and quality control during construction. The norms of the laboratory equipments for such field laboratories are prescribed by the MERI, Nasik depending upon the size of the project and the quantities of various important items of work involved. There are also regional laboratories at several places in addition to the field laboratories to meet the requirements of any special testing work. Confirmation testing work is also done at the fully equipped laboratories at Maharashtra Engineering Research Institute, Nasik.

2.3.9.2 Responsibility of maintaining quality of work is entrusted to the field organizations in charge of construction. Normally quality7 control is exercised by an independent field unit which is in charge of the field laboratory and works under the project organization. In case of World Bank aided projects, there is a separate quality control circle at Pune headed by a Superintending Engineer with divisional and sub-divisional level units which assist the field organizations for maintaining proper quality control.

2.3.9.3 The Irrigation Department of Maharashtra has published Hand Books on Quality Control which are intended to serve as practical

guides on quality control on the construction of earth – embankments and concrete and masonry works.

2.3.10 Instrumentation

2.3.10.1 Instruments are provided on almost all the important dams in the State, to monitor their behaviour. Several agencies are involved in the preparation of proposals, layout and designs of instrumentation, procurement and field installation of instruments, maintenance and taking observations and analysis of the data, etc.

2.3.10.2 Regular observations of the various instruments are being taken by the field officers and these are submitted to DSO for further process.

2.3.10.3 The Irrigation Department of Maharashtra has published a Hand Book on "Instrumentation" which is intended to serve as a practical guide on instrumentation regarding installation, maintenance, upkeep and operation of instruments and collection & analysis of the data, etc.

2.3.11 Operation and Maintenance

The dams are being operated and maintained by the field officers.

2.3.12 General Aspects

In addition to the above, the Dam Safety Organization of the State also deals with the following works:

(a) Conducting check inspections of dams.

(b) Preparation of upto date registers of dams in the State.

  (i) Register of large dams.
  (ii) District-wise registers of small dams.

(c) Compilation of record of dams (major & medium dams)

  (i) Design reports of dams and ancillary works, including instrumentation.
  (ii) Record drawings.
  (iii) Completion reports.
  (iv) Data Books

(d) Compilation and scrutiny of operation manuals of dams.

(i) Gate operation schedules and flood inundation maps of gated dams.
(ii) Emergency Action Plans of all high and medium hazard potential dams.

(e) Compilation of miscellaneous information.

(i) New gorge filling works.
(ii) Installation of wireless stations on all major projects during monsoon.

2.4 Uttar Pradesh

2.4.1 Organization

2.4.1.1 There are 80 dams in the State which are 15 metres or more in height or which impound 6000 ha.metre or more of water under the jurisdiction of the Irrigation Department. A Dam Safety Cell has been created by the Government and is functioning since August 1982. The Organization consists of one Director, one Hydrologist, two Executive Engineers and six Assistant Engineers. The main functions of the Cell are maintenance of an inventory of dams and compilation of the history of the dams to bring out areas requiring special attention for their safety. The Cell also monitors the administrative and technical procedures being adopted on all aspects of dam safety and recommends improvement where any deficiency is noticed.

2.4.2 Periodic Inspection Programme

2.4.2.1 The officer in charge of the dam inspects the dam at least once before monsoon. The Executive Engineer inspects the dam once before monsoon and thereafter as per requirements. The Superintending Engineer inspects the dam once before the monsoon. In respect of major, important and potentially more hazardous dam, inspections are done more frequently and in greater detail and also at a higher level. A maintenance manual for earth dams has been published by the Uttar Pradesh Irrigation in 1970. There is a Uttar Pradesh State Engineers Academy at Kalagarh, which also organizes refresher courses on various subjects including dam safety.

2.4.2.2 The inspection reports are sent to the next higher officers for further suitable action.

2.4.2.3 Guidelines for safety inspection of dams compiled by the Central Water Commission has been provided to field engineers for guidance in carrying out the inspection by dam safety cell. Field engineers have been asked to furnish certificate in respect of safety of dams before monsoon season.

2.4.3 Dam Safety Inspection

Checklists for maintenance and repairs of earth dams is given in the maintenance manual. The inspection is done by the field engineers directly and no such reports and follow-up action is sent to the Cell.

2.4.4 Geological Aspects

One post of Geologist has been sanctioned by the Uttar Pradesh Government in the Dam Safety Cell.

2.4.5 Emergency Action Plans

At present there are no detailed dam failure inundation maps for any dams. There is also no practice to prepare emergency preparedness plans for existing dams.

2.4.6 Technical Aspects

These are examined in the Central Designs Organization at Lucknow and Roorkee. The detailed technical designs are done as per IS Code and other standards on the subject.

2.4.7 Quality Control

At every project site quality control is set up with field laboratories to collect samples and carry out tests on smaller works. Samples are taken by the field staff and sent to outside laboratories at Roorkee and Lucknow, etc.

2.4.8 Instrumentation

Instrumentations are being provided in dams under construction as prescribed in standards and codes. Instrumentation has been done in a few important major dams only. The collected instrumentation data is being analyzed.

2.4.9 Operation and Maintenance

2.4.9.1 The operation and maintenance of the dam is done according to the standing regulation orders of the Chief Engineers. A common

maintenance manual for the earth dam published by the Uttar Pradesh Irrigation in 1970 is available for guidance. This manual specifies the duties and checklists. Pre- and post-monsoon inspections and repairs are generally carried out by the field engineers.

2.4.9.2 Uttar Pradesh Irrigation Department has brought out a "Maintenance Manual for Earth Dams" for guidance of field engineers. It specifies the important maintenance features and duties of various officers responsible for the maintenance of the dams. The common causes of failures and remedial measures have also been outlined for guidance of field officers. As per the manual, it is applicable for earth dams upto 30 metres in height as higher dams would require special study and more detailed maintenance instructions.

2.4.9.3 The manual contains detailed instructions on maintenance during monsoon and non-monsoon period. It also specifies in Chapter 6 by way of guidelines, the duties and responsibilities of various officers concerned with the safety of earth dams.

The manual also lists out the following:

(a) Records to be maintained at dam site.
(b) Lists of drawings and data to be maintained at dam site.
(c) Proforma for statement of inspection data for the previous year (which includes action taken).
(d) Daily report proforma
(e) Checklist for maintenance and repairs of earth dams.
(f) Proformae for record of seepage, piezometers, piezometer inspection, etc.

2.4.10 Typical Regulation Order

2.4.10.1 The manual contains a typical regulation order (Pili Reservoir) for guidance.

2.4.10.2 It specifies the regulation points and staff to be stationed. Proformae for daily gauge, rainfall, river discharge and filling of the reservoir are also given.

2.4.10.3 A schedule for filling and emptying the reservoir has been specified which indicates the dates on which particular reservoir levels should be attained. Instructions for observations for determining silting pattern, performance of relief wells and drainage systems, materials to be kept in reserve – their quantity and locations are

also specified. T&P articles to be provided to maintenance and patrolling gauges are also indicated.

2.5 Kerala (Irrigation)

2.5.1 Organization

The Kerala Public Works Department have 11 projects under their jurisdiction. A Dam Safety Cell has been created and is functioning in the office of the Chief Engineer, PIDO, Trivandrum. The Organization consists of one Executive Engineer, one Design Assistant and one Junior Designer who have been deployed for this work from the Design Organization to do this work in addition to their allotted duties. The main functions of this Cell are to document the data pertaining to dams.

2.5.2 Periodic Inspection Programme

The State does not have any periodic inspection programme. If any field officer notices some unusual or potentially dangerous situation, the matter is brought to the notice of higher authorities for instructions.

2.5.3 Dam Safety Inspections

The Department has issued a checklist for maintenance guidelines which is the same as thus circulated by the Central Water Commission. In addition, there are departmental instructions regarding inspection of irrigation structures and their maintenance which comprises of a checklist / questionnaire. The inspections are conducted by the field officers and the reports are not received in the Dam Safety Cell.

2.5.4 Emergency Action Plan

There is no practice to prepare a dam failure inundation map or emergency preparedness plans.

2.5.5 Technical Aspects

2.5.5.1 Unit Hydrograph method is used for determining the maximum flood and for providing suitable spillway. Model studies are also conducted.

2.5.5.2 There are no special manuals but the designs are prepared based on the guidelines and the relevant Indian Standards.

2.5.6 Quality Control

Some of the projects under execution are equipped with laboratories for quality control with an Executive Engineer in charge of the unit. This unit is answerable directly to the Chief Engineer.

2.5.7 Instrumentation

The old dams are instrumented to the bare minimum but these are not functioning properly. Instrumentation data has not yet been analyzed.

2.5.8 Operation and Maintenance

Maintenance is being done as per guidelines given in Kerala PWD Manual which contains checklist / questionnaire.

2.6 Kerala (State Electricity Board)

2.6.1 Organization

The Kerala State Electricity Board have 19 dams under their jurisdiction. There is no dam safety organization as such but there is an organization to look after the safety of the dams under Idukki Project. This organization consists of one Director with one Deputy Director and three Assistant Executive Engineers. The organization is known as the Research Organization, Kothamangalam.

2.6.2 Periodic Inspection Programme

No periodic inspection programme except for dams in Idukki Project. Dam monitoring unit of research organization under Kerala State Electricity Board is responsible for inspection of dams in Idukki Project. Checklists / manuals are available only for dams of Idukki Project.

2.6.3 Technical Aspects

Efforts are made to see that all the dams owned by Kerala State Electricity Board are maintained to the latest requirements in the field of design, construction and maintenance. But proper and sufficient personnel still remains to be mustered for this job.

2.6.4 Quality Control

Kerala State Electricity Board maintains quality control laboratories in all the projects under construction which though attached to the Construction Wing, performs independently and is under the Chief-in-Charge of the Project.

2.6.5 Instrumentation

Instruments are provided only in Idukki, Cheruthoni, Kulamanu and Idamalayar dams. Regular observations are taken and analysis of data are being carried out.

2.6.6 Operation and Maintenance

At present in Kerala State Electricity Board, Deputy Director, Research Organization is attending to maintenance and operation of dams in Idukki Project. There are no separate organizations for other dams. Operation manual, maintenance manual and checklists are available for Idukki dam.

2.6.7 Emergency Action Plan

No emergency action plans to cover any possible failures of dams constructed and maintained by Kerala State Electricity Board have been evolved so far.

2.7 Orissa

2.7.1 Organization

2.7.1.1 In Orissa, the operation and maintenance of all large, medium and small dams is being done by the Irrigation and Power Department. Mandira dam on river Sankh is operated and maintained by M/s Hindustan Steel Limited, Rourkela and Jalaput dam on Machkunda river operated and maintained by Andhra Pradesh State Electricity Board.

2.7.1.2 The Dam Safety Organization in Orissa is headed by Superintending Engineer, Dam Safety and Hydraulic Research Circle. Two Executive Engineers are attached for dam safety functions.

2.7.2 Periodic Inspection Programme

2.7.2.1 Dam safety inspections are conducted by Superintending Engineer, Dam Safety & Hydraulic Research Circle, Burla and Executive

Engineer, Dam Safety (Major Projects) Division and Dam Safety (Medium Projects) Division in accordance with the framework of designated duty and based on the guidelines and safety inspection of dams issued by Dam Safety Organization of Central Water Commission. The Phase I investigation for all completed and on-going medium and major projects has been completed and the inspection reports have been submitted to Engineer-in-Chief, Irrigation, Orissa. The Phase II investigation of dam safety inspection has not yet been started.

2.7.2.2 The Superintending Engineer, Safety Circle submits suggestions to the Engineer-in-Chief in respect of improvements in the administration and technical methods required to ensure dam safety as and when such necessities are needed in the course of inspection.

2.7.3 Geological Aspects

A Superintending Engineer (Geophysics) is functioning under the Engineer-in-Chief and he generally conducts geophysical exploration during inspection stages. Geophysical inspections during the pre-construction stages are done by the Engineering Geology Division of the Geological Survey of India.

2.7.4 Technical Aspects

(a) The State is following the guidelines issued by the CWC.
(b) The IS Code of practices is followed in the design of the dam.

2.7.5 Quality Control

The quality control organization at the State level and at project level controls the quality of work.

2.7.6 Instrumentation

Generally instrumentation is being done only in respect of major projects and this is done by the respective projects. A proposal is being made to entrust all instrumentation work to the Dam Safety Circle.

2.7.7 Operation and Maintenance

The operation and maintenance is being done by senior engineers, stationed at head works. Superintending Engineers have been stationed at major dams.

2.7.8 Emergency Action Plan

Emergency Action Planning has not yet been developed.

2.8 Tamil Nadu

2.8.1 Organization

2.8.1.1 There are 43 (forty three) dams under the jurisdiction of Tamil Nadu PWD (Irrigation Department) and 44 (forty four) dams under the control of Tamil Nadu Electricity Board.

2.8.1.2 The Dam Safety Cell in PWD in Tamil Nadu is attached to the Chief Engineer (Irrigation). The Cell comprises of one Assistant Executive Engineer, one Assistant Engineer, one Assistant D'man, one Assistant and one Office Assistant and is functioning under the control of Deputy Chief Engineer (Inter State Waters). The Cell is entrusted with the task of ensuring safety of dams in PWD, Tamil Nadu. The main functions of the Cell are documentation of details in specific formats, continuous monitoring and review of inspection reports and seepage flows and taking necessary follow-up action.

2.8.2 Periodic Inspection Programme

The field Superintending Engineers and Executive Engineers have been instructed from Chief Engineer's (Irrigation) office during April 1982 to follow the guidelines for safety inspection of dams based on the checklists furnished by the DSO and submit the inspection reports. After review of the inspection reports, the final decision regarding the remedial measures, if found necessary, is taken by the Chief Engineer (Irrigation). The guidelines issued already to the field officers in connection with the safety inspection of dams have been further amplified during 11/84 and 1/86.

2.8.3 Technical Aspects

(a) Generally the design flood is estimated using Ryve's formula. For some recent dams, unit hydrograph method has been adopted.

(b) (i) For the projects which are 30 m or more in height, the seismic coefficient recommended by the "Standing Committee constituted by the Government of India to advise on the seismic coefficient to be adopted in the design of River Valley Projects" is being followed.

(ii) For the projects which are less than 30 m in height, the seismic coefficient as per I.S.Code is adopted.

(c) Structural designs are as per I.S.Code.

2.8.4 Dam Safety Inspections

Dam Safety Evaluation Inspections have not yet been taken up.

2.8.5 Quality Control

In large projects, separate staff for quality control is established. This unit works directly under the control of the Chief Engineer of the Project. In case of other projects, the field officers themselves control the quality of the work. The quality of work is also ensured by frequent inspection by the higher officers.

2.8.6 Instrumentation

Instrumentation in dams are provided where essentially required and their working monitored.

2.8.7 Operation and Maintenance

Maintenance guidelines have been issued by the Chief Engineer (Irrigation) in April 1982.

2.8.8 Emergency Action Plan

There is no practice of preparing Emergency Action Plan. This will be taken up and details worked out in due course.

2.9 Damodar Valley Corporation

2.9.1 Organization

2.9.1.1 There are four dams owned and operated by Damodar Valley Corporation. These are Tilaiya, Konar, Maithon and Panchet.

2.9.1.2 A Dam Safety Cell is functioning in Damodar Valley Corporation. This Cell is headed by the Chief Engineer (Civil) with Deputy Chief Engineer (Civil), Superintending Engineer (Engineering Circle), Superintending Engineer (Circle I & II), Manager, Reservoir Operation and respective Maintenance Senior Divisional Engineers of the Dam.

2.9.2 Periodic Inspection Programme

2.9.2.1 Pre- and Post-monsoon inspections are being carried out by Level I (Superintending Engineers) and Level II (Sr.Divisional Engineers / Executive Engineers) officers. Items of inspection are generally as per the instructions of the Dam Safety Organization of the Central Water Commission issued from time to time. Special inspections are also being carried out by the two levels of engineers from time to time as the situation warrants.

2.9.2.2 There is no regular system for imparting training to the officers engaged in dam safety. The officers are sent to attend workshop or seminars.

2.9.2.3 Inspection reports are compiled and monitored by the Sr.Divisional Engineer, under the guidance of Manager, Reservoir Operation. Special items requiring remedial measures are placed before the dam safety cell which are discussed in various meetings and finally placed before the Chief Engineer (Civil) for advice.

2.9.3 Dam Safety Inspections

Dam safety inspections are carried out as per the checklists prepared by Dam Safety Organization of the Central Water Commission with minor changes.

2.9.4 Geological Aspects

The services of Geological Survey of India are requisitioned for geological and surface exploration and for interpretation of data whenever required.

2.9.5 Emergency Action Plan

There is no practice to prepare a dam failure inundation map. Emergency preparedness plan have also not been prepared so far.

2.9.6 Technical Aspects

Design floods are reviewed from time to time and spillway capacities, freeboard are being assessed accordingly. In re-assessing, latest relevant code of ISI are followed.

2.9.7 Structural Aspects

The relevant IS Codes are being followed.

2.9.8 Instrumentation

Piezometer settlement pipes are provided in earth dams. Some instruments have been installed at Konar dam after its distress. Regular observations are being taken and the data is being analyzed.

2.9.9 Operation and Maintenance

2.9.9.1 The existing practice for operation of the reservoir in Damodar Valley Corporation is incorporated in Damodar Valley Corporation reservoir manual.

2.9.9.2 There is a committee known as "Damodar Valley Reservoir Regulation Committee" with Member (Floods) of Central Water Commission as its Chairman. This Committee meets periodically to review the reservoir operation of DVC reservoirs.

2.9.9.3 Maintenance is carried out by the Maintenance Division as per CWC guidelines.

2.10 Bhakra Beas Management Board

2.10.1 Organization

2.10.1.1 Bhakra Beas Management Board is looking after the administration, maintenance and operation of a big irrigation and power complex consisting of three major hydro-electric projects, namely Bhakra dam, Beas dam, BSL Project, including Pandoh dam.

2.10.1.2 A Chief Engineer stationed at each of the three project sites looks after the safety of the dam under his charge and is assisted by the field and design engineers.

2.10.2 Periodic Inspection Programme

2.10.2.1 Periodic inspection of work of all the three dams is being done regularly by field engineers as stipulated in the publication entitled "Criteria for operation, maintenance and observations published by each project and necessary reports are sent to the Chief Engineer and Director (Designs) through their respective Superintending Engineer. As a result of field inspection, discussions and study of the problem in detail, necessary remedial measures, if required, are adopted. Annual observation memorandum for each project is

prepared on the basis of the observed, field data, and these are put up to the Board of Consultants for review and advice.

2.10.2.2 Detailed checklists work-wise for dry testing before initial filling, during initial filling, de-watering, etc., have been prepared and supplied to field engineers. Checks required to be done before the onset of monsoons, during monsoon and during routine and other maintenance have also been incorporated in the operating instructions issued to the field engineers.

2.10.3 Emergency Action Plan

Dam failure inundation map and Emergency Action Plans have not been prepared.

2.10.4 Hydrological Aspects

2.10.4.1 A network of snow gauges, rain gauges, automatic rain gauges, discharge sites with reliable communication system, etc., was created to determine the soundness of the previous available data and for collecting further data which is necessary for deciding the regulation of supplies from the reservoir from time to time.

2.10.4.2 A separate Regulation Directorate has been created to regulate the flow of water judiciously for maximum benefit of the water for the partner States. A separate Hydrological Cell has been created under this Directorate for comprehensive observation of hydrological data. This Hydrology Cell is also in constant touch with other related agencies for rain forecasts, glacier / avalanche studies, snowfall studies, etc., and also for deciding regulation of supplies from the reservoir.

2.10.4.3 The silt survey and sedimentation studies were carried out annually in the first few years of the commissioning of the project and on alternate years thereafter to know the pattern of silting in the reservoir and the loss of reservoir storage capacity.

2.10.4.4 The design flood for both Beas and Pandoh dams have been estimated as per USBR criteria. Estimation of flood for Bhakra dam designed nearly 40 years ago was based on various empirical formula and probable flood frequency studies. Recently, studies were carried out for Pandoh dam by CWC to work out the SPF and PMF. Similar studies for Bhakra and Beas dams have also been initiated.

2.10.5 Technical Aspects

2.10.5.1 A separate Design Directorate was created for the design of permanent works of Bhakra Beas project to deal with the design of various works and also to maintain a record of construction activities. The relevant Indian Standards and design criteria adopted for other similar works in India and abroad were consulted for evolving the requisite designs. For problems concerning designs of the important works, technical memos were prepared and presented to the Board of Consultants for advice.

2.10.5.2 A network of seismological observatories around the dams and their appurtenant works were installed to assess and monitor the seismic behaviour of the structures and also to find out the effect of impounding of water in the reservoirs on the seismicity of the area. The School of Earthquake Engineering, Roorkee was consulted for fixing up the seismic coefficient for the design of various structures and these were also got approved by the Board of Consultants.

2.10.5.3 The BBMB has a data bank which gives complete details of drawings, computation, model tests reports, specifications memos work-wise along with the source from where taken and are kept for ready reference.

2.10.6 Operation and Maintenance

Guidelines for maintenance staff have been laid down in the publication of "Guidelines for Operation, Maintenance and Observations" prepared separately for each dam and its appurtenant works. In addition, detailed instructions for operation, maintenance and checklists, etc., important do's and don'ts along with instructions are displayed at conspicuous places.

2.10.7 Instrumentation

2.10.7.1 A Design Directorate to monitor the structural behaviour of the three dams under the charge of BBMB and to process the instrument data has been created.

2.10.7.2 Instruments have been provided for all the three dams. Regular observations of various instruments are being taken by field engineers. The annual observation reports for individual projects giving complete details of the structural behaviour of works as obtained from the instrument data are being prepared and is being put up to a special committee of technical experts headed by the Chairman, Central Water Commission.

2.11 West Bengal

The dams in West Bengal are mostly owned and operated by Irrigation and Waterways Directorate.

2.11.1 Organization

A Dam Safety Cell has been created for monitoring the activities in connection with dam safety. The functions and composition are not finalized. At present it is engaged in documentation of existing dams and in checking safety of large dams. The Cell is headed by one Assistant Engineer.

2.11.2 Period Inspection Programme

The periodic inspection programme consists of inspection by Executive Engineer twice a year and by Superintending Engineer once a year.

2.11.3 Training

There is no facility for imparting training to staff in dam safety.

2.11.4 Dam Safety Inspection

The "Guidelines for Safety Inspection of Dams" prepared by the Dam Safety Organization of CWC are adopted. Checklists and instructions issued by CWC for inspection of dams are followed.

2.11.5 Emergency Action Plan

There is no practice of preparing Emergency Action Plans. On the basis of flood forecasting system there is a procedure for alerting the area likely to be inundated wherever danger is apprehended.

2.11.6 Technical Aspects

Detailed investigations and designs are done on the basis of standards adopted by I.S.I., CWC, etc. Designs done are reviewed if design criteria are revised. There is no system for review at fixed intervals.

2.11.7 Hydrological Aspects

As per standards laid down by I.S.I. and guidelines for preparation of projects, works of re-evaluation of adequacy of spillway of existing large dams is under progress.

2.11.8 Quality Control

For major projects separate Quality Control Wing is set up. In other cases necessary arrangement is made under the engineer in-charge of construction. In case of separate quality control unit this is also responsible to the project in-charge of construction.

2.11.9 Instrumentation

Instrumentation is provided in all large dams. Not all the instruments are functioning properly. Analysis of observations are made during dam safety inspections.

2.11.10 Operation and Maintenance

Superintending Engineers and Executive Engineers are in charge to guide operation especially during floods. Operation manual has been prepared for one large dam.

2.12 Karnataka Power Corporation

2.12.1 Organization

2.12.1.1 There are six dams under the jurisdiction of Karnataka Power Corporation, viz. Talakalale, Linganamakki, Bommananahalli Pickup dam, Chakra dam, Savehakklu dam and Tattihalla dam.

2.12.1.2 There is a Dam Safety Cell in Karnataka, which reviews the safety of dams under the Irrigation Department and also the Karnataka Power Corporation. The Secretary to PWD, Government of Karnataka is the Chairman and Chief Engineers of major projects are Members. The Director, Karnataka Engineering Research Station, Shri Krishnarajasagara is the Member-Secretary.

2.12.1.3 The Chief Engineer (Civil Designs), Karnataka Power Corporation is also a member of the Dam Safety Cell.

2.12.1.4 The main functions of the Dam Safety Cell is to review the inspection checklists furnished by the various projects to the Dam Safety Cell and suggest measures regarding safety of the dam, etc.

A sub-Committee has been constituted by the Dam Safety Cell for review of the reports and placing them before the Dam Safety Cell.

2.12.2 Periodic Inspection Programme

The inspection programme consists of an inspection by the Chief Engineer in charge of the dam twice in a year, one before monsoon and the other after monsoon, the Project Engineer in charge of the dam twice in a year, one before monsoon and the other after monsoon, independent of Chief Engineer's inspection. The Divisional Engineer has to inspect the dam once in a month. The inspection of the dams are carried out as per the guidelines issued by the Dam Safety Organization of the CWC.

2.12.3 Dam Safety Inspection

The inspection checklists issued by the Dam Safety Organization of the CWC are being followed. There is no regular training programme.

2.12.4 Geological Aspects

A Divisional Geologist is in charge for carrying out geological and sub-surface exploration, interpretation of data and day to day problems. Assistance of Geological Survey of India is also taken.

2.12.5 Structural Aspects

Panel of experts are consulted. The panel consists of Shri N.G.K.Murty, Shri P.M.Mane, Shri K.C.Thomas, Shri M.S.Balsundram and Member (D&R), CWC.

2.12.6 Quality Control

Independent quality control unit is set up at the project locations which are technically and administratively under the control of Chief Engineer (Designs), independent of the Construction Wing.

2.12.7 Instrumentation

Instrumentation is provided in all the dams. Most of the instruments are in working condition and the data is being analyzed.

2.12.8 Operation & Maintenance

The manuals issued by the Dam Safety Organization of the CWC are being followed.

2.13 Karnataka (Irrigation)

2.13.1 The Government of Karnataka created a Dam Safety Cell in July 1981 comprising Additional Secretary, PWD, Irrigation as Chairman, Chief Engineer, Upper Krishna Project (Canals) and Chief Engineer (Logistics), Karnataka Power Corporation as Members and Deputy Secretary, PWD (Irrigation) as Secretary.

2.13.2 With a view to involving the expertise available with both Irrigation Department and Power Corporation, the Dam Safety Cell was expanded in August 1981 with five Chief Engineers as Additional Members and Director / Chief Engineer, Karnataka Engineering Research Station, Krishnarajasagar as Member Secretary. The Chief Engineer (DSO), CWC is a member of this Cell.

2.13.3 The terms of reference of the Dam Safety Cell are as under:

(a) To prepare and update checklists for the preparation of inventory of dams and to compile the history of each dam.

(b) To review the particulars furnished by the Chief Engineer on the checklist and to identify such of the areas which require special attention of the Cell and offer advise thereon.

(c) To inspect such of the identified areas and to forward its findings and recommendations to the Government for taking further action.

(d) To suggest remedial measures, follow-up actions subsequent to the inspection by the Cell and to forward its report to the Government.

(e) The final recommendations of the Cell with probable financial implications of such recommendations will be placed before the State Cabinet for its decision.

2.13.4 The members of the Dam Safety Cells felt that there should be a sub-Committee for review of the data documented for the dam. Accordingly the Government of Karnataka has set up a sub-Committee with the following members:

(i) Director, Karnataka Engineering Research Station, Krishnarajasagar.

(ii) Chief Engineer, Water Resources Development Organization, Bangalore

(iii) Representative from CWC) Members of the
) Dam Safety Cell
(iv) Geologist)

2.13.5 One Superintending Engineer and some staff have been deputed for review of the data books (documentation) and checklists of various dams and to put up to the sub-Committee.

~~5~~ 1

Chapter III

EVALUATION OF EXISTING PROCEDURES

3.1 General

3.1.1 As per the directive of the first State Irrigation Ministers' Conference, a Dam Safety Organization was created in the Central Water Commission in May 1979. Within a short period of its existence, this Organization has been called upon to advise on a number of problems.

3.1.2 In India, by and large, storage dams were owned, constructed and maintained by the respective State Governments. The responsibility for ensuring their safety rests with the owner.

3.1.3 The Dam Safety Organization in the Central Water Commission consisting of one Chief Engineer with one Director initially was intended to assist the State Governments to identify causes of distress and to recommend measures for restoring the integrity of the structure. The services rendered by this organization are only on specific request from the State Governments.

3.1.4 It was realized that it would not be possible to cater to simultaneous requests from different States on problems encountered in respect of dam safety by the single agency located at the Centre with the staff initially sanctioned. This was considered in the Fifth Conference of State Ministers of Irrigation who resolved that the State Governments should also constitute their own Dam Cells / Organizations with a view to build up appropriate expertise at the State level to cater to the requirement of the States. These Cells of the States inter-alia were required to maintain an inventory of dams, compile history of each dam to bring out areas requiring special attention to review and monitor administrative and technical procedures adopted in respect of dam safety. In pursuance of the above resolution, the following States have created Dam Safety Cells / organizations:

Andhra Pradesh, Goa, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Rajasthan, Tamil Nadu and Uttar Pradesh & West Bengal.

3.1.5 Only the State of Bihar which owns significant number of dams is yet to create a Dam Safety Cell.

3.1.6 The staffing pattern in the various State Cells is given in Appendix V.

3.1.7 All dams in this country are by and large owned by the State Governments through their various departments like Irrigation Department, State Electricity Board, Corporation, Municipal Corporation, Public Undertakings who are semi-Government organizations. In fact the dams were owned originally by Irrigation Department in most of the States. With the formation of State Electricity Board, the ownership of hydro dams has gone over to the Electricity Boards. This has become a regular feature for hydro-electric projects in most of the States. For example in Uttar Pradesh, the owner of Rihand dam is the State Electricity Board while the maintenance is being looked after by Irrigation Department and the funds are made available to the Irrigation Department by the State Electricity Board. In Gujarat, all dams are owned and maintained by the State Government through the Irrigation Department and come under the purview of Dam Safety Organization. Maharashtra is the only State wherein a few dams are owned by private agency, i.e. TATAS, Zilla Parishad and Bombay Municipality. A question arises whether all these Governments, Semi-Governments / Departments should create a Cell and which would be the right organization to undertake this task. The departments who own maximum number of dams in the State shall take the burden of building an expertise in dam safety and to this effect the Cells may be constituted. The other departments who own the dams in the State, i.e. State Electricity Board, Municipal Corporation, Public Undertakings shall seek the assistance of these Cells for getting their dams reviewed and also shall send review reports to them. If any Executive Order or orders / legislations are required in this behalf, the same shall be enacted at the State level. From consideration of background and available infrastructure and expertise it appears desirable that these Cells shall be created by the Irrigation Department in the State who incidentally owns maximum number of dams.

3.1.8 Among the States, Maharashtra and Gujarat have gone in a systematic way to evolve appropriate machinery to take care of dam safety aspects. In Gujarat, the Dam Safety Cells are charged with the responsibility of conducting safety inspection in respect of all dams, major and medium in their States. As against this in Maharashtra, the Dam Safety Cell has an advisory role. On the administrative side, Gujarat has a Chief Engineer who has under him design organization and GERI and the Cell itself is manned by two Superintending Engineers, one exclusively for dam safety and gates and the other reviewing hydrological aspects of all existing

dams. The organizations set up in the other States are not as elaborate as has been in existence in Gujarat and Maharashtra.

3.1.9 In Andhra Pradesh which has significant number of dams, the existing Executive Engineer has been asked to look after the dam safety aspects also. Obviously such a situation appears to be inadequate to the task involved in dam safety.

3.1.10 It would be observed from the details given in Chapter II that there is no uniformity either in the administrative set up or functions of the Dam Safety Organization in the State. While the administrative set up may have relation with the number of dams, it would be necessary to have very clear cut demarcation of its functions vis-à-vis the functions of the existing departments who are in charge of the dams, lest we introduce complacency. Maharashtra Government have gone to the extent that it may be useful to finalize the Emergency Action Planning even at the stage of sanctioning of the project. They have stipulated in their manual that Emergency Action Plan should be prepared before gorge filling work is taken up. Such stipulations are not indicated by the other States. Further, the size of the dams that come under the purview of the Cell also differ from State to State. For example, in Gujarat the activities of the Cell are confined to major and medium dams which cater to irrigation for more than 10000 and 2000 hectares respectively, irrespective of the height of the dam or its storage. From the point of view of risk and hazard, height and quantum of water stored behind the dam are significant parameters to be reckoned for their falling under the care of Dam Safety Cell. As against this, in Maharashtra, all large dams fall under the purview of Dam Safety Cell. The Government of Maharashtra have also in their scheme, an advisory dam inspection and safety service comprising 4 to 5 retired Chief Engineers of Maharashtra State to advise the Government regarding safety aspects of the dam in the State.

3.1.11 On the technical side also variations are noticed both in Gujarat and Maharashtra and perhaps Karnataka also.

3.1.12 The procedures and practices adopted from the conceptual stage of Bhakra, Beas and Pong dams till they are translated to reality and in their subsequent maintenance, have been highly systematic and thorough.

3.1.13 In Gujarat particularly, there is a Superintending Engineer (Geology) attached to the Central Design Organization. Under his guidance, the Engineering Geology Divisions of the State

Government are carrying out geological investigation and sub-surface investigation, etc. However, certain projects are also referred to GSI whereas in Maharashtra there is a geological unit under Superintending Engineer (CDO) and the investigations are planned and executed in consultation with the GSI. Kerala has not furnished any information as to the machinery available for geological investigation. It is presumed that GSI is consulted. The Kerala State Electricity Board has a Superintending Engineer (Geophysical) who conducts geophysical exploration during inspection stage and detailed investigations are done by GSI. In Tamil Nadu, GSI is consultant for geological and surface exploration.

3.1.14 In other States also, GSI is consulted. As regards computing design flood, practices vary from State to State and many States have designed their inflow design flood on the basis of empirical formula.

3.1.15 Designs are based on ISI standards though in some States the criteria are indicated but ISI have not been strictly adhered to. However, USBR practices are also followed. On the construction side, there has been a separate quality control organization in most of the major and medium projects and the administrative set up is in keeping with the size of the project. Rules for operation and maintenance did exist in most of the States even though they did not have the brand name of the dam safety. In pursuance of the resolution adopted in the Irrigation Ministers' Conference, Dam Safety Cells have been created in 12 States. These are now charged with the responsibility of bringing out adequate manuals on operation and maintenance of hydraulic structures throughout the State. For example, many people were not aware of the existence of a manual, viz. 'Maintenance Manual of Earth Dams' published by Uttar Pradesh Irrigation in 1970. The Maharashtra Government have recently taken up preparation of a Dam Safety Manual, particularly for operation and maintenance. Fort the rest of the States, there appears to be a need for filling up the gap in the existing machinery to ensure effective dam safety surveillance.

3.1.16 On the instrumentation side, which is vital for monitoring of dam safety, there appears to be a communication gap between the officer-in-charge of design / construction and officers who take over maintenance. There are many instances where the officers in charge of maintenance are not aware of the instrumentation proposal that has gone into the dam and there exist many missing links. The initial readings of the instrument are rarely available for

an instrument embedded in the dam, the absence of which has made subsequent analysis difficult.

3.2 Technical report of design and construction.

3.2.1 Prior to independence, the dam building activity was not as intense as it became after independence. In our urge to catch up with all round development in the world, a large number of irrigation and hydro-electric projects were taken up. In the process, only the basic necessities required in the activities of the project were carried out, since time was at a premium. The record preparation and its management was relegated to the background. This is borne out by the fact that whereas completion report for old dams like Periyar and Rihand are available, no such well-compiled documents are available for many dams constructed after independence. Such records at a later date will assume great importance was not thought of for dams constructed after independence. The importance of such records, however, has been day-lighted as the necessity has now arisen to review the various aspects of design and construction with a view to determine its safety, vis-à-vis the present standards.

3.2.1 Each River Valley Project is unique and presents many complicated problems peculiar to that particular project. In spite of detailed investigations, surprises are met within the foundation and modifications from the original design need to be made in the light of feedback received from the field during construction. Many challenging problems are encountered during construction which could not be solved on the conventional methods and solution of the same might have resulted in new method of construction technique and innovations. Unless these experiences are properly recorded they would be lost for posterity. It is, therefore, necessary that completion report of all important and major projects shall be undertaken by the Chief Engineer of the project when the project is in 50% completion stage.

3.2.2 He should take advance action to identify the various chapters that need to go with the completion report. The quantum of data that need to be presented in the completion report with regard to quality control exercised during construction, the extent of geological features that need to be incorporated in the report need to be decided by him, in consultation with the Engineering Geologist. He should also identify engineers who would write chapters and those identified officers shall be responsible for preparation of the chapter assigned to them. It would be desirable if they are kept in the same project till these final chapters are written by them.

However, due to administrative exigencies, if engineers are transferred to some other project, they should still be responsible for completion of the chapter assigned to them. These officers shall be given suitable financial incentive to motivate them to take up this work in right earnest and complete them on time.

3.2.3 A separate financial provision in the project report shall be provided for preparing the completion report including its printing etc. It shall also cover the cost of micro filming important technical and quality control data that need to be kept for posterity.

3.2.4 As regards fixing of priorities in writing completion report of projects, first priority will be accorded to on-going projects for which immediate data is available and the personnel involved in design and construction are there within the project area to take up the task of writing the completion report chapter by chapter. Second priority will be accorded to those projects which have been completed recently and for which completion reports are not available. In writing the completion reports for such dams, the records will have to be searched and the personnel involved in the various phases of design and construction will have to be located before commencing writing of the completion report. The third and last priority will be given to those projects that have been constructed long back and for which much efforts are required to locate the data for compiling the completion report. It is likely that the personnel involved in the various activities of the project might have retired from service. Fixation of the above priorities are essential to ensure that some progress is achieved within a reasonable time in writing the completion reports and valuable time and energy are not dissipated in searching old records.

3.3 Design Memoranda

3.3.1 The preparation of memorandum on all aspects of design is a good practice which has been followed in many major projects like Bhakra, Beas, Ramganga and presently in Sardar Sarovar and Navagam projects. The practice should be extended to all medium sized projects also. The memoranda should be put up to the dam safety panel for the projects and their views / recommendations obtained. A copy of the memo should be sent to the Dam Safety Cell of the State. By this process, the collective wisdom of the top experts in the field is brought to bear in the planning stage of the project and this will go a long way for strengthening of design cell of the State as well as Central Water Commission.

3.3.2 A copy of the memorandum together with the report of the panel should be sent to Dam Safety Cell in the State and Chief Engineer (DSO), Central Water Commission.

3.3.3 The personnel manning the design cell in the State should be a chosen one, who have the required aptitude for original work and design. Provision to give special design allowance shall be made to attract the best talent in the department.

3.4 Preservation of records

3.4.1 All technical data from planning to completion and relating to subsequent operation, i.e. hydrological data, drawings, memos, specifications, design computations, model test reports, geological reports, survey reports, seismological reports, special studies, construction drawings, operating instructions from suppliers of equipments, structural analysis report, foundation conditions and remedial measures taken and field reports should be preserved for future reference. The photo negatives, photostats of all drawings, completion plans, survey sheets & geological plans be prepared for future references.

3.4.2 A data bank complete with the above details along with the source from where these can be located be prepared work-wise. The micro-filming of the important drawings, reports and computations may also be done. These shall be preserved for the entire life of the project.

3.5 Dam Safety Organization in the Central Water Commission

3.5.1 Coming to the organization at the Centre, it is seen that the organization as sanctioned provides for one Chief Engineer and one Director with complementary staff. Realizing that this is too inadequate, the Commission on its own attached two more Directorates, viz. Special Analysis & Instrumentation Directorate and Foundation Engineering Design Directorate to give the necessary support to the Organization.

3.5.2 This Organization has done commendable work in bringing out guidelines for safety inspection checklists, etc., and has also been instrumental in setting up Dam Safety Cells for effective surveillance and monitoring of dams in the States. It has also developed the following computer programmes:

- Conventional stability analysis for Gravity Dams.
- Simplified method of dynamic analysis of Gravity Dams by Chopra's method.
- Dynamic analysis of Gravity Dams by FEM.
- Programme for rehabilitation of existing dam by backing on the downstream face.

3.5.3 With a view to up-dating technical know-how of instrumentation and dam safety surveillance, a UNDP proposal has been framed and the proposal is in advanced stage of being taken up for implementation. The proposal envisages training of CWC and State officers in instrumentation as well as dam surveillance programme. It also provides for workshop to be organized on instrumentation and underwater investigations of dams and the necessary equipment required for these investigations are also proposed to be obtained through UNDP aid.

3.5.4 States are advised to utilize the facilities developed at the Centre and arrange to depute senior / middle level officers to these workshops.

3.5.5 Out of 22 States and 9 Union Territories in this country, only 12 States have constituted Dam Safety Cell. The following States / Union Territories in the country have yet to create Dam Safety Cells and develop dam safety expertise.

1. Assam	2. Bihar	3. Jammu & Kashmir
4. Manipur	5. Meghalaya	6. Sikkim
7. Andaman & Nicobar	8. Tripura	9.Arunachal Pradesh
10. Delhi		

3.5.6 For some more years to come, the Centre will have to provide necessary support both in respect of design of hydraulic structures and also for their surveillance to these States. The number of dams in all the above States is of the order of 50. It is recommended that the safety review of these dams shall be initiated by the Centre. This would call for strengthening Dam Safety Organization in the Central Water Commission for effective implementation of the dam safety programme in the country.

3.5.7 The Dam Safety Organization in the Central Water Commission should also oversee the safety status of such dams, the failure of which would have inter-State repercussions. They shall also assist in developing appropriate mechanism for coordinated activity for such dams.

3.5.8 The Dam Safety Organization need to be strengthened in the following disciplines:

(a) Development of computer programme, Numerical studies, including Finite element techniques.
(b) Dam Safety Surveillance.
(c) Hydrology.

3.5.9 In respect of (a) & (b) the existing directorates need to be strengthened. Separate staff will have to be provided for hydrological review. Such strengthening of the Dam Safety Organization in the Centre is essential for taking up the additional responsibility as suggested in para 3.4.6, and also for effective dam safety programme in the country.

3.6 The Standing Committee

3.6.1 In the Standing Committee only one State is represented, i.e. Gujarat. Since many States have significant number of dams, it is essential that they are represented on the Standing Committee. The Committee, therefore, recommends that all States having significant number of dams be represented on the Committee. Such broad-based Committee would help in the follow up action on the recommendations of this report of the Standing Committee. The Standing Committee should meet at least once a year to review the dam safety programme in the country.

Chapter IV

SUGGESTED ADMINISTRATIVE SET UP FOR THE DAM SAFETY CELL IN THE STATE, ITS FUNCTIONS AND PRIORITISATION FOR SAFETY REVIEW

4.1 Introduction

4.1.1 A well planned administrative machinery is essential to achieve the objective of ensuring the safety of dams. The administrative set up in each State will have to be governed by the number of major dams in the State. Some of the States which have hardly a few dams, the administrative set up need not be as elaborate as has been suggested for States having significant number of dams. The assistance of the Dam Safety Organization of CWC may be availed in such cases.

4.1.2 The Government of Gujarat and Maharashtra have gone a systematic way in developing infrastructure required for dam safety surveillance. The Bhakra Beas Management Board have a very well manned dam safety surveillance and monitoring procedures. In Maharashtra State dam inspection and dam safety services are constituted with advisory capacity as its main function. As against this, Gujarat State have attempted to involve Dam Safety Cell in a more effective way for implementation of dam surveillance programme. There is a school of thought which holds the view that a Dam Safety Cell should be made responsible for the safety of the dam. In the context of Indian condition and administrative set up, the owners invariably being Government agencies, barring a few exceptions, an independent authority either in the Centre or at the State would bring in dual responsibility leading to responsibility with none. In view of this, the Committee recommends the responsibility for the safety of the dam shall rest with the owner of the dam. A similar concept is in existence in the Railway Act. This is also reflected in the Dam Safety Procedures in other countries like USA, UK, Switzerland, Finland, etc.

4.2 Administrative set up

4.2.1 Each State which has more number of major dams (more than twenty) should have a post of Chief Engineer under whom the following departments may be attached:

(a) State Engineering Research Laboratory,
(b) Design and Investigation Wing,
(c) Dam Safety Cell

4.2.2 If separate Chief Engineers are existing in respect of the above discipline, then the Dam Safety Cell should be placed under the Chief Engineer, Design & Investigation Wing. The Dam Safety Cell shall include one Hydrology Unit which would undertake the review of the inflow design flood after fixing priorities.

4.2.3 The Cell may be headed by an officer not below the rank of Superintending Engineer initially, and may consist of one expert on the design of concrete and masonry dams and another expert on earth and rockfill dams with supporting technical staff. One of them should have a good geotechnical background. An identified officer from GSI should be associated with the Cell.

4.3 Functions

4.3.1 Existing Dams

4.3.1.1 Only large dams as defined by the ICOLD may be considered for identification by the Cell / Organization in their dam safety programme. Tailings dam should also be included. A large dam has been defined by the ICOLD as either:

A dam above 15 m in height measured from the lowest portion of the general foundation area to the crest; or

A dam between 10 and 15 m in height provided it complies with at least one of the following conditions:

(a) the length of crest of the dam to be not less than 500 metres;

(b) the capacity of the reservoir formed by the dam to be not less than one million cubic metres;

(c) the maximum flood discharge dealt with by the dam to be not less than 2000 cubic metres per second;

(d) the dam has specially difficult foundation problems; or

(e) the dam is of unusual design.

4.3.1.2 The technical documentation of all identified projects should be compiled and kept for record by the Cell. The latest techniques of microfilming and keeping data in the computer is suggested.

4.3.1.3 Each State should issue executive order for inspection, maintenance and surveillance of dams.

4.3.1.4 The responsibility for the safety of the dam rests with the engineer in-charge.

4.3.1.5 The follow up action on the executive order, the implementation and monitoring aspect will be taken care of by the Cells constituted in the State.

4.3.1.6 The State Cell shall arrange safety review of dam which are more than 15 metres in height or which store 50,000 acre feet or more of water by an independent panel of experts once in 10 years. The State Cell shall develop its own mechanism for safety review of the balance dams in their State. The Dam Safety Cell / Organization of the State shall submit an annual report of the review done to the State with copy to Dam Safety Organization of CWC.

4.3.1.7 The State should also arrange for review of spillway capacity of the existing dams after assigning priorities and convey the recommendation for provision of additional spillway / modification of operation if called for or any other alternative means by which it could be accommodated, to the Secretary to the Government who in turn will pass it on to the concerned Chief Engineer for implementation. A copy of that letter shall also be endorsed to the Dam Safety Cell for monitoring.

4.3.1.8 Pre- and post-monsoon inspection of the dam shall be done by an engineer not below the rank of an Executive Engineer. A responsible engineer should be stationed at the dam site throughout the monsoon period and he should send periodical reports about the behaviour and health of the dam.

4.3.1.9 His report should be forwarded to the Superintending Engineer who in turn will forward it to Chief Engineer with copy to Dam Safety Cell for information.

4.3.1.10 If there are no problems, the Dam Safety Cell should record the report for future reference.

4.3.1.11 If there is / are any follow action(s) to be taken, a letter may be addressed by the Cell to the Chief Engineer requesting him to let the Cell know whether he would require any special assistance from the Dam Safety Cell or he is himself in a position to undertake repairs indicated in the inspection report(s).

4.3.1.12 If the request from the Chief Engineer comes for assistance then the senior officers of the Dam Safety Cell along with the expert in the discipline in the design office of the State / Centre as the case may be should visit and find out whether they are in a position to offer appropriate remedial measures. If the problem is complicated, they should immediately write to the Secretary to the Government through appropriate channel to constitute a panel to go into the problem to identify the cause / causes and suggest remedial measures.

4.3.1.13 The Dam Safety Cell should be responsible for speedy formation of the panel and it should act as secretariat to the panel. The coordination of various studies / investigations suggested by the panel should be done by the State's Cell.

4.3.1.14 The panel should consist of the following:

(a) Chairman – an experienced dam engineer who has background of design and construction.

(b) Chief Engineer (DSO) of Central Water Commission or his representative.

(c) Chief Engineer of the concerned project.

(d) Head of the Dam Safety Cell as Member-Secretary.

The panel should have the powers to co-opt any expert whose advice is considered essential for assessing the problems.

4.3.1.15 Dam Safety Cell should be responsible for monitoring the studies / investigations and for arranging the panel's inspection, investigation suggested by them, etc. They should also be responsible for preparation of the panel's report.

4.3.1.16 One copy of the panel's report should go to the Secretary of the Department who in turn should forward it to the concerned Chief Engineer for speedy implementation. An advance copy of the report may also be sent by the Cell to the Chief Engineer concerned.

4.3.1.17 The monitoring of implementation of the proposal and expediting the same should be the responsibility of the Chief Engineer of the project.

4.3.1.18 Chief Engineer of the project should keep the Cell informed of the performance of the remedial measures.

4.3.1.19 Instrumentation data of the dam should be collected by the Chief Engineer of the project and forwarded to the Design Wing for review.

A copy of the performance report prepared by the Design Wing should be sent to Dam Safety Cell for information.

4.3.1.20 If the feedback from the instrumentation data warrants a review at short intervals, the same should be done by the Design Wing.

4.3.1.21 The structural behaviour report based on instrumentation data should be sent to the Chief Engineer / owner of the project.

4.3.1.22 The Dam Safety Cell should compile statistics concerning failures and should have the burden of preparing the FIR report of any failure / accident in their State.

4.3.1.23 The Cell should be responsible for initiating action for constitution of a Committee to go into the causes of failure with a view to increase knowledge in the field.

4.3.1.24 The Dam Safety Cell should act as a data bank in respect of dam safety.

4.3.1.25 The establishment of Dam Safety Cell and safety review of existing dams by independent panel suggested by the Committee would throw additional financial burden on the State exchequer. Since dams are national assets and dam failure would become national disaster, the Committee suggests that financial assistance in the form of matching grants may be provided by the Centre towards the expenditure for establishment of the Cells and safety review. The cost of repair proposal as a result of safety review should be borne by the owner.

4.3.2 New Dams

4.3.2.1 All dams defined as large dams by this Committee should be designed by a competent Design Organization. Necessary orders should be issued to this effect. For all major dams in the State, it would be desirable to constitute an independent Dam Safety Panel to advise the project authorities in all phases of dam building activity. This would ensure the availability of collective wisdom for ensuring building safe dams. They should be constituted on the

lines of World Bank Dam Safety Panels and the implementation of their recommendations should rest with the Chief Engineer of the project. The monitoring of compliance of the recommendations should rest with the Cell.

4.3.2.2 During the course of the construction, the Cell should review quality control data for new projects for which the Chief Engineer is required to send the data to the Cell. The review report should be sent to the Chief Engineer of the project by the Cell for his comments with a copy to the Secretary to the Government. The object of this is to ensure that the quality of the work is reviewed periodically and any corrective measures if called for can be undertaken before it is too late. This procedure will assist the Cell in its inspection of the dam prior to first impoundment. In case of dams where exclusively a Dam Safety Panel has been constituted, the review of the quality control aspect need not be done by the Dam Safety Cell of the State. This job preferably should be left to the Dam Safety Panel who should also advise on the soundness and readiness of the dam prior to its first impoundment.

4.3.2.3 However, for projects where Dam Safety Panels are not in existence, the Dam Safety Cell along with the expert in the State shall inspect the new dams prior to their first impoundment and give its assessment regarding soundness and readiness of the dam for its maiden filling.

4.3.2.4 In addition to the routine instrumentation that are planned, seismological instrumentation to assess the seismic status of the project site and the response of the structure should be planned for all dams lying in Zone IV and above, and also for major dams in other zones.

4.3.2.5 The Cell should ensure close surveillance on the performance of the dam for the first consecutive three years and compile a report on the same.

4.3.2.6 The Cell should also ensure preparation of completion report relating to the dam by the project authorities.

4.3.2.7 The Cell should be responsible for collection and compilation of the salient technical details of design and construction of each new project.

4.3.2.8 The Cell should also ensure assistance in the preparation of reservoir operation schedule including detailed standing operating procedures for the dam.

4.3.2.9 The Cell should ensure that the project engineers frame a disaster preparedness plan.

4.3.2.10 The Cell should arrange for training courses for quality control staff and other engineers involved in design construction and maintenance of dams.

4.3.2.11 The Cell also should bring out manuals on operation and maintenance of hydraulic structures throughout the State in consultation with design and construction engineers.

4.3.2.12 After about an initial period of three years, the dam shall be classified as an existing dam and the functions of the Cell as detailed under existing dams will apply.

4.4 Prioritisation of safety review

4.4.1 The Cell should identify all dams, as indicated in para 4.3.1.1.

4.4.2 Engineering data should be collected in respect of the dams identified above. Such data should be furnished by the engineer in-charge of the project.

4.4.3 The Dam Safety Cell should make random checking of the technical data received; by site visit, to ensure the correctness of the data.

4.4.4 Of the dams in the above category, they should identify dams with distress / inadequate spillway capacity / age factors.

4.4.5 The Dam Safety Cell should prepare a programme of review of safety of dams in the State from

(a) Hydrological consideration; and
(b) Structural consideration.

4.4.6 The following guidelines are suggested to fix priorities for reviewing the safety of dams. While fixing interse priority, the hazard potential of the dam in question shall also be taken into account as the hazard rating offers a very useful tool for the establishment of priorities for examining and rehabilitation of older dams. In addition, the following considerations shall apply:

(a) Dams showing extreme distress with significant danger potential.

(b) Dams having grossly inadequate spillway capacity.

(c) Dams where deficiencies have been noticed in the design criteria followed.

4.4.7 Hydrological review of all projects defined by the Committee should be arranged by the Cell. A separate hydrology wing may be established for this purpose, if warranted. The guidelines determining hydrological safety of existing dams elaborated in Chapter V may be followed.

4.4.8 Adequate rain gauge stations, including automatic recording rain gauges, with mechanism for transmission of data by wireless should be established in the catchment area of all dams. Wherever the safety of the dam is threatened due to inadequate capacity of spillway, their installation becomes all the more vital and therefore the project authorities / owner should ensure establishment of automatic rain gauge in the catchment area, arrange for the transmission of rainfall data through wireless to the dam site and also work out the likely inflow based on the rainfall data so obtained. In such places, they should also exhibit at the site the reservoir operation rules governing. These operation rules shall be mounted on a photo frame and exhibited in the office of the engineer in charge at site so that they are not lot in the files.

4.4.9 The responsibilities for preparation of operation table for dams where inadequate spillway have been identified rests with that of the Dam Safety Cell. These rules of operation shall be prepared by the Cell and forwarded to the Chief Engineer in charge of the project for his comments, if any. If he has no comments, he should forward the same for the strict compliance by the site in-charge.

4.4.10 Keeping in view the considerations mentioned in para 4.4.6, structural safety of the existing dams shall be reviewed as per ISI Code (modification thereof, if any) and the stresses obtained / factor of safety attained on the basis of ISI Code shall be reviewed from safety angle, taking into account points indicated under structural safety review.

4.4.11 For dams showing extreme distress with significant danger potential, the Cell shall initiate action for the formation of a panel referred under the functions of the Cell. The Cell shall ensure speedy implementation of the submission of the Panel's report and subsequent follow-up action on its recommendation followed by monitoring the performance.

Chapter V

GUIDELINES FOR DETERMINING HYDROLOGICAL SAFETY OF EXISTING DAMS

5.1 Introduction

5.1.1 Every artificial storage can be a potential hazard to downstream life and property. All storage dams are provided with spillways, the primary purpose of which is to reduce this artificial hazard to negligible or acceptable level.

5.1.2 The decision on spillway capacity of a dam, including the decision on its surcharge storage, freeboard, etc., constitutes an important hydrologic and engineering decision affecting the safety of the dams. These decisions were being taken on the basis of "empirical" formulae based on regional experience and not adequately supported by systematical data and analysis. The Central Water Commission for the first time formulated a design flood criteria for hydraulic structures in the early sixties. This criteria was circulated to various States and was finalized in 1968.

5.1.3 In regard to the major projects under the Plans, CWC utilized these design criteria for ensuring, within workable limits that this criteria is followed in all new projects. However, in minor and medium projects which were either not examined, or not examined in detail, conformity with the criteria would not be adequately ensured. Also the various existing projects and projects under construction were not necessarily conforming to the criteria.

5.1.4 Even where projects are designed as per the CWC criteria, with the increase in data base in particular in regard to storms some times the inflow design flood estimates may be revised upwards. In such a case also, the existing structure may not come up to the norms.

5.1.5 The dam safety service was initiated in CWC in around 1980. This service brought to the notice of all State Governments, the need to review design floods to ensure the safety of the dams in general, in the light of the existing criteria for new dams.

5.1.6 In 1985, the Indian Standards Institute finalized the draft of a standard entitled 'Guidelines for fixing spillway capacity of dams.' This is somewhat more comprehensive than the existing CWC criteria in regard to storage dams. These guidelines are under printing and would replace the existing CWC design criteria.

5.1.7 In its part 1.1 of scope, the ISI guidelines state that the standard is for constructing new spillways and are not for deciding the adequacy of old structures. Thus, there seems to be a need for separate guidelines for deciding adequacy of old structures.

5.2 Need for Separate Guidelines

5.2.1 The question of whether guidelines for fixing spillway capacity consistent with the safety of dam should be of a general nature covering both new and existing structures or whether these should be separate for the two types of structures, is debatable. An important view is that social equity would demand the same standards of safety for the population in the country, irrespective of whether they are likely to be affected by new or old structures in case of hydrological failure. However, new guidelines, which generally are more stringent, can easily be accommodated while planning new projects which are tagged on with a package of costs and benefits. Another view, therefore, is that it would be more pragmatic and practicable to have separate guidelines for review of the old dams.

5.2.2 The fact that a particular dam is not having adequate safety from hydrologic angle may or may not necessitate immediate remodeling to ensure the safety. This again is debatable and different views as indicated above could be taken.

5.2.3 In this situation, the present suggestion is to proceed as follows:

- There shall be two separate guidelines, one for existing dams and another for new dams. However, the two guidelines would not differ in the choice of inflow design floods. They may differ marginally in regard to the freeboard, clearances and safety factors. Thus, although two guidelines would exist, these would not differ radically.

- A separate guideline for fixing priority amongst the existing dams in regard to their modification for greater safety under floods would be formulated. While it would be desirable to improve the status of each dam which does not conform to the guidelines for existing dams, these guidelines would allow differing action on some dams, in preference to some others in view of constraints on funds and organizations capabilities as they may exist.

- The prioritization of the dams not coming upto the norms for interse priority of action could be done on two considerations as follows:

  (a) On the basis of the largest flood that can be safely negotiated as compared to the appropriate inflow design flood; or

  (b) On the basis of the likely structural status (say, factor of safety) which the dam would have in case the inflow design is encountered (with relaxed ambient conditions, etc.) as appropriate to the case, as compared to the desirable structural status.

  For the purpose of the present draft, the scheme at (a) above is followed.

5.3 Review of adequacy of spillway and allied provisions in existing dams.

5.3.1 It is proposed that these guidelines would be the same as the guidelines for new dams which have already been discussed above and which has been reflected in the latest Indian Standards. However, while reviewing adequacy of spillway capacity, relaxation of the following ambient conditions may be considered on the merits of each case.

(a) For existing dams, impingement level to be considered can be lower than that for new dams, after taking into account a practicable schedule of filling.

(b) For existing dams, where a flood forecasting possibilities exist and have been proved in the field, a reasonable pre-depletion may also be allowed, although this is not allowable for new dams.

(c) For existing dams, where the gate maintenance is very satisfactory, and after making sure of standby arrangements, the design condition I of gate failure may not be considered.

(d) Relaxation of freeboard and clearance.

For new dams, as per clause 4.1, freeboard and clearance above MWL of design condition II are necessary as per the relevant ISI. For existing dams, these could be relaxed on

case to case basis. A properly designed solid parapet wall may be considered for the freeboard.

5.4 Prioritisation for modification of existing dams for greater safety.

5.4.1 Since at any time funds for this purpose would be limited, and also there could be constraints on organizational capabilities etc., it would be necessary to have a guideline for deciding the priorities in tackling existing dams for greater safety under floods.

5.4.2 These could be arrived at as follows:

(i) Consider an existing project and its spillway and other allied provisions.

(ii) Work out the inflow design flood as per the ISI standards for the new dams.

(iii) Route the flood with ambient conditions as per new dam and check if it is successful. If it is successful, no action is required. If not, consider if ambient conditions and freeboard and clearances can be relaxed as mentioned above. If after such relaxation the dam is successful in negotiating the inflow design flood, no action is required. If the dam is unsuccessful, the bahaviour of the dam under the design flood, such as reduction of freeboard and clearances, physical overtopping, likelihood of development of tension, likelihood of water hitting the deck bridge, etc., may be brought out.

(iv) By trial studies through proportionate reduction of inflow design flood, the percentage of the inflow design flood which can be successfully negotiated by the dam under the relaxed conditions may be worked out.

(v) The inflow design flood type depends upon the hazard potential in the eventuality of a failure. In some projects it may be possible to relocate the downstream habitation at a safe level in such a way that after such reallocation, the standard project flood may become the relevant inflow design flood for this dam. Such possibilities may be examined with some cost estimate of the relocation, if found feasible. In such cases, the safety of the dam against reduced inflow design flood may be worked out, repeating the steps one onward above mentioned.

(vi) After completing such studies for all dams within a State, the extent of inadequacy of the spillway capacity may be classified according to the following:

(i) The maximum inflow flood that can be passed through the dam with the relaxed ambient conditions, expressed as a proportion of the inflow design flood.

(ii) The likely effect of the inflow design flood on the safety of the dam, i.e. whether the dam has reasonable chance of not failing under such a flood.

(vii) Where an existing dam is found to have inadequate hydrologic safety in the review, immediate action would also be initiated to frame an emergency action plan as a disaster prevention measure. Such an action plan would be kept active until the permanent corrective measures are evolved and implemented.

~~556~~

Chapter VI

STRUCTURAL REVIEW

6.1 Methodology

This would involve the following:

(a) Study of design criteria that went into the design / construction of dam.

(b) Fixation of review criteria.

(c) Geological considerations.

6.2 Study of design criteria

The study of design criteria that went into the design / construction of the dam would call for elaborate efforts to find out the criteria that were used at the time of design / construction of the dam in question. In some of the major project in the country, design memoranda for each component of the project have been prepared and these have to be studied to locate the criteria that have gone into the dam. Where such detailed design memoranda are not available, this work would become laborious and time-consuming as it would involve digging up of old records looking to articles published in various journals, etc. It is in this context, the Committee would recommend that in respect of major projects, design memoranda in respect of each component of the project should be prepared by the organization as these would facilitate quick appraisal of structural safety of dams.

It is more vital that the details of reports on foundation geology as revealed during construction, the treatment for the foundation, departures made from design during execution, drawings of the structure as constructed and the standard of quality control exercised during construction needs to be studied in depth. The importance of preparation of technical reports on design and construction after completion of the project becomes relevant about which specific recommendation has been made in Chapter III of the report.

6.3 Review of design criteria

6.3.1 Fixing of review criteria for assessing structural safety of the existing dam is indeed a complex affair. The Committee has the following alternatives to choose:

(viii) Should the criteria conform to the present standards. Or

(ix) Alternatively can relaxation be allowed.

6.3.2 If we opt for the second, we are posed with the following technical, legal and moral problems:

How to ignore the performance of the dam which has been standing for all these years? How can you fix a lower level of safety for an existing dam?

What moral right one has got to subject the people below the existing dam to a lower level of safety when compared to people who come under new dams?

Legally it would amount to discrimination / negligence. If we opt for the first, we are faced with:

Undertaking an engineering decision which may not be economically viable.

There may be instances where appropriate remedial measures have yet to be developed like alkali silica reaction.

In the context of financial constraints, do we bring them to the present standards immediately, or alternatively use the available resources to provide additional benefits elsewhere?

Taking a decision on this aspect of safety review would call for an inter-disciplinary effort. It would be better if the existing dam can conform to the present ISI Code with modifications thereof, if any. However, more often than not, it is found that they do not conform strictly to the codal provisions. The structural safety of the dam shall be assessed taking into account the latest state-of-art. Each case has, therefore, to be decided on its own merit and precedents shall have no place in such a review.

6.3.3 In a situation where safety review indicates that the existing dams do not conform to the present standards, it would be obligatory on the part of the owner to plan disaster preparedness, including dam

break model studies to meet the unlikely event of a failure indicating therein the possible inundation downstream of the reservoir consequent to dam break. Such dam break model studies shall take into account the deficiencies noticed in the review of the structure.

6.4 Seismic considerations

6.4.1 The current procedure adopted for earthquake resistance design of dams is based on the conventional pseudo-static method outlined in IS 1893-1975. In case of concrete and masonry dams falling in seismic zones of high intensity and / or high dams over 50 to 60 m in height, further detailed dynamic analysis using Finite Element Method or by any other simplified method has now come into vogue.

6.4.2 After the Koyna earthquake, the seismic zoning map of India has been revised and the Government of India constituted a Standing Committee under the Chairmanship of Member (D&R), CWC to recommend the design seismic coefficient for River Valley Projects. On this Committee, GSI, IMD, School of Earthquake Engineering, Roorkee, and NGI, Hyderabad are represented. The data received by the Committee are examined and seismic parameters are recommended for design of dams. For evaluation of existing dams, the recommendation of the Standing Committee should be sought, only in such cases where it had not been before the Standing Committee at the design stage.

6.4.3 A two-tier basis indicated below for design of hydraulic structure is now an accepted practice:

Design Basis Earthquake (DBE)

Maximum Credible Earthquake (MCE)

The dam structure is checked by applying both the criteria to ensure that the separate stipulations made in each criteria is satisfied. In the event of maximum credible earthquake, the dam should be safe and some repairable damages are accepted.

6.4.4 As per the existing ISI Code, gravity dams have to be designed for no tension at the heel. However, in the revised ISI Code, a tension of the magnitude 1.5 kg/cm^2 has been permitted at the heel of the dam under full reservoir conditions when pseudo-static method of analysis for earthquake forces are adopted. Where dynamic stress

analysis is used for DBE, tension upto 6.25% and for MCE, upto 12.5% of the allowable compressive stress is permitted.

6.4.5 Embankment dams are also affected by earthquake. The particle readjustment capacity and the non-rigidity of the material forming the earth and rockfill dams reduce the impact of seismic forces on the structure to a great extent. The embankment dams, therefore, appear to have an edge over rigid dams provided there are no liquefaction hazards associated with the material forming the dam foundation system.

6.4.6 It is well known that prior to the occurrence of the Koyna earthquake, the entire Deccan Zone was considered to be safe from earthquakes and the design of dams within this zone did not cater for resistance to earthquakes. In general, for dams designed within this country prior to the Koyna earthquake, the criteria adopted for earthquake resistance design was not as rigid as was followed after this event. The crux of the problem is whether the existing criteria is to be applied to existing dams. It would be rational to presume that in an ideal case, the present criteria should be applied to existing dams. If those dams are still found to be safe under the present earthquake resistant design criteria, then there is no problem. In practice, more often than not, it will be seen that some of the existing dams do not measure upto the present standard of earthquake resistant design criteria. In such cases, it is not possible to spell out any general guidelines for safety review. Each dam has to be treated on its own merit and certain aspects have to be examined to undertake engineering solutions to make the structure safe against earthquake.

6.4.7 The fact that no masonry or concrete gravity dam has failed due to earthquake is a pointer to the effect that the present standard may not be applied in toto to the existing masonry / concrete structures. However, certain factors may be taken into account before deciding on the engineering solutions to be applied to make the existing dams safe from earthquake forces. The main factors that should be taken into consideration could be as under:

- Seismicity of the area;
- Age of the dam
- Location of the dam
- Degree of maintenance

- Past history of occurrence of disaster in the area at which the dam is situated;

- Disaster potential in case of the failure of the dam.

6.4.8 For earth and rockfill dams of course, the fail safe criteria will be more appropriate. For earth and rockfill dams, an engineering solution may not be sufficient and disaster preparedness will have to be resorted to in such cases.

6.4.9 While undertaking engineering solution for the existing dams, it would be pertinent to note that dams built earlier were founded on good foundations and in areas which are geologically favourable.

6.4.10 Taking into consideration the number of small dams in the country, the Committee addressed itself to the problem arising in reviewing all the dams in the country from seismic considerations. Keeping this in view the Committee suggests the following guidelines:

(a) The safety of all dams identified in high seismic zones (Zone IV & V) shall be reviewed from seismic considerations.

(b) For dams located in other seismic zones, the priority shall be based on the height of the structure and the hazard involved thereof in the event of its failure.

(c) Pre- and post-construction monitoring of the seismic status of dams should be carried out for dams located in high seismic zones.

6.5 Assessment of seepage in masonry dams

6.5.1 All hydraulic structures without exception are required to serve the purpose of retaining huge mass of water of the reservoir formed by the very existence of the structures and to release the water stored in a well defined and controlled manner for the purpose of irrigation, power, flood control, etc. whereas huge quantities of water may be released through various outlets for the purposes mentioned above, it often happens that a minute quantity gets released through the body of the dam which is a function of the material properties of the dam, size of the structure and the water head stored. The release of this minute quantum of water is termed as seepage. A distinction need to be made here between seepage and leakage. The water that gets released due to imperfections in the construction joints or due to imperfect compaction of materials or through piping are not functions of the

permeability of the materials of the structure and are termed as leakage. Release of water in small quantities over a long period of time through the pores of the material constituting the dam where the quantum of flow has a specific relation with the permeability of the dam material, the lake level and on the area exposed to the water mass is known as seepage.

6.5.2 A well constructed dam using appropriate materials of construction should be ideally watertight allowing for very low quantum of seepage through its body. From the point of view of imperviousness of the construction material, concrete dams should be considered the least pervious followed by masonry dams, earth and rockfill dams which have a comparatively high perviousness as compared to the other two. An excessive seepage can endanger the safety of the dam and can often lead to undesirable conditions.

6.5.3 Measurements of seepage are often indicators of the functioning of a dam and the state of safety of a dam can be approximated once the permissible seepage through a particular dam can be specified. The crux of the problem lies in the fact that whereas the permeability limits of various materials constituting the dam is known, the permeability limits of the completed dam does not yield itself to easy measurement. Inferences on the safe magnitude of seepage for the dam as a whole cannot also be worked out based on the permeability values of the constituent materials. It is here that we have to resort to in-situ measurements and determine the limits of permissible seepage based on simple mathematical calculations.

6.5.4 A simple mathematical relation can be derived for seepage through a concrete / masonry dam by the application of Darcy's law and assuming a slit type drainage provision wherein all the seepage water from the upstream face of the dam gets drained through the porous drains and no water escapes to the downstream portion past the porous drains. It is also assumed that concrete / masonry are permeable in nature, having higher coefficient of permeability in the horizontal direction. The second assumption of course is a logical outcome of the hydrostatic head of water acting on the upstream face of concrete / masonry dams which are either vertical at the bottom portion or are steeply inclined to the base resulting in the hydrostatic pressure to act either in a horizontal or near horizontal direction.

6.5.5 By applying Darcy's law to the dam area exposed to the reservoir, we obtain an expression in the following functional form:

$$Q = f(k,L,d,H^2,h^2)$$

where

Q = Seepage quantity

k = permeability as defined in Darcy's equation

L = characteristic length of the structure

d = distance of the drain hole from the upstream face of the structure

H = characteristic height of the structure

h = lake level

For a particular dam, the above function reduces to

$$Q = \emptyset\ (k,h^2)$$

The discharge and the reservoir level being measurable quantities permeability of the concrete / masonry dam as a whole can be evaluated for varying reservoir heads. In fact, the two end points would be permeability coefficients at MDDL and FRL.

6.5.6 In practice, the process would consist of measurement of seepage (as distinct from leakage) for varying reservoir levels for a few well constructed concrete / masonry dams and determine the coefficient of permeability. Having obtained these values, it would be possible to fix approximately the permeability limits that would be considered appropriate for a specific dam in question. By this process it would be possible to specify the upper limit of seepage for a specific dam and also the average seepage quantum.

6.6 Assessment of seepage in embankment dams

6.6.1 Seepage in embankment dams is a vital parameter to assess the behaviour of embankment dam.

6.6.2 The seepage measurement can be used to assess the behaviour of the embankment by adopting the following rough procedure:

(i) Compute seepage discharge with reservoir at FRL from flownet.

(ii) Separate the discharge for the zone below minimum drawdown level (say Q1) and above minimum drawdown level (say Q2) with Q1 + Q2 = 'X'.

(iii) Let the observed discharge be 'Y'.

(iv) If 'Y' is equal to 'X' it appears to indicate the attainment of steady seepage for continuous FRL condition which is not likely with reservoir fluctuations. The cause for this need to be investigated.

(v) If 'Y' is greater than 'X' there is an urgent need for detailed inspection / investigation.

(vi) If 'Y' is less than 'X' then a comparison of (Y – Q1) with Q2 gives indication of saturation in zone above minimum drawdown level which can be corroborated with pore pressure observations in the section, if possible.

6.6.3 In fact this method can be used as a rough guide in cases where no pore pressure measurement facilities are existing.

6.6.4 The data of seepage at the toe of the dam, and its turbidity is of extreme importance for evaluating the safety. Dam should be divided into convenient reaches and seepage monitored reach-wise. Most of the Indian rivers carry a significant amount of silt and as years to by earth dams are in a better position with regard to their performance provided they are not overtaken by a high flood and their upkeep is properly maintained. Reduction of seepage is a good parameter with regard to behaviour aspect of the dam.

6.7 Geological considerations

6.7.1 The foundation problems may be related to the weak rock zones, structural discontinuities and permeable zones.

6.7.2 The engineering geologist need to orient the geotechnical investigations covering the following subjects:

Regional geology and geo-environment.

Identification of foundation problem.

Meaningful sub-surface exploration with justification.

Analysis of data for design consideration.

~~561~~

Chapter VII

GUIDELINES FOR INSPECTION, OPERATION AND MAINTENANCE

7.1 Inspection

7.1.1 The Dam Safety Organization of the Central Water Commission has prepared "Guidelines for Safety Inspection of Dams." The guidelines were presented during the workshop on dam safety organized by Central Board of Irrigation and Power in October 1983. The CBIP have sent copies of these guidelines to all the States.

7.1.2 The guidelines cover all types of water resources structure in a comprehensive way, to include the gamut of all things that need to be looked into while doing safety inspection. Modifications may be required to meet specific types of structures / site conditions prevailing in the States. The States are advised to follow these guidelines as closely as possible.

7.1.3 The Earthquakes Committee of the United States Committee on Large Dams (USCOLD) has prepared a publication titled "Guidelines for inspection of dams following earthquakes." These guidelines may be followed during inspection of dams following an earthquake.

7.2 Operation and Maintenance

7.2.1 Even a well constructed dam may face problems and difficulties if it is not properly maintained. The maintenance budget of most of the structures, it is noticed, hardly covers the establishment charges leaving very little funds for carrying out actual maintenance. The budget provisions for maintenance of hydraulic structure need to be upgraded and this should be on the basis of the present cost of the structure instead of the original cost. This should be upgraded once in ten years.

7.2.2 In case of remedial works, necessary as a result of review for existing dams, a detailed estimate has to be prepared and got sanctioned before the commencement of work. If such repairs are to be undertaken as a consequence of the panel's recommendation, the Dam Safety Cell shall act as a catalyst to arrange for speedy sanction of the estimate. The estimate, however, shall be prepared by the Chief Engineer in charge of the project. In case of emergency repairs, the work will be commenced and the estimate submitted for ex-post-facto sanction.

7.2.3 Each river valley project / dam should have an operation and maintenance manual which should contain detailed instructions, procedures and rules for operation and maintenance of the dam and its appurtenant works. It should also include instructions regarding operation, maintenance and record of observations in respect of working of various facilities as well as the equipment / instruments embedded within the body of the dam and its appurtenant works.

7.2.4 A copy of the operation and maintenance manual should always be handed over to any new officer who joins the project and is charged with the responsibility of maintenance of dams.

7.2.5 Operation and maintenance manuals should be prepared by the design office in consultation with the construction and maintenance organization / Dam Safety Cell of the State. The procedure formulation should also involve administrative authorities and requirement of downstream riparian rights. Any modifications considered necessary as a result of field experience in following the instructions contained in the operation and maintenance manual, shall be proposed by the field engineers to the design office. All amendments considered necessary by the design office shall be done after getting the approval from the competent authority in consultation with the Dam Safety Cell.

7.2.6 An adequate flood forecasting system with wireless communications needs to be established for reservoirs wherever such a system is likely to provide enough advance information of incoming flood volumes useful for reservoir operation.

7.2.7 In respect of major projects, the State Government may consider the formation of an Expert Committee consisting of experienced design and construction engineers of dams to advise on the various problems encountered during operation and maintenance stage. Annual memos may be prepared regarding the performance of dams and other important components of the project and see the advise of the experts. Copies of these memos may be sent to Dam Safety Cell in the State as well as Chief Engineer, Dam Safety Organization.

7.2.8 It would be necessary that before shifting the operation and maintenance staff from one project to another, it should be ensured that the staff posted in their place are properly trained and at no time all the staff is new at a project.

7.3 Principles of Reservoir Operation

7.3.1 The aim of reservoir operation is to reduce the risk of man-made floods to the area on the downstream through carefully prepared reservoir regulation schedules, release procedure and gate operation schedules aided by an accurate & reliable flood forecasting and warning system.

7.3.2 In case of ungated reservoirs the only fact that needs to be carefully decided is the design flood, the adequacy of spillway and the freeboard. These need to be periodically reviewed with the help of continuous short term data built up during the course of operation.

7.3.3 In case of gated reservoirs, while it is desirable to fill the reservoir early, it should not be brought to near F.R.L. if late monsoon inflows are adequate to fill the reservoir.

7.3.4 In case of the gated reservoir having flood control storage space, the operation could be flexible keeping the requirements of both conservation and flood control in view. The reservoir operation should be carefully coordinated between flood disposal and the building up of the conservation storage. This is achieved by preparing guide curves and gate operation schedules and efficient system of flood forecasting.

7.3.5 The Regulation Manual for Damodar Valley Reservoirs was prepared by CWPC in April 1969, and this deals with integrated regulation of the four DVC multipurpose reservoirs at Panchet, Maithon, Konar and Tilaiya for the principal benefits of flood control, irrigation, industrial, domestic water supply and power. This can be referred to with benefit for developing integrated regulation manual for a system of reservoirs in a basin.

7.3.6 The Government of Maharashtra has brought out a Dam Safety Manual Chapter 7, entitled "Flood Forecasting, Reservoir Operation and Gate Operation" for general guidance of field staff engaged on the operation and maintenance of dams in the State. The Manual contains guidelines relating to principles and techniques of flood forecasting, operation of flood forecasting systems, principles of reservoir operation, preparation of guide curves for reservoir filling and regulation, gate operation schedules for gated dams and flood disposal, flood fighting, constitution of flood coordination committees, flood plain zoning and details of various data to be collected and registers to be maintained relating to reservoir operation and floods. The Manual is quite exhaustive and other States may develop similar documents to meet the specific

requirements of the State relating to reservoir operation, flood disposal and safety of dams and downstream property.

7.4 Gate Operation Schedules

7.4.1 The gate operation schedules must be based on the site conditions, the results of model studies and the regulation schedule of the reservoir. The gate operation schedule should clearly indicate the complete sequence and stages of operation of various gates corresponding to various lake levels and flood situations.

7.4.2 Operating instructions for important structures should be displayed near associated equipment. Each operating device should permanently and clearly marked for easy identification of equipment, and proper security arrangements should be made to ensure that unauthorized persons cannot operate or tamper with the equipment.

7.4.3 All mechanical and electrical equipments should be maintained properly and inspected at regular intervals to avoid any mishap in case of emergency. The working of spillway gates, outlet gates and undersluices and low level outlets should be specially checked before the onset of monsoon every year so as to ensure that these are not jammed and become inoperative.

7.4.4 Proper measurement of short period water levels during floods, short duration rainfall measurement in the catchment, outflow rating calculations and maintenance of gate operation records, etc., is very essential for all existing reservoirs. Automatic water level recorders in the reservoir, to monitor drawdown effect caused by outflow, should be installed in all reservoirs at suitable places.

7.4.5 An efficient and reliable flood forecasting system should be established to formulate accurate forecasts of inflow and volume of floods and regulation of gates for efficient flood disposal.

7.5 Silt Surveys

7.5.1 Reservoir silt survey should be done at regular intervals and the area capacity curve of the reservoir should be accordingly revised. If some major slides / mishaps take place in the reservoir which considerably affects its capacity, silt surveys will be conducted

immediately thereafter. These surveys should be more frequent in the initial years so as to know the trend of silting.

7.5.2 Flood carrying capacity of the river channels downstream of the dam shall be reviewed at intervals of five years.

7.6 Record of Operation

7.6.1 Proper measurement of water levels at short intervals during floods, short duration rainfall measurement in the catchment, outflow rating calculations and maintenance of gate operation record, etc., are very essential for existing reservoirs. Automatic water level recorders in the reservoir should be installed in all reservoirs at suitable places.

7.6.2 In Maharashtra State, regular workshops are conducted every year before the monsoon for training of dam operating staff in reservoir operation. The workshops are of a short duration of 4 to 5 days and are conducted at the regional training centre at Paithan dam through the Engineering Staff College, Nasik. The workshops are intended to acquaint the staff engaged on actual operation of reservoirs in the State with the techniques and methodology of reservoir operation and related aspects. The trainees include mostly Assistant Engineers and Junior Engineers posted on maintenance and operation of important dams in the State.

7.6.3 The training syllabus of the workshop includes lake filling schedules, flood hydrology (a broad appraisal), flood forecasting, flood disposal, flood moderation and upstream & downstream safety, collection of hydrological data at the dam sites, maintenance of records, maintenance and operational aspects of spillway gates, and vigilance of dams during monsoon. In addition to the lectures, the trainees are taken round the existing facilities at Paithan dam for practical demonstrations and drills in various related aspects of the course.

7.6.4 The Committee recommends that such training programmes should be organized in other States.

Chapter VIII

EMERGENCY PREPAREDNESS

8.1 Nature of disaster and its effects.

8.1.1 A situation of emergency arises in case of an impending disaster. The disaster itself may be natural or man-made. While natural disasters run through a definite known cycle of events and follow certain norms of localized scale, man-made disaster neither have known cycle of events nor are they necessarily spatially and temporarily restricted. In other words, natural disaster barring earthquake, may be considered to be structured events while man-made disasters are unstructured.

8.1.2 Floods are one of the natural events, which often spell disaster. The existence of a dam upstream of the flood plain may either mitigate the extent of the calamity or accentuate it. As such, the disaster due to the existence of a dam may have the quality of a natural disaster or qualities of both natural and man-made disaster. The disaster would be considered natural if the quantum of outflow from the dam is equal to the inflow flood. If, however, due to the very existence of a dam the outflow exceeds the inflow, the disaster can be logically classified as man-made. In the event of dam break also, it will then be purely man-made.

8.2 Planning for emergency

8.2.1 The emergency preparedness plan should, however, be applicable for both natural and man-made disaster. The man-made disaster arising out of an outflow in excess of the inflow can be taken care of by developing operation rules with built-in factor of safety and adequate and efficient warning system. Our greater concern is to evaluate the disaster, consequent to dam break.

8.2.2 The aim of management cannot be the handling of the natural phenomena itself, but rather to lessen or mitigate its impact upon human beings and natural environment. In order to carry out such measures it is necessary to have a proper plan and well-defined measures which would help reduce the risk of disaster. Assessment of a country's vulnerability to disaster should be regarded as an essential element in the planning and implementation of measures which are designed to prevent or mitigate the disaster. If this basic element is ignored, disasters will keep occurring and take its toll and a great deal of avoidable damage will continue to occur which will ultimately have a disastrous effect on the economy of the country.

8.2.3 An integrated disaster plan would encompass the disaster prevention and disaster preparedness and these two aspects are like the two faces of the same coin. One part cannot be dealt exclusively without the other.

~~567~~

8.2.4 Disaster preparedness can minimize loss of life and property by proper planning in advance so that measures are available to counteract the disaster. Visualizing challenges in advance and equip yourself to meet it effectively is the hallmark of rational human being. Such planning would call for correct assessment of the following items:

- ❖ Evaluation of the disaster – advance knowledge of the likely occurrence of flood or cyclone.
- ❖ To identify the likely effects on property and human beings with a view to assess the damage potential of the disaster.
- ❖ Vulnerability analysis and hazard area mapping to identify the most common area prone to such type of disaster.
- ❖ Review of organization and machinery for proper upkeep and maintenance of flood control works like dams, embankments, etc.
- ❖ Review of the provision of anti-disaster shelter – adequacy of medical aid facility, transportation, food, etc.
- ❖ Review of existing method of flood and cyclone warning system with a view to rectify the missing links and gaps and modernizing the system in accordance with the latest state-of-art, if necessary.

8.3 Prioritisation of the projects for emergency preparedness

8.3.1 It would be ideal if emergency preparedness plans can be developed for all dams whose failure would endanger human life and property. However, due to financial and other constraints it may not be possible to prepare emergency preparedness plan in a single stage for all projects in one go. In fact, emergency preparedness plans shall be prepared for certain priority situations to be decided on the basis of the following considerations.

(i) Dams in distress (dams whose level of safety has been adjudged low after review).

(ii) Projects with an earth dam component for which inadequacy of spillway has been identified during review and which even after adoption of engineering solutions, there exists a remote

possibility of overtopping while managing the reviewed design inflow flood.

(iii) Projects with an earth dam component for which the inadequacy of spillway has been identified, but engineering solution to manage the design inflow flood without overtopping would need considerable time and funds.

(iv) Dams constructed from masonry or concrete without an element of an earth dam. Here again, disaster preparedness shall be done for a possible outflow beyond the capacity of the downstream channel, but the dam is saved in the process.

(v) For dams having a nuclear power plant on the downstream, studies will be conducted in consultation with the Atomic Energy Commission.

(vi) While fixing interse priority, the hazard potential of the dam in question shall also be taken into account.

8.4 Inputs for preparation of emergency plan

8.4.1 Planning of emergency preparedness plan would get facilitated if the "flood plain zoning bill" has been enacted and is given effect to for the basin under consideration. Such an approach would lessen the effect of the disaster at a later stage.

8.4.2 Release of large amount of water due to combination of flood coupled with dam break, disaster preparedness shall be done for the dams listed above in the same order of priority.

8.4.3 Inundation map is the first input for planning an effective emergency preparedness plan. The following guidelines are suggested:

- ✓ Assess the safe carrying capacity of the downstream channel and the safe levels.
- ✓ Assess the inundation area for
  - ❖ 25 years flood;
  - ❖ 50 years flood
  - ❖ For routed design flood

- ❖ For PMF + dam break

8.4.4 Inundation map may be prepared for 25 years flood, 50 years flood and routed PMF in the order in which they are indicated above. The inundation map for floods coupled with dam break shall be prepared subsequently after conducting studies on dam break and collecting additional data, etc.

8.4.5 Dam break studies

8.4.5.1 There are computer programme packages to evaluate inundation area due to dam break floods:

Model Solution	Technique	Remarks
HEC I DB	Modified Pulse Kinematic Wave	Well documented, easily applied, incorporates variation in breach geometry and time rate of breach formation. Presently limited to single dam application with dry downstream channels.
USTFLO (Corps of Engineers)	Explicity, Staggered Grid	Requires usage of separate programme to calculate geometric elements (GEDA), designed for river routing, usage for dam break flood difficult. Requires relatively small time steps and fixed distance steps.
DAMBRK (National Weather Service)	Four point, weighted difference implicit.	Designed specifically for dam break floods, is easily applied and extremely versatile. Handles variable breach and time rate of breach formation, using storage or dynamic routing in reservoir. Will handle multiple (domino type) failures and will route super-critical or sub-critical flow.
MOC-LIF (United States Geological Survey)	MOC explicit method of characteristics, LIF - Four or Six point linear implicit.	Not widely used. Treats dam as internal node, propagates a single bore, sub-critical flow only. Limited to single dams. Requires trapezoidal cross sections, evenly spaced distance steps, small time steps, relatively expensive computational cost.

8.4.5.2 The DAMBRK model is more versatile compared to other models. This model is available in the Dam Safety Organization, Nashik. The following minimum data is required for this model:

- ❖ Breach geometry (simplified to rectangular or trapezoidal shape parameters).
- ❖ Time rate of breach formation.
- ❖ Reservoir elevation – surface area points.

- Two or three valley cross sections. The cross sections should be chosen to accurately describe valley storage and conveyance. More sections generally improve the accuracy of computed peak stages.

- Valley roughness coefficients.

- Boundary inflow hydrograph and lateral inflow hydrograph.

- Reservoir elevation at start of failure and initial water surface elevation at the downstream end of the channel.

- Description of downstream channel flow conditions, i.e. sub-critical or super-critical.

8.5 Preparation of Inundation Maps

8.5.1 The population and property situated within the area prone to inundation and damage must be surveyed to identify the emergency potential.

8.5.2 Based on this survey, the index maps and detailed maps of likely inundation area due to dam break floods to be prepared by the Executive Engineer. The index maps and detailed maps of the dam break inundation area should ordinarily be prepared and handled as secret documents. These maps should also indicate location of safe high ground which can be used for evacuation and shelter purposes.

8.5.3 The inundation maps should be prepared to the scale of 2 cms = 1 km or 1 : 50,000 or the scale of available topographical maps. A list of towns and villages, important public buildings and installations, railway lines, railway stations, post and telegraph offices and roads which may come under the flood line, should be prepared on the index map itself.

8.5.4 In respect of cities or towns and the villages falling in the likely inundation area of dam break floods, the detailed contour maps of the entire area showing contours at 0.5 m. intervals should be prepared. The hypothetical dam break flood line, the 25 years return period outflow and the maximum spillway design discharge flood line (wherever relevant), the various populated sectors, streets and roads, public buildings, important installations and all prominent places must be marked on these plans. The detailed maps should be prepared on the available town planning or city survey or land record plans or village maps.

8.5.5 Normally such maps are available for the command area of irrigation projects having direct canals. These maps with additional surveys covering the likely inundation area will also serve the purpose in majority of the cases.

8.6 Arrangement for public safety

8.6.1 The Revenue Officers should be informed to select suitable higher locations where the people from flood prone area should be shifted in case of necessity. Details of such locations to be used for evacuation and shelters should be worked out and clearly marked on these detailed maps. The particulars of the railways and road bridges in the flood zone should be obtained and likely flood levels to which they might be subjected should be intimated to the revenue authorities and the authorities in charge of the bridges.

8.6.2 The above maps and details should be scrutinized and approved by competent officers of Irrigation Department as under:

Sl.No.	Category of Hazard Potential	Competent Authority
1	High	Regional Chief Engineer
2	Medium	Superintending Engineer
3	Low	Executive Engineer

8.6.3 The approved plans of inundation area should be supplied to the following authorities:

- Chief Engineer (Irrigation Department)
- Commissioner of Revenue Division
- Superintending Engineer
- Executive Engineer
- Collector of the District

8.6.4 Sufficient spare copies of the approved plans should also be kept ready to be supplied to any other officials concerned at short notice.

8.6.5 Location of readily available equipment material, labour and engineering expertise which can be commandeered need to be identified and properly planned. All emergency preparedness plans

shall be reviewed after a period of 5 to 10 years depending upon its operation.

8.7 Public participation

8.7.1 Public participation to make emergency preparedness plan a success is an absolute must. Consequently, the MLAs, MPs in the disaster prone area, and all responsible persons of the locality shall be involved in the emergency preparedness plan. The help of voluntary organizations like Ramakrishna Mission and others shall be utilized. To chalk out the plan of action and fixing responsibility a meeting shall be convened at the District Magistrate level before the flood season every year to assign responsibilities and indicate their duties in the unlikely event of disaster.

8.8 Efficient communication system

8.8.1 An efficient communication system to achieve success of emergency preparedness plan is absolutely essential and this has to be worked out in consultation with local authorities and administrative set up. More often than not, the entire communication facility gets disrupted in a disaster situation. The wireless facility which is slightly free from the general encumbrances of the communication system shall invariably be a part of the emergency preparedness plan. Department of Police invariably has wireless sets and there are standing instructions with them that they should convey disaster messages effectively and in time.

8.8.2 All departments who are to deal with the emergency preparedness plan shall be identified and the officer who is to be the nodal officer in each department shall be identified and such officers will be provided residential telephone in addition to their office telephones. It is evident that the emergency preparedness plan is an integrated matter and requires technical expertise and specific administrative procedures if it is to be made practical, pragmatic and successful.

8.8.3 The Government of Maharashtra has brought out a Dam Safety Manual Chapter 8 entitled "Preparedness for dealing with emergency situation on dams", which is quite exhaustive and it may be used for developing similar plans to meet the specific requirement of each State.

~~513~~

Chapter IX

NEED FOR LEGISLATION

9.1 Introduction

In a welfare State, one of the object of legislation is to guide the behavioural pattern of individuals or groups in a society resulting in a general good to the greatest numbers. In an Utopian concept, a Government which rules the least is the best. Implied in the above, it follows that the individuals and groups have attained a degree of perfection in their behavioural pattern and their attitudes. However, the Utopian concept cannot be reached. Therefore, it follows that the Government has got to resort to legislation to bring in general good of the greatest numbers.

9.2 Importance of dam safety

The concept of dam safety as a separate discipline, even though was in existence in different form, has been a latecomer. While the dams constructed the world over have been the kingpin for the advancement of human civilization, it also poses a potential hazard in the event of failure. A failure of a dam brings in its wake loss of life and disastrous economic consequences in the basin. Hence, there is a definite urgency to regulate the monitor supervision of these dams to take timely corrective steps to prevent failure and in the unlikely event of failure shall be prepared with appropriate plans to mitigate its effects. Visualizing in advance the challenges that are likely to come up and to equip oneself to meet it is the hallmark of rational human being.

9.3 Basic contents of Dam Safety Legislation passed by in foreign countries.

9.3.1 In many advanced countries, particularly UK and Switzerland, etc., Dam Safety Legislation has been enacted for this purpose. In other countries it is still in the proposed stage. However, we have no idea how effective these have been and what difficulties they have encountered in enforcing them. The basic structure of the legislations as drafted by USCOLD are as under:

9.3.1.1 The intent of the act is to provide for the regulation and supervision of all dams and reservoirs exclusively by the State to the extent required for the protection of public safety.

9.3.1.2 Creation of a Central authority for the above.

9.3.1.3 Insistence of competent, licensed, experienced civil engineers in dam design assisted by qualified engineering geologists, specialists of other disciplines connected thereof to be in charge of planning, construction and operation of reservoirs.

9.3.1.4 Approval of the agency shall be sought for undertaking construction of new dams, enlargement of old dams or removal of existing dams and also to review and approve the design, construction, alteration, repair, maintenance and operation, etc.

9.3.1.5 The approval given by the agency in respect of any of the above shall not be construed to relieve the owner or operator of a dam or reservoir of his legal duties / obligations or liabilities instant to the ownership and operation of the dam or reservoir. Implied in this the responsibility for the safety of the dam rests with the owner.

9.3.1.6 The findings and orders of the agencies and the certificate of approval of any dam or reservoir issued by the agency are final and conclusive and binding on all owners and State agencies regular or otherwise as to the safety of the design, construction, maintenance and operation of any dam. However, there is a provision for the owner to seek legal recourse against the decision of the agency.

9.3.1.7 All owners are required to obtain approval of the agency with regard to safety of the dam under their control which has to be done by appropriate application and the legislation indicates also fees to be paid along with the application, the time limit for the application to be processed, etc.

9.3.1.8 The agency may by a consulting board of two or more consultants not previously associated with the structure to report to the agency of its proposed action with respect to this consideration. The cost of it shall be borne by the owner.

9.4 Functions of the agencies

9.4.1 For all dams and reservoirs under the jurisdiction of the agency, except those dams which are federally owned, the agency shall review and approve the design, construction, alteration, repair, etc.

9.4.2 Approval of agency is required for taking up new work, or making alteration for existing structure or to remove a structure.

9.4.3 Agency has power to review rules and regulations which do not conflict with the provisions of the act.

9.4.4 Agency has power to determine whether a proposed dam constitute a danger to life and property and shall recommend such measures to the owner as are necessary to the satisfaction of the agency to remove the resultant danger to life and property.

9.4.5 Agencies are required to get appropriate investigations and studies conducted before coming to any conclusion with regard to the safety or otherwise of the dam.

9.4.6 Agency is armed with the power for enforcement of the act.

9.4.7 Agency shall in times of emergency can declare repair or breach of dam or such recommendations shall be carried at owner's expenses, failing which agency shall have it repaired at owner's expenses.

9.4.8 Agency shall also give certificate for the initial filling of the reservoir and the owner has to put in application as soon as the dam is ready for its maiden filling. No water shall be impounded by the reservoir prior to issuance of the certificate. The agency has power to revoke a certificate or issue a certificate with terms and conditions as they deem fit.

9.4.9 Before revoking the decision, the agency is required to give a hearing to the owner to understand his side of the case.

9.4.10 The agency shall also issue instructions for alterations, enlargement and repairs of any dams which pose significant danger potential.

9.4.11 The agency shall also order removal of any unsafe dams. This shall be done by the agency only after site inspection and determining that all danger to life and property as a result thereafter has been eliminated.

9.5 Complaints as to the unsafe condition of dam

9.5.1 After receipt of complaint the agency shall cause an inspection to be made unless the proper records, inspection reports on file with it are found adequate for determination to find whether the complaint is valid. The agency shall recover from the complainant the cost of investigations required, if the complaint is found to be without merits after investigation. If it is found that a complaint was genuine, the money deposited by the complainant shall be returned and the owner requested to take appropriate action.

9.5.2 The agency has powers for periodic inspection at State expense for the purpose of ascertaining compliance with approved plans and specifications. During such inspection if it is found that some modifications are called for, they may get the same ordered to get them done. Owner has right to appeal through the independent consultant to review the order of the agency.

9.5.3 The supervision over maintenance and operation of the dams and reservoirs in the State other than those owned by the federal Government is vested in the agency. The agency shall have the dams reviewed by an independent panel for structural safety of the dam at the State expenses at regular interval, say 3 to 5 years. However, the cost involved on the recommended measures shall be borne by the owner. The agency is also authorized to declare emergency in the initial filling of the reservoir and shall have powers to take commend of the situation. However, the agency take over will not operate to relieve the owner of the dam or reservoir liability for any negligent act by the owner or his agent. The cost of such emergent operation shall be recovered from the owner. The legislation also provides for fines and punishment.

9.6 Dam Safety Act – Constitution

9.6.1 In India, under the Constitutional dispensation of legislative powers, the States have been assigned a primary role in the development of water. Entry 17, List II of the Seventy Schedule to the Constitution reads:

> *Water, that is to say, water supplies, irrigation and canals, drainage and embankments, water storage and water power subject to the provisions of Entry 56 of List I.*

9.6.2 However, the Centre has been given the responsibility of "Regulation and development of inter-State rivers and river valleys to the extent of which such a regulation and development under the control of Union is declared by Parliament by law to be expedient in the public interest" under Entry 56 of List I.

9.6.3 Under this, the Union has power to legislate over inter-State rivers and river valleys. The Union has not acted so far to extent its control over the water resources development (beyond legislating, the River Boards Act 1956 which has not been made use of and the Betwa – River Board Act 1976 enacted when the concerned States, namely States of Uttar Pradesh and Madhya Pradesh requested the Union to enact).

~~517~~

9.7 Present condition in the country

9.7.1 In India, dams are mostly owned by State Governments. Some dams are owned by Public Sector Undertakings, Boards and Corporations, which are also Government agencies. Tatas own a few dams privately. As against this position, in foreign countries where dam legislation has been attempted, dams are owned (operated) by private agencies and they are many in number. The Tailings Dam that failed in Italy recently which took a toll of 200 lives was owned by a private concern and had exchange of ownership. This situation is non-existent in India. In fact, it is significant to note that in the model law, i.e. proposed by US COLD, the federal dams are outside the purview of the proposed act.

9.7.2 Dam is made safe if adequate precaution and care are exercised at every stage from the point of conception of the scheme till it is translated to reality. The various important stages are:

- Investigation;
- Design;
- Construction;
- Operation & Maintenance

9.7.3 Dams in India are investigated, designed constructed and maintained by qualified engineers appointed by the State / Public Undertakings.

9.7.4 The various input data required in the preparation of a project are outlined by the Planning Commission in consultation with CWC and the proforma that are prescribed for the preparation of the project report is quite exhaustive and elaborate. Meticulous compliance on the various points raised in the proforma would certainly ensure adequate precautions even in the formative stage of the project.

9.7.5 All new projects to be undertaken in the Irrigation & Power Sector by the State are to be approved by the Planning Commission and the technical details of the project are scrutinized and examined by CWC, who in turn advise the Technical Advisory Committee of the Planning Commission with regard to its clearance. There are IS Codes that govern the design of water control structures and strict adherence to these would result in a safe structure.

9.7.6 In most of the major projects quality control during construction is watched by an independent agency other than construction agency which is also under the Chief Engineer. In fact in India, the Chief

Engineer / Executive Engineer is basically the kingpin for the safety of the dam or dams. He has got to take decisions keeping the exigencies of work and the need for quality control to ensure safety of the dam.

9.7.7 Before foundation is laid the foundation has to be cleared by the Resident Geologist of the project. The importance of this stipulation can be gauged by the fact that nearly 40% of the failures of dam have been attributed to foundation failure. Before a concrete or masonry block is raised, the OK signal of the quality control has to be obtained. Of late the major projects aided by World Bank are assisted by Dam Safety Panel which comprises of experts from various disciplines where collective wisdom of the experts are brought to bear on the project problems at all stages. When work is executed through contract, payments are made only after a certificate is given in the M.B. "Certified that the work has been done as per specifications and drawings" approved by the competent authority.

9.7.8 Coming to the operation and maintenance of the reservoir, there are existing departmental rules and manuals and these are obligatory. In some of the advanced States like Maharashtra, they are bringing out dam safety manual which is quite exhaustive and elaborate.

9.7.9 The manual has gone to the extent of making obligatory, preparation of Emergency Action Plans for all dams before taking up the work of closure of river channel or building up any storage. The manual goes to the extent of indicating that it may be useful to finalize the Emergency Action Plan for any storage project even at the stage of finalizing the technical sanction so that the hazard potential of the project can be known beforehand and the same can be fully considered while finalizing the relevant technical details and designs. Such Emergency Action Plan also suggests dam break model studies to be conducted for formulating emergency planning. The Uttar Pradesh Government has also brought out a manual regarding operating instructions for maintenance of dams.

9.7.10 In 1979, realizing the importance of dam safety, a Dam Safety Organization was created in Central Water Commission. This Organization has been instrumental for setting up Dam Safety Cell in various States by a resolution adopted in the State Ministers' Conference. Dam Safety Cells have been set up in 12 States. The awareness about implication of dam hazard and the consequence of failure thereof are being disseminated by holding workshops and discussions with State level officers and lectures by Directors of

Central Water Commission. A Workshop on Dam Safety was organized under CBI&P in October 1983, wherein Chief Engineers and Engineers of the State associated with dam safety participated. The following documents which have significant importance for monitoring the safety of the dams have been prepared and circulated:

- Guidelines for Dam Safety Inspection.
- Literature relating to mode and causes of failure.

9.7.11 In the year 1981, the Dam Safety Organization initiated action for review of design flood of dams in the country and a letter was addressed by the then Union Minister for Agriculture and Irrigation to the Chief Ministers of all States to take up review of design flood of all existing dams in their States. Gujarat Government have already reviewed quite a number of their dams and have also evolved appropriate technical modification / strategies to overcome the inadequacy. The States of Maharashtra and Uttar Pradesh have also initiated action. The BBMB which owns dams on Bhakra Beas complex has also initiated review of design flood of their dams. However, there exists a significant gap in many States with regard to maintenance and operation of their reservoirs. This is possibly due to

- Inadequate funds for maintenance;
- Inadequate appropriate technical staff for maintenance as there is an unwillingness of the staff to be on maintenance;
- Communication gap when the project is handed over to maintenance from the construction stage.

9.7.12 These aspects are dealt with by the review committee in the other chapters of the report. Thus it is seen that most of the objectives that are proposed to be covered by dam safety act are being covered in the existing rules, procedures / conventions in the country.

9.7.13 It is seen that in some of the new dams which we have constructed do have some problems. These problems are not due to lack of any deficiency in the working of any rules and codes, but concerns the implementation aspect of the same. Advocators of Dam Safety Act advance an argument that a law would help to ensure compliance of the provisions of the law when once it is put into statute. It needs to be remembered that legislation by itself cannot provide any guarantee against the risk of disaster, but what is lacking in the country is not lack of rules and procedures, but an effective

inspection and surveillance system which can reduce the probability of failure of a dam to a large degree.

9.7.14 If the State Government were to approach the legislature to legislate on matters of dam safety, it would amount to the executive asking the legislature to enact a law to govern its own activities. The executive under subsidiary legislative powers can frame appropriate rules and regulations to ensure effective dam surveillance, maintenance, etc. There appears to be no need for a legislation on this behalf.

9.7.15 If a law is to be passed by the Centre, it would need amendment of the Constitution as to equip the authority with sufficient powers. However, it is a moot point in a large country like India with dams scattered all over the country how effective it will be.

9.7.16 With the present laws that are available in the country, it is possible to fix responsibility for actions or inactions which result in negligence resulting in failure of a dam. In fact, wherever a failure has taken place, an enquiry has been constituted under the existing laws and the causes identified. Law does not provide any flexibility. Water resource structures are combined efforts of various disciplines and their operation also need close cooperation of all the disciplines. The subject of dam safety is inter-disciplinary, cross sectorial and all pervasive in character. So, in assessing a particular situation it would need flexibility which would not be provided if there is a law under statute.

9.7.17 In this connection it would be relevant to mention that in the introduction to the model law prepared by the "Committee on the model legislation for safety of dams" prepared by US Committee on Large Dams they have observed as under:

> *"Some States may prefer to put some of the requirements into administrative or technical rules or regulations rather than into the statute itself to provide more flexibility. Experience has shown that incorporation in the basic law removes the requirements from possible frequent changes by a succession of administrators."*

9.7.18 In our country, the Government happens to be the owner of most of the dams. The Committee, therefore, feels that the situation that exists in foreign countries does not exist in this country and there is no need for legislation on the lines as it exists in other countries. In the context of Indian condition and administrative set

up, the owners invariably being Government agencies, barring a few exceptions, an independent authority either in the Centre or at the State would bring in dual responsibility, leading to responsibility with none. In view of the above, the creation of a separate dam safety authority would also not meet the requirements. As for effective functioning, the Dam Safety Organization has to function with the assistance of the design organization and operation and maintenance authorities.

9.7.19 The Committee feels that a legislation on the following lines would serve the purpose for the present, the contents of which would be as indicated below. Procedural and technical details of the dam safety work are not proposed to be covered by the act. They will be dealt with by the States' concerned organizations.

9.8 Contents of legislation

9.8.1 All large dams shall be investigated, designed and constructed by recognized organizations consisting of qualified, experienced and competent engineers.

9.8.2 All the States which have significant number of dams shall constitute a body called "Dam Safety Organization." This Organization shall be manned by competent technical people and adequately staffed and funded.

9.8.3 The functions of the Organization shall be in accordance with the guidelines of the Standing Committee's report.

9.8.4 The Dam Safety Organization of the State shall prepare annual report of its activities, and these shall be submitted to the Government. A copy of the same shall be sent to the Central Water Commission. The Central Water Commission through its Dam Safety Organization, shall maintain liaison with the Dam Safety Organizations in the States to provide necessary technical assistance when requested.

9.8.5 The Dam Safety Organization of the State shall provide to Central Water Commission, documentation of projects, annual report of status of dams and report of enquiries into failures and such other data as required, or in such other forms or manner as it may direct.

9.8.6 The Dam Safety Organization of the Centre will prepare an annual report on the subject for consideration of the Ministry of Water Resources.

9.8.7 A technical enquiry shall always be instituted to investigate the causes of failure of any dam.

~~562~~

Chapter X

SUMMARY OF ACTION POINTS

10.1 New dams shall be investigated, designed and constructed as per guidelines / procedures and IS Codes and the state-of-art of dam engineering.

(Chapter I)

10.2 Each State which has significant number of major dams shall create a Dam Safety Cell in the State.

(Chapter III)

10.3 Keeping in view the infrastructure and expertise available in the State, it appears desirable that the Dam Safety Cell shall be created by the Irrigation Department in the State who incidentally owns maximum number of dams. This Cell shall be responsible for safety review of dams owned by other agencies.

(Chapter III)

10.4 The technical report of design and construction of a project is a vital document for subsequent review. It is, therefore, necessary that completion report of all important and major projects shall be undertaken by the State. Action need to be initiated by the Chief Engineer of the project for drafting the completion report when the project is in 50 % completion stage. The officers who have to provide chapters need to be identified. It would be desirable if the officers are kept in the same project till final chapters are written by them. Suitable financial incentive to motivate them to take up this work in right earnest is recommended. A separate financial provision in the project report shall be made for preparing the completion report including its printing cost, etc. It shall also provide for micro filming of important drawings of the dam as constructed including geological features as revealed after excavation, technical and quality control data that need to be kept for posterity.

(Chapter III)

10.5 Preparation of design memorandum of all aspects of design is a good practice and this practice should be extended to medium projects also.

(Chapter III)

10.6 The Dam Safety Organization at the Centre shall be strengthened to discharge its functions effectively and also assist some of the States which have not yet developed the requisite expertise in dam engineering.

(Chapter III)

10.7 The Committee recommends that all States having significant number of dams should be represented on the Standing Committee. Such broad based representation would help in the follow up action on the recommendations of the Standing Committee. The Standing Committee should meet at least once a year to review the dam safety programme in the country.

(Chapter III)

10.8 The States shall arrange safety review of dams which are more than 15 metres in height or which store 50,000 acre feet or more of water by an independent panel of experts once in 10 years. Matching financial grants shall be provided by the Centre towards expenditure incurred for establishment of the Cell and safety review. The State shall, however, bear the cost of repairs, resulting from such review.

(Chapter IV)

10.9 The functions and responsibility of the Dam Safety Cell so constituted at the State shall be modeled on the lines suggested in Chapter IV.

(Chapter IV)

10.10 It is desirable that all major and medium projects are guided by a panel of experts, even from the stage of design if not investigation, till the project is completed.

(Chapter IV)

10.11 The priorities for safety review of existing dams shall be on the lines as suggested in Chapter IV.

(Chapter IV)

10.12 With a view to assist the State Cell in fixing priorities for safety review, guidelines have been indicated in Chapter IV, V and VI relating to assessment of safety in dam, hydrological, structural and

seismological assessment. It is hoped that these guidelines would provide the necessary assistance in safety review.

(Chapters IV, V & VI)

10.13 Even a well-constructed dam would face many problems and difficulties if it is not properly maintained. The present budget provision for hydraulic structures is too inadequate. The budget provisions for maintenance of hydraulic structures need to be increased and these should be on the basis of present cost of the structure instead of the original cost which can be reviewed once in 10 years or at such time as dictated by inflation.

(Chapter VII)

10.14 Each river valley project should have an operation and maintenance manual which contains detailed instructions, procedures and rules for operation and maintenance of the dam and its appurtenant works.

(Chapter VII)

10.15 Operation and maintenance manual should be prepared by the Cell in consultation with design and construction engineers.

(Chapter VII)

10.16 Adequate flood forecasting system with wireless communication need to be established for reservoirs where such system is likely to help in giving advance information about incoming flood volume useful for reservoir operation.

(Chapter VII)

10.17 The State Cell shall develop their own guidelines for safety inspection keeping in view their requirements. Such guidelines shall draw their basic contents from the guidelines framed by CWC.

(Chapter VII)

10.18 Assessment of country's vulnerability to disaster shall be regarded as an essential element in the planning and implementation of the measures which are designed to prevent or mitigate the disaster.

(Chapter VIII)

10.19 Guidelines for emergency preparedness plan have been spelt out in Chapter VIII. The States may find them useful for preparing their disaster preparedness plan.

(Chapter VIII)

10.20 Investigation, design and construction shall be done by recognized institutes manned by qualified engineers with expertise in dam technology.

(Chapter IX)

10.21 In matters of legislation, the Committee feels that the conditions prevailing in India are different from those that are prevailing in foreign countries where owners of dams are private agencies. In India dams are by and large owned by the Government Organizations. In the context of Indian conditions, the Committee does not feel the need for a legislation on the lines indicated in foreign countries. However, there are many missing links and with a view to streamline the procedure in respect of discipline of dam safety, the Committee has, therefore, spelt out the broad framework of legislation.

(Chapter IX)

(M.A. Chitale)
Chairman
Central Water Commission and Ex-Officio
Secretary to the Govt. of India.

Chairman,
Standing Committee

Members

(K. Madhavan)
Member (D&R), CWC.

(N.K. Sarma)
Member (WR), CWC.

(B.M. Hukku)
Deputy Director General
Geological Survey of India.

(Dr. R.P. Sarkar)
Director General
India Meteorological Deptt.

(O.P. Dutta)
Member (Irrigation)
Bhakra Beas Management Board.

(J.P. Mistry)
Secretary(Irrigation)
Government of Gujarat.

(G.S. Narayana)
Chief Engineer (DSO), CWC.
Member-Secretary.

~~586~~

ACKNOWLEDGEMENT

Most of the State Governments have rendered us unqualified cooperation and more so the Government of Maharashtra, Gujarat and Bhakra Beas Management Board. We are grateful to the State Governments and their officers for helping us to finalize this report.

The Committee was initiated by Shri Mahesh Chand, Chief Engineer, Dam Safety Organization and the guiding spirit behind was Shri Pritam Singh, ex-Chairman, Central Water Commission, and the Committee would like to recall their contribution at this juncture.

An intellectual report of this kind could not have been finalized without whole-hearted cooperation and advice of the Members of this Committee. We had had cooperation of Ganga Brahmaputra Water Studies Organization and the Publication Branch of Central Water Commission in the typing and binding of this report. We are also grateful to the Tamil Nadu Government for sending us coloured transparencies of the Periyar Rehabilitation works.

The report has been typed by Shri Hans Raj and Shri Rajendra Babu. Their work is acknowledged.

~~587~~

APPENDIX - I

No. 18/18/80-I.T.
Government of India
Ministry of Irrigation

New Delhi, 17 August 1982

OFFICE MEMORANDUM

Sub: Standing Committee to review the existing and to evolve unified procedure of dam safety for all the dams in India.

The practices of safety inspection of dams presently adopted varies from State to State. In order to evolve a uniform simplified procedure based on the latest 'State-of-the Art'. The Government of India is pleased to constitute a Standing Committee to review the existing practices of inspection/maintenance of dams and allied structures in various States and to evolve standard guidelines for the same.

The Standing Committee shall consist of the following:-

1.	Chairman, Central Water Commission	Chairman
2.	Member (D&R)), Central Water Commission	Member
3.	Member (WR), Central Water Commission	Member
4.	Commissioner for Indus Water, Ministry of Irrigation.	Member
5.	Director General, Geological Survey of India (or his representative)	Member
6.	Director General, India Meteorological Department (or his representative)	Member
7.	Member (Irrigation), Bhakra Beas Management Board, Chandigarh.	Member
8.	J.F.Mistry, Chief Engineer, Irrigation Department, Government of Gujarat.	Member
9.	Chief Engineer, (DSO), Central Water Commission	Member Secretary

The terms of reference to the Committee are as under:

a) Review practices of various agencies in the country responsible for or involved with site selection, design, construction, regulation, inspection, maintenance and operation, repairs and ultimate disposition of dams which could affect the safety and integrity of the structure.

b) To suggest means of improving the effectiveness to each agency, engaged in its dam safety efforts.

The expenditure involved on TA/DA and other incidentals of the official members would be borne by the concerned controlling authorities. Expenditure on non-official members, if any, would be borne by the Central Government.

Sd/-
(C.S. HUKMANI)
Joint Secretary to Govt. of India

~~528~~

APPENDIX – II

IMPORTANT REFERENCES AND CODES FOR INVESTIGATIONS			
1	IS	1192-1981	Velocity - area methods for measurements of flow of water in open channels
2	IS	1194 - 1960	Forms for recording measurement of flow of water in open channel.
3	IS	2912 - 1964	Recommendation for liquid flow measurement in open channels by slope-area method (approximate method).
4	IS	2913 - 1964	Recommendation for determination of flow in tidal channels.
5	IS	2914 - 1964	Recommendation for estimation of discharge by establishing stage - discharge relation in open channels.
6	IS	4986 - 1983	Code of practice for installation of raingauge (non-recording type) and measurement of rain.
7	IS	4987 - 1968	Recommendations for establishing network of raingauge stations.
8	IS	5542 - 1969	Guide for storm analysis.
9	IS	6065 - 1971 (Part I)	Geological and geotechnical maps for river valley projects - recommendations for the preparation of
10	IS	5313 - 1969	Guide for core drilling observations.
11	IS	4078 - 1967	Indexing and storage of drill cores - code of practice for
12	IS	4464 - 1967	Presentation of drilling information and core description in foundation investigation.
13			Guidelines for investigation of major irrigation and hydro electric projects (CWC Aug.1975).
14			Report on the Committee to decide uniform yardsticks for investigation, design and research units (Government of India, Ministry of Irrigation, June 1982).
15	IS	5002 - 1969	Method for determinatio of sample size to estimate the average quality of a lot of process.
16	IS	4905 - 1968	Method for random sampling inspectin tables.
17	IS	2500 [Part (I) 1963]	Inspection by attributes and by count of defects.
		Part (II) 1965	Inspection by variable for percent defectives.
18	Hiranandani & Chitale		Stream Gauging.
19	BDC	47	Preliminary investigation and collection of data.
20	BDC	49	Geological investigation and subsurface exploration.

This list mentions only the important IS Codes and references

~~580~~

APPENDIX - III

IMPORTANT REFERENCES AND CODES FOR DESIGN			
1	IS	5512 - 1972	Criteria for design of solid gravity dams.
2	IS	7894 - 1975	Code of practice for stability analysis of earth dams.
3	IS	8826 - 1978	Guidelines for design of large earth and rockfill dams.
4	IS	4997 - 1968	Criteria for design of hydraulic jump type stilling basins with horizontal and sloping aprons.
5	IS	4999 - 1968	Recommendations for grouting of pervious soil.
6	IS	5050 - 1968	Code of practice for design, construction and maintenance of relief wells.
7	IS	5186 - 1969	Criteria for design of chute and side channel spillways.
8	IS	5477	Methods of fixing the capacities of reservoirs.
		(Part I) 1969	General requirements
		(Part II) 1969	Dead storage
		(Part III) 1969	Live storage
		(Part IV) 1971	Flood storage
9	IS	6066 - 1971	Recommendations for pressure grouting of rock foundations in river valley projects.
10	IS	6939 - 1973	Methods of determination of evaporation from reservoirs.
11	IS	7365 - 1974	Criteria for hydraulic design of bucket type energy dissipators.
12	IS	8237 - 1976	Code of practice for protection of slope for reservoir embankments.
13	IS	8414 - 1977	Guidelines for design of under-seepage control measurements for earth and rockfill dams.
14	IS	8605 - 1977	Code of practice for construction of masonry in dams.
15	IS	9429 - 1980	Code of practice for drainage system for earth and rockfill dams.
16	IS	10135 - 1982	Code of practice for drainage system for gravity dams.

This list mentions only the important IS Codes and references

APPENDIX – III (contd.)

IMPORTANT REFERENCES AND CODES FOR INVESTIGATIONS			
17	IS	10137 - 1982	Guidelines for selection of spillways and energy dissipators.
18	IS	4967 - 1968	Recommendations for seismic instrumentation for river valley projects.
19	IS	6524 - 1972	Code of practice for installation and observation of instruments for temperature measurement inside dams : Resistance type thermometers.
20	IS	6532 - 1972	Code of practice for design, installation, observation and maintenance of uplift pressure pipes for hydraulic structures on permeable foundations.
21	IS	7356	Code of practice for installation, maintenance and observation of instruments for pore pressure measurements in earth dams.
		(Part I) - 1974	Porous tube piezometers
		(Part II) - 1976	Twin tube hydraulic piezometers
22	IS	7436	Guide for types of measurement for structures in river valley projects and criteria for choice and location of measuring instruments.
		(Part I) - 1974	For earth and rockfill dams.
		(Part II) - 1976	Concrete and masonry dams.
23	IS	7500 - 1974	Code of practice for installation and observation of cross-arms for mreasurement of internal vertical movement in earth dams.
24	IS	8226 - 1976	Code of practice for installation and observation of base plates for measurement of foundation settlemeent in dams and embankment.
25	IS	8282 (Part I) - 1976	Code of practice for installation, maintenance and observations of pore pressure measuring devices in concrete and masonry dams: Part I Electrical resistance type cell.
26	IS	9116 - 1979	Water stage recorder (float-type)
27	IS	10334 - 1982	Code of practice for selection, splicing, installation and providing protection to the open ends of cables used for connecting resistance type measuring devices in concrete and masonry dams.
28	IS	10434 (Part I) - 1982	Guidelines for installation, maintenance and observation of deformation measuring device in concrete and masonry dams.
			Part I Resistance type joint meters.
29	IS	1893 - 1970	Criteria for earthquake resistant design of structure (second revision).
30	Design of small dams		USBR
31	Concrete Manual		USBR
32	Earth Manual		USBR
33	BDC - 54		Criteria for fixing spillway capacity.

This list mentions only the important IS Codes and references

~~591~~

APPENDIX – IV

PERIODICAL INSPECTION OF DAMS

Schedule showing size of dams and the competent inspecting authority

Sl. No.	Type of dam	Height from deepest river bed in m.	Impounded gross storage capacity upto FRL in M Cum.	Spillway capacity in M.Cum/sec.	Inspection authority	Inspection report to be sent to	Remarks
1	Mini	0 to 5	0 to 5	0 to 100	Junior Engineer	Sub Divisional Officer / Executive Engineer	
2	Small	5 to 15	5 to 30	100 to 1000	Sub Divisional Officer / Sub Divisional Engineer	Executive Engineer	
3	Large	15 to 30	30 to 300	1000 to 3000	Executive Engineer	Superintending Engineer concerned	
4	Large	30 to 60	300 to 1000	3000 to 10000	Superintending Engineer	Superintending Engineer, Dam Safety Organization, Chief Engineer of Region.	
5	Large	More than 60	1000	10000	Superintending Engineer, Test Check by Regional Chief Engineer		

Note : Dam satisfying any one of the above criteria to fall in the reservoir higher category.

~~592~~

APPENDIX - V

STAFF STRENGTH IN THE STATE DAM SAFETY CELLS

State	Dy.CE	Supr.Engr. / Director	Exe.Engr. / Dy.Dir.	A.E.E. / A.E.	Supr. / J.E.	Hydro-logist	Geo-logist	Remarks
Gujarat	-	2	5	6	-	-	-	
Maharashtra	-	1	3	-	-	-	-	
Uttar Pradesh	-	1	2	6	-	1	1	
Kerala (Irrg)	-	-	1	-	2	-	-	
Kerala (SEB)	-	1	1	3	-	-	-	
Orissa	-	1	2	2	-	-	-	
Tamil Nadu	-	-	-	2	-	-	-	
DVC	2	7	7	-	-	-	-	
BBMB	-	-	-	-	-	-	-	Respective CE responsible for dam safety job.
West Bengal	-	-	-	1	-	-	-	
Karnataka (Power Corpn)	-	-	-	-	-	-	-	Review Unit only
Karnataka (Irrg.)	-	-	-	-	-	-	-	Review Unit only

~~593~~

Back cover: 100 year old Periyar Dam:
Strengthened by buttressing

~~594~~

Annexure-7

~~505~~

GOVERNMENT OF INDIA
CENTRAL WATER COMMISSION
DAM SAFETY ORGANISATION

Standardized Data Book Format, Sample Checklist and Proforma for Periodical Inspection of Dams

October 1988
New Delhi

No. 3/19/NCDS/DS/ 1145-61
Government of India
Dam Safety Organisation
Central Water Commission

428, Sewa Bhawan, R.K. Puram
New Delhi-110066.
Dated 7th October, 1988.

To

Sub:- Standardised Data Book Format, Sample Checklist and Proforma for Periodical Inspection of Dams.

Sir,

As decided in the second meeting of the National Committee on Dam Safety held on 28.7.1988, the revised formats on the following items are enclosed herewith.

1. Data Book Format
2. Sample Checklist
3. Proforma for periodical inspection of dams.

In the revision of the above documents, comments received from the States have been incorporated.

Documentation of all the projects may be done in the Data Book Format. The Committee had desired that the pro-forma for periodical inspection of dams may be used in the initial stages, till the inspection teams are trained in dam safety inspection. The choice between the formats 2 and 3 for physical inspection of dams would be left to the States.

Copies for further circulation may kindly be made at your end.

Yours faithfully,

Encl:- as above.

(A.B. JOSHI)
Chief Engineer (DSO) and
Member-Secretary, National
Committee on Dam Safety.

~~507~~

Standardized Data Book Format, Sample Checklist and Proforma for Periodical Inspection of Dams.

INTRODUCTION

In order to evolve a uniform procedure for compilation of basic data on dams and for periodical inspection of dams, the following formats have been prepared:

1. Data Book format
2. Sample checklist
3. Proforma for periodical inspection of dams

Comments received from the States have been incorporated in the above documents.

Data Book format

Documentation of all projects may be done in the Data Book format which is the primary data base for the team evaluating the safety of a dam. This format is based on the 'Preliminary manual for safety evaluation of existing dams' published by the United States Bureau of Reclamation and suitably modified.

Sample checklist

The sample checklist prepared is based on the field examination checklist of the United States Department of Interior, Water and Power resources Service. This has been suitably modified to suit Indian conditions. The checklist is presented in a generalized form. Some items included under embankment dams, which are also applicable for concrete dams, have not been repeated. Detailed checklists have to be prepared for individual dams.

Proforma for periodical inspection of dams

This proforma is based on the proforma brought out by the Dam Safety Organization of Maharashtra State. Suitable modifications have been carried out and relevant information from similar proforma prepared by other States have also been incorporated.

~~508~~

Data Book Format

Proper assessment of dam safety involves a thorough review of design, construction and performance records prior to conducting a field examination. The Data Book is an unpublished document which is prepared before the initial safety inspection of each dam. This book is abbreviated, convenient source of information, summarizing all pertinent records and history related to the safety of a dam and is a reference for the evaluation team. This Data Book should answer most questions about the dam. A list of reference is included if additional information is needed. Continual updating of the Data Book will be required as future inspections are made, new problems arise, new investigations are undertaken and remedial treatments performed.

The format outlined in the Data Book should be followed as closely as possible. Adjustments to fit the conditions at a particular dam site may be needed. However, major changes in the outline may be avoided.

1. GENERAL

1.1 Scope of the project.
1.2 Description of dam & appurtenances.
1.3 Description of project and features related to safety of dam.
1.4 Photographs showing different phases of construction.
1.5 Salient features including Index Plan.
1.6 Key personnel
(include for each name, designation & address, office telephone & home telephone).

1.7 Access.

1.7.1 Highways to dam.
1.7.2 Closest town, railway station.

1.8 Emergency preparedness.

1.8.1 Communications
1.8.2 Downstream warning systems
1.8.3 Auxiliary power
1.8.4 Security of the site

1.9 Checklist for inspections.

2. GEOLOGY

2.1 General

2.2 Regional geology

2.2.1 Geologic history
(include such items as rock types and tectonics).

2.3 Site geology

2.3.1 Geomorphology
2.3.2 Rock types
(include such items as lithology, petrography, mineralogy & engineering properties).
2.3.3 Local structure
(include such items as description and significance)
2.3.4 Special problems
(This should include appropriate subjects such as landslides, solution & subsidence).

2.3.5 Effect of geology on design.
2.3.6 Adequacy of investigations on state-of-the-art.

2.4 Seismicity
(Include design earthquake, current evaluation of maximum credible earthquake and status of any seismic evaluation or re-evaluation).

2.5 References

2.5.1 Reports & data
2.5.2 Drawings
2.5.3 Memorandums

3. HYDROLOGY

3.1 Description of drainage basin.
3.2 Design floods
(include inflow design flood) – is it current?
3.3 Flood routing criteria
3.4 References and memorandums

4. RESERVOIRS

4.1 Description (include basin & reservoir)
4.2 Operation
4.3 Contour-capacity table
4.4 Evacuation capability
4.5 Reservoir geology

4.6 Landslides

4.6.1 Summary
4.6.2 Description

4.7 Restrictions

4.8 References

4.8.1 Reports and data
4.8.2 Drawings
4.8.3 Memorandums

5. FOUNDATION

5.1 Description

- 5.1.1 General
- 5.1.2 Geology

5.2 Condition

- 5.2.1 General
- 5.2.2 Seepage
- 5.2.3 Deficiencies and problem areas

5.3 Design and analysis

- 5.3.1 Design
- 5.3.2 Description of treatment
  - 5.3.2.1. Cutoff
  - 5.3.2.2. Grouting
  - 5.3.2.3. Drainage
- 5.3.3 Analysis
- 5.3.4 Special studies (effects of adjacent structure)
- 5.3.5 Adequacy of design
- 5.3.6 Remedial measures undertaken to remove the deficiencies, if any, and to overcome the problems encountered during construction.
- 5.3.7 Additional studies required.

5.4 Instrumentation

- 5.4.1 Structural
  - 5.4.1.1 Description
  - 5.4.1.2 Evaluation of Results
- 5.4.2 Seepage
  - 5.4.2.1 Description
  - 5.4.2.2 Evaluation of results

~~602~~

5.4.3 Frequency of readings

5.4.3.1 Current provisions
5.4.3.2 Adequacy

5.4.4 Comments of adequacy and justification for additional instrumentation.

5.5 Historical events relative to safety of dam

5.6 References

5.6.1 Reports and data
5.6.2 Drawings
5.6.3 Memorandums

6. DAM

6.1 Description
(Type of dam, layout, galleries, general, etc.)

6.2 Condition of dam

6.2.1 General
6.2.2 Deficiencies and problems

6.3 Construction materials

6.3.1 Description of materials
6.3.2 Pre-construction testing
6.3.3 Quality control during construction
6.3.4 Post-construction testing

6.4 Design and analysis

6.4.1 Leading criteria
6.4.2 Analysis
6.4.3 Special studies
6.4.4 Adequacy of design
6.4.5 Additional studies required

~~606~~

6.5 Instrumentation

6.5.1 Structural

6.5.1.1 Description of installation
6.5.1.2 Evaluation of results

6.5.2 Leakage and seepage
(include description of installation, evaluation of results and permeability tests carried out in the masonry / concrete, results & remedies.)

6.5.3 Reading frequency

6.5.3.1 Current provisions
6.5.3.2 Adequacy

6.5.4 Comments on adequacy and justification for additional instrumentation.

6.6 Historical events related to safety of dam.

6.7 References

6.7.1 Reports and data
6.7.2 Drawings
6.7.3 Memorandums

7. SPILLWAY

7.1 Description
[Intake structure, crest structure (gated, ungated, flash-boards, bridges), conveyance structure, stilling basin, exit channel, power sources, etc.]

7.2 Condition
7.2.1 General
7.2.2 Deficiencies and problems
7.2.3 Potential problems

7.3 Historical events
(Maximum releases to date, frequency of operations, damage reports, examinations, etc.)

7.4 Hydraulic design

7.4.1 General
7.4.2 Flood routing
(include use of outlet works and control of reservoir for floods.)
7.4.3 Limitations
(effects of various gate malfunctions)

7.5 Structural design
(general, foundation, geology, drainage, anchorage)

7.6 Detailed drawings of gates, embedded parts & hoist equipments.
7.7 Instrumentation
[include settlement points (last reading, plotting and analysis) and other instrumentation]

7.8 Operation

7.8.1 General
7.8.2 Mechanical
7.8.3 Maintenance schedules

7.9 References

7.9.1 Reports and data
7.9.2 Drawings
7.9.3 Memorandums

8. RIVER OUTLET WORKS

8.1 Description
(Intake channel, intake structure, trash racks, closure method, upstream conveyance structure, gate chamber, downstream conveyance structure, control structure, stilling basin, exit channel, power sources, diversion during construction, bypass system).

8.2 Condition

8.2.1 General
8.2.2 Deficiencies and problems
8.2.3 Potential problems

~~885~~

8.3 Historical events
(Maximum releases to date, modifications, damage reports, examinations, etc.)

8.4 Hydraulic designs

8.4.1 General
8.4.2 Discharge requirements
8.4.3 Restrictions of operation
8.4.4 Use with inflow design flood and flood routing
8.4.5 Evacuation of reservoir (procedures)

8.5 Structural design
(General, foundation, geology, drainage, anchorage, etc.)

8.6 Instrumentation
[Include settlement points (last reading, plotting and analysis) and other instrumentation]

8.7 Operation

8.7.1 General
8.7.2 Restrictions
8.7.3 Mechanical
8.7.4 Flood and emergency conditions

8.8 References

8.8.1 Reports and data
8.8.2 Drawings
8.8.3 Memorandums

9. POWER OUTLETS

9.1 Description
(Intake structure, trash racks, closure method, penstocks, turbines, tailrace, exist channel, etc.)

9.2 Condition

9.2.1 General
9.2.2 Deficiencies and problems

9.3 Historical events
(Damage reports, major malfunctions, examinations, etc.)

9.4 Hydraulic design

9.4.1 Normal operation (discharge)
9.4.2 Use with IDF flood routing
9.4.3 Use with evacuation of reservoir

9.5 Structural design
(General, foundation, geology, drainage, anchorage, etc.)

9.6 Operation

9.6.1 General
9.6.2 Restrictions
9.6.3 Mechanical
9.6.4 Flood and emergency conditions

9.7 References

9.7.1 Reports and data
9.7.2 Drawings
9.7.3 Memorandums

10. ACCESS ROADS

10.1 Description
(Type of road, length, bridges, maintaining agency, etc.)

10.2 Condition

10.2.1 General
10.2.2 Deficiencies and problems

10.3 References

10.3.1 Reports and data
10.3.2 Drawings
10.3.3 Memorandums

11. MODEL STUDIES

12. OTHER FEATURES

(Any other features pertinent to the safety of the dam. Outline should be compatible with the outlines shown.)

13. REPORTS OF EXPERTS OR CONSULTATIVE COMMITTEES, IF ANY

14. SAFETY REVIEWS

~~687~~

Sample checklist for embankment and concrete dams

Date of inspection: _____

A. GENERAL

Sl.No.	Item	Remarks
(1)	(2)	(3)

1. Name of project
2. Purpose of project : Water supply / power / multipurpose / irrigation
3. Name of dam
4. Year of completion
5. First filling (years / levels)
6. Benefits accrued :
   (a) Irrigation
   (b) Water supply
   (c) Power
   (d) Other benefits

7. Important controlling levels (in metres)

   (a) Top of dam
   (b) Maximum water level
   (c) Full reservoir level
   (d) Sill level of irrigation sluices
   (e) Sill level of scouring sluices
   (f) Spillway crest level
   (g) Minimum drawdown level
   (h) Lowest river bed level
   (i) Deepest foundation level

8. Important salient features

   (a) Dead storage capacity
   (b) Area of foreshore at FRL
   (c) Design flood adopted (PMF / SPF / any other)
   Give relevant magnitude
   (d) Design spillway discharge
   capacity & type of spillway
   (e) Type, number and
   size of spillway gates
   (f) Location, sill level and capacity of
   low level outlets and scouring sluices.

~~608~~

(g) Height of the dam in metres

(i) above deepest foundation
(ii) above lowest river bed

(h) Gross storage capacity in million cubic metres

(i) at FRL
(ii) at MWL

(i) Length of the dam (at crest) in metres.

9. Name and designation of the inspecting officer

10. Date of inspection and the corresponding reservoir water level

11. Maximum and minimum water levels reached during the last season with dates

12. Maximum overflow during preceeding monsoon with dates.

13. History of past distress, if any, and brief details of remedial measures carried out.

14. Does the officer-in-charge of the operation & maintenance of dam possess all the records as given in the Annexure I.

15. When and by whom was the dam inspected immediately preceding this inspection?

16. Are the items pointed out during the last inspection properly attended to? (if not, state deficiencies yet to be corrected)

~~689~~

Annexure I

Record required at site (referred in item 14 of General)

Records that may be required for proper inspection and maintenance shall be available at site. These shall be properly maintained and kept up-to-date by including latest information available. Data in respect of upstream gauging stations, flood warning system and communication channels, if installed, shall be properly maintained.

General

1. Final detailed project report and details of modifications done during construction and a set of final drawings (as executed).

2. Index Plan of the area in which the dam is located showing important towns, roads, rail routes and communication facilities.

3. Index Plan of downstream area showing natural flood zone, flood zones corresponding to spillway design flood and dam break flood and all important towns / villages and property lying in these flood zones.

4. Contour map of dam site extending upto 200 m or 10 times the dam height (whichever is less) on upstream and downstream, showing all features of the dam like toe lines, fills, drains, relief walls, access roads, etc.

5. Record drawings of longitudinal section of dam foundation or cut off trench showing details of foundation stratigraphy, stage-wise construction of COT filling and raising of dam section or embankment zoning details and foundation treatment.

6. Record drawings of cross-sections of dam showing details of foundation treatment, under seepage control, zoning, internal and external drainage, all protective arrangements and stage-wise construction

7. Contour Plan of dam site with foundation trench showing details of foundation treatment and foundation drainage.

8. Contour Plan of reservoir basin.

9. Contour capacity and area capacity curve.

10. Reservoir maps showing silted basin, if observed.

~~610~~

11. Plan of the catchment area showing rain gauge stations and capacities of upstream storages.

12. Material properties adopted for design.

13. Details of design criteria followed.

14. Design report on flood studies and spillway design flood.

15. Design reports of outlets, power outlets river sluices, intake, conduit, energy dissipation arrangements and details of gates of hoists.

16. Geological data on the foundations and abutments.

17. Copies of geological reports, details of special foundation and abutment treatment carried out.

18. Record of tail channel geology and tail channel erosion.

19. Instrumentation drawings with details.

20. Instrumentation data and behavioural record.

21. Details of communication system, telephones, wireless, etc., directory of important key officers, flood warning procedures.

22. Flood forecasting system.

23. Photographs showing various phases of construction, pre-construction, etc.

Earth – Rockfill dams

1. Stage-wise construction record of the dam showing volumes and heights achieved in each season and time rate of progress.

2. Record of special compaction done near concrete / masonry structures, abutment contacts and outlet locations, if available.

3. Summarized records of compaction, control sampling and complete laboratory and field test resulted on all record samples.

4. Foundation details and geology as observed.

5. Data of water intake tests.

6. Detailed drawings and record of relief well observations.

7. Design report for the earth dam, covering the under-seepage control, stability of embankment junctions with masonry dam, instruments installed, etc.

8. Drawings showing the typical cross sections, including zoning, drainage arrangements, detailed details of slope protections provided for, etc., as per actual construction.

9. Details and location of instruments embedded / installed in and around the structures.

10. Record of corrective measures, repairs and treatment that have been done subsequent to construction.

11. Details of design criteria followed.

12. Photographs showing all phases of construction.

13. Important inspection reports and reports of consultants.

Concrete / Masonry dams

1. Details of construction history, including stages of construction, particularly in low blocks where considerable time elapsed prior to resumption of work.

2. Summarized data on control tests, carried out during construction in respect of concrete, mortar and their constituent materials, if available.

3. Reports on hydraulic model studies.

4. Drawings showing the details of energy dissipation arrangements, including foundation levels of apron, training walls and end weir.

5. Details and location of instruments embedded / installed in and around the structure.

6. Summarized data of observations on embedded / installed instruments.

7. Detailed drawings of all service facilities like internal lighting, emergency lighting, drainage, etc.

8. Drawing showing the uplift measurements and pressure relief arrangements.

9. Summarized data of uplift pressures observed..

10. Summarized data of seepages, leaching observed in the drainage gallery and downstream face of the dam, their locations, etc.

11. Record of corrective measures, repair or treatment that have been done subsequent to completion.

12. Important inspection reports and reports of consultants.

13. Details of design criteria followed.

14. Photographs showing all phases of construction.

Operation and Maintenance

1. Gauge data of the river prior to the construction and after completion of work.
2. Detailed observations of flood discharges.
3. Detailed observations of hydraulic performance of energy dissipation basins.
4. Record of past performance stating briefly the defects developed and remedial measures carried out.
5. Drawings of outlets, maximum discharge capacity, maximum design operating head.
6. Standing orders regarding operation of the dam.

   (a) Designers operating criteria.
   (b) Standing operating procedures.
   (c) Flood forecasting procedures.
   (d) Gate operation procedures.
   (e) Emergency Action Plan

7. Standard reference literature for operation and maintenance of reservoir, dam, ancillary work, gates, instrumentation, etc., including I.S. specifications, codes, manuals, manufacturers' literature, etc.

~~613~~

Checklist for
INSPECTION OF EMBANKMENT DAMS

DAM

Upstream face

Slope protection _____
Erosion _____
Vegetative growth _____
Settlement _____
Debris _____
Burrows or burrowing animals _____
Unusual conditions _____

Downstream face

Slope protection _____
Signs of movement _____
Seepage or wet areas _____
Vegetative growth _____
Drainage _____
Unusual conditions _____

Abutments

Seepage _____
Cracks, joints & bedding planes _____
Drainage _____
Slides _____
Vegetation _____
Signs of movement _____

Crest

Surface cracking _____

Durability _____

Settlement _____

Lateral movement (alignment) _____

Camber _____

Drainage _____

Drainage

General _____

Longitudinal drains & dwarf bunds _____

Seepage and drainage

Locations (s) _____

Estimated flow (s) _____

Colour (staining) _____

Erosion of outfall _____

Toe drain and relief walls _____

Measurement

Method _____

Amount _____

Change in flow _____

Clearness of flow

Colour _____

Fines _____

Condition of measurement devices _____

Records _____

Special items

_____

_____

_____

SPILLWAY

Approach channel

Vegetation (trees, etc.) _____

Debris _____

Slides above channel _____

Channel slide slope stability _____

Log boom _____

Slope protection _____

Control structure (observed operation)

Apron

Surface condition _____

General condition of concrete _____

Movement _____

Settlement _____

Joints _____

Cracks _____

Crest

Surface condition _____

General condition of concrete _____

Cracks or areas of distress _____

Signs of movement _____

Gates

Condition _____

Hoist equipment _____

Leakage _____

Lighting _____

Exercising frequency _____

Walls

Surface condition _____

General condition of concrete _____

Movement (offsets) _____

Cracks or areas of distress _____

Settlement _____

Joints _____

Drains _____

Backfill _____

Bridge

Condition of piers _____

Surface of roadway slab _____

Structural condition of slab & beams _____

Bridge bearings _____

Overall condition _____

CHUTE

Debris _____

Walls

Surface condition _____

General condition of concrete _____

Movement (offsets) _____

Cracks or areas of distress _____

Settlement _____

Joints _____

Condition of backfill _____

Floor

Surface condition _____

General condition of concrete _____

Baffle blocks / energy dissipators _____

Movement _____

Settlement _____

Joints _____

Drains _____

Cracks _____

Stilling basin (observed operation)

Debris in basin _____

Walls

Surface condition _____

General condition of concrete _____

Movement (offsets) _____

Cracks or areas of distress _____

Settlement _____

Joints _____

Condition of backfill _____

Floor (if visible)

Surface condition _____

Condition of concrete _____

Movement (offsets) _____

Cracks or areas of distress _____

Joints _____

Erosion _____

Outlet channel

Adequacy _____

Slope protection _____

Stability of side slopes _____

Flood bank and protective arrangement _____

Vegetation or other obstructions _____

Special items

_____

_____

_____

Inlet works (if visible)

Trash racks _____

Trash rack concrete structure _____

Intake stop logs

General condition _____

Protective coating _____

Seals _____

Inlet and upstream channel _____

Gate structure

General condition _____

Leakage _____

Metal work (air vent, gate stems, etc.)

General condition _____

Protective coating _____

Gate

General condition _____

Protective coating _____

Cavitation _____

Leakage (closed) _____

Exercising frequency _____

Operation at the time of examination _____

Gate hoist

General condition _____

Reservoir level gauge _____

Communications _____

Security _____

Alternate source of power _____

Flood forecasting system _____

RESERVOIR

Reservoir level gauge _____

Log boom _____

Landslides (individual designation and Location for identification) _____

Special items

_____

_____

_____

~~890~~

ACCESS ROAD

Condition _____

Ditches _____

Bridge

General condition _____

Vegetation at abutments & piers _____

Bridge supports _____

Foundations _____

Substructures – piers _____

Bridge bearings _____

Moving parts _____

Accumulation of birds' nests, etc. _____

Visual inspection of scour protection _____

Protective coatings _____

Main supporting members

Deteriorated and/or damaged members _____

Protective coatings _____

Bridge deck

General condition _____

Drainage _____

Expansion joints _____

Guard rails _____

Sign boards _____

Live load capacity _____

Special items

_____

_____

_____

~~631~~

CHECKLIST FOR INSPECTION OF CONCRETE DAMS

DAM

Upstream face _____

Downstream face

- General condition _____
- Seepage on downstream face _____
- Measurement of seepage _____

Crest

- Offsets _____
- Roadway _____
- Walls _____
- Parapet wall _____
- Lighting, etc. _____

Galleries

- Concrete _____
- Metalwork _____
- Electrical _____
- Ventilation _____
- Seepage _____

Drainage gallery

- General condition _____
- Ventilation _____
- Cleanliness _____
- Lighting _____
- Movement (alignment) _____
- Cracks _____
- Drains & drainage (all drains should be open) _____

Location of seepages _____

Measurement of seepages _____

Amount of flow _____

Uplift pressures _____

Probing of foundation & formed drains _____

Chemical analysis of water _____

Amount of leaching _____

Drainage sump _____

Pumping arrangements _____

Alternative source of power _____

Special items

_____

_____

_____

FOUNDATION AT DOWNSTREAM

Toe of dam

Leakage around dam _____

Location _____

Amount _____

Measurement methods _____

Instrumentation

Structural _____

Seepage _____

Reservoir level gauge _____

Operation during examination _____

Special items

_____

_____

_____

SPILLWAY

Control structures

- Crest _____
- Sluices _____

Gates

- Type of gate _____
- General condition _____
- Protective coatings _____
- Leakage (closed) _____
- Exercising frequency _____
- Operation of gates at the time of examination _____

Controls for gates

- Mechanical
  - Hoists _____
  - Wire ropes _____
  - Protective coatings _____
- Electrical
  - Power supply _____
  - Standby power _____
  - Operation instructions _____

Stop logs

- General condition _____
- Protective coating _____
- Seals _____

Stilling basin

- Walls _____
- Floor _____
- Weir _____

River channel below basin

- Riprap _____

Erosion _____

Vegetation _____

Special items

_____

_____

_____

OUTLET WORKS

Intake

Trash rack _____

Concrete _____

Outlet conduit

Metal work _____

Cavitation _____

Control facilities

Gatehouse _____

Crane _____

Gate and controls

General condition _____

Protective coatings _____

Cavitation _____

Exercising frequency _____

Operation at the time of examination _____

Control system

Electrical _____

Auxiliary power _____

Mechanical _____

Operating instructions _____

POWER FEATURES
(if related to safe operation or structural integrity of dam)

Intake structure _____

Trash rack

General condition _____

Cleaning arrangement _____

Intake gate(s) _____

Intake gate hoist _____

Gantry crane

Mechanical _____

Electrical _____

Paint _____

Operating instructions _____

Operation during examination _____

Storage area _____

Tail race

Draft tube closure structure _____

Draft tube gates _____

Gantry crane (hoists) _____

Standby power unit

Condition _____

Exercising frequency _____

Automatic features _____

Operation during examination _____

Special items

_____

_____

_____

~~625~~

PROFORMA FOR PERIODICAL INSPECTION OF LARGE DAMS

Date of inspection _____

B. GENERAL

Sl.No.	Item	**Remarks**
(1)	**(2)**	**(3)**

1. Name of project
2. Purpose of project : Water supply / power / multipurpose / irrigation
3. Name of dam
4. Year of completion
5. First filling (years / levels)
6. Benefits accrued :
   (a) Irrigation
   (b) Water supply
   (c) Power
   (d) Other benefits

7. Important controlling levels (in metres)

   (a) Top of dam
   (b) Maximum water level
   (c) Full reservoir level
   (d) Sill level of irrigation sluices
   (e) Sill level of scouring sluices
   (f) Spillway crest level
   (g) Minimum drawdown level
   (h) Lowest river bed level
   (i) Deepest foundation level

8. Important salient features

   (a) Dead storage capacity
   (b) Area of foreshore at FRL
   (c) Design flood adopted (PMF / SPF / any other)
   Give relevant magnitude
   (d) Design spillway discharge
   capacity & type of spillway
   (e) Type, number and
   size of spillway gates
   (f) Location, sill level and capacity of
   low level outlets and scouring sluices.

~~627~~

(g) Height of the dam in metres

(i) above deepest foundation
(ii) above lowest river bed

(h) Gross storage capacity in million cubic metres

(i) at FRL
(ii) at MWL

(i) Length of the dam (at crest) in metres.

9. Name and designation of the inspecting officer

10. Date of inspection and the corresponding reservoir water level

11. Maximum and minimum water levels reached during the last season with dates

12. Maximum overflow during preceding monsoon with dates.

13. History of past distress, if any, and brief details of remedial measures carried out.

14. Does the officer-in-charge of the operation & maintenance of dam possess all the records as given in the Annexure I.

15. When and by whom was the dam inspected immediately preceding this inspection?

16. Are the items pointed out during the last inspection properly attended to?

(if not, state deficiencies yet to be corrected)

~~636~~

Annexure I

Record required at site (referred in item 14 of General)

Records that may be required for proper inspection and maintenance shall be available at site. These shall be properly maintained and kept up-to-date by including latest information available. Data in respect of upstream gauging stations, flood warning system and communication channels, if installed, shall be properly maintained.

General

1. Final detailed project report and details of modifications done during construction and a set of final drawings (as executed).

2. Index Plan of the area in which the dam is located showing important towns, roads, rail routes and communication facilities.

3. Index Plan of downstream area showing natural flood zone, flood zones corresponding to spillway design flood and dam break flood and all important towns / villages and property lying in these flood zones.

4. Contour map of dam site extending upto 200 m or 10 times the dam height (whichever is less) on upstream and downstream, showing all features of the dam like toe lines, fills, drains, relief wells, access roads, etc.

5. Record drawings of longitudinal section of dam foundation or cut off trench showing details of foundation stratigraphy, stage-wise construction of COT filling and raising of dam section or embankment zoning details and foundation treatment.

6. Record drawings of cross-sections of dam showing details of foundation treatment, under seepage control, zoning, internal and external drainage, all protective arrangements and stage-wise construction

7. Contour Plan of dam site with foundation trench showing details of foundation treatment and foundation drainage.

8. Contour Plan of reservoir basin.

9. Contour capacity and area capacity curve.

10. Reservoir maps showing silted basin, if observed.

11. Plan of the catchment area showing rain gauge stations and capacities of upstream storages.

12. Material properties adopted for design.

13. Details of design criteria followed.

14. Design report on flood studies and spillway design flood.

15. Design reports of outlets, power outlets river sluices, intake, conduit, energy dissipation arrangements and details of gates of hoists.

16. Geological data on the foundations and abutments.

17. Copies of geological reports, details of special foundation and abutment treatment carried out.

18. Record of tail channel geology and tail channel erosion.

19. Instrumentation drawings with details.

20. Instrumentation data and behavioural record.

21. Details of communication system, telephones, wireless, etc., directory of important key officers, flood warning procedures.

22. Flood forecasting system.

23. Photographs showing various phases of construction, pre-construction, etc.

Earth – Rockfill dams

1. Stage-wise construction record of the dam showing volumes and heights achieved in each season and time rate of progress.

2. Record of special compaction done near concrete / masonry structures, abutment contacts and outlet locations, if available.

3. Summarized records of compaction, control sampling and complete laboratory and field test resulted on all record samples.

4. Foundation details and geology as observed.

5. Data of water intake tests.

6. Detailed drawings and record of relief well observations.

7. Design report for the earth dam, covering the under-seepage control, stability of embankments junctions with masonry dam, instruments installed, etc.

8. Drawings showing the typical cross sections, including zoning, drainage arrangements, detailed details of slope protections provided for, etc., as per actual construction.

9. Details and location of instruments embedded / installed in and around the structures.

10. Record of corrective measures, repairs and treatment that have been done subsequent to construction.

11. Details of design criteria followed.

12. Photographs showing all phases of construction.

13. Important inspection reports and reports of consultants.

Concrete / Masonry dams

1. Details of construction history, including stages of construction, particularly in low blocks where considerable time elapsed prior to resumption of work.

2. Summarized data on control tests, carried out during construction in respect of concrete, mortar and their constituent materials, if available.

3. Reports on hydraulic model studies.

4. Drawings showing the details of energy dissipation arrangements, including foundation levels of apron, training walls and end weir.

5. Details and location of instruments embedded / installed in and around the structure.

6. Summarized data of observations on embedded / installed instruments.

7. Detailed drawings of all service facilities like internal lighting, emergency lighting, drainage, etc.

8. Drawing showing the uplift measurements and pressure relief arrangements.

9. Summarized data of uplift pressures observed..

10. Summarized data of seepages, leaching observed in the drainage gallery and downstream face of the dam, their locations, etc.

11. Record of corrective measures, repair or treatment that have been done subsequent to completion.

12. Important inspection reports and reports of consultants.

13. Details of design criteria followed.

14. Photographs showing all phases of construction.

Operation and Maintenance

1. Gauge data of the river prior to the construction and after completion of work.
2. Detailed observations of flood discharges.
3. Detailed observations of hydraulic performance of energy dissipation basins.
4. Record of past performance stating briefly the defects developed and remedial measures carried out.
5. Drawings of outlets, maximum discharge capacity, maximum design operating head.
6. Standing orders regarding operation of the dam.

    (a) Designers operating criteria.
    (b) Standing operating procedures.
    (c) Flood forecasting procedures.
    (d) Gate operation procedures.
    (e) Emergency Action Plan

7. Standard reference literature for operation and maintenance of reservoir, dam, ancillary work, gates, instrumentation, etc., including I.S. specifications, codes, manuals, manufacturers' literature, etc.

~~632~~

PROFORMA FOR PERIODICAL INSPECTION OF DAMS

Inspection of dams and ancillary works

B. **EARTH DAM**

Item No.	Item of inspection	Observation & recommendations, if any, of the inspecting officer	Remarks of reviewing officer
(1)	(2)	(3)	(4)

1. Downstream drainage

(a) Are there any signs of water logging, slushy condition or growth of acquatic weeds on the downstream of the dam?

(b) Are there any standing pools of water in the downstream area of the dam? If so, give their locations and extent.

(c) Are there any boils observed in the vicinity of the downstream toe of the dam?

(d) Is the downstream area sufficiently clear and free draining?

(e) What is the depth of ground water table on the downstream as evident from the existing walls in the vicinity of the dam?

Does the water table show any marked variation in accordance with the variations in reservoir water level?

(f) Are all the exposed drains working satisfactorily?

(g) 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 patching to these drains intact?

(iii) Is there any weeds growth in their drains?

(iv) Indicate other defects noticed in these drains, if any.

(h) Outfall drain

(i) Is the outfall drain in proper shape and grade and freely draining?

(ii) Is the outfall drain properly cleaned and maintained?

(iii) Does the outfall drain show any stagnant pools of water or weeds growth?

2. Surface drainage of downstream slope

(a) Is the condition of the downstream slope drainage arrangements satisfactory?

(b) Is the paving to these drains intact?

(c) Are all the drains properly maintained and free of vegetation growth and debris?

(d) Does the slope have a tendency to develop severe rain cuts at any location?

(e) Enumerate any other defects noticed in the surface drainage of downstream slope.

3. Seepage measurements

(a) Is the quantity of seepage being daily or periodically measured with respect to water level in reservoir and recorded? Please

check the registers and record observations.

(b) Does it show any abnormal rise or fall? If so, does it have any relation to a certain reservoir level elevation?

(c) Does the seepage flow show a turbid colour at any stage? Was such a phenomenon observed at any stage at any location in the past?

(d) What is the measured rate of seepage flow with date and reservoir level?

(i) On the day of present inspection
(ii) Maximum since last June
(iii) Minimum since last June.

(e) Is the portion upstream and downstream of measuring points of seepage easily accessible with proper steps and path and free vegetation growth?

(f) Are the measuring points properly located, constructed and maintained so as to give accurate and reliable measurements of seepage?

(g) Is the method of taking seepage measurements satisfactory?

(h) What is the design seepage discharge? State your observation on comparison.

4. <u>Earth dam section crest</u>

(a) Is the crest profile at proper elevation?

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).

(b) Is the surface of the crest free from undulations and local depressions or heaving?

Does it provide an all-weather road surface?

(c) Does it develop any visible cracks in transverse or longitudinal directions? If so, attach a map showing their locations and extent. Depth and width of cracks must be ascertained by taking open trenches extending below the bottom of cracks.

(d) What is the condition of the edges of crest? Is ramp provided? Any road crossing provided? Have they got eroded and cut up resulting in reduced effective width?

(e) Is the crest free from local slips throughout its length on either sides?

(f) Do the headers, guard stones and parapet wall provided at the edges of the crest appear in proper profile and plumb?

5. <u>Earth dam section – upstream and downstream slopes</u>

Indicate the general conditions of upstream pitching, downstream pitching / turfing and rock toe.

a) Do the upstream and downstream slopes show any sign of bulging or concavity? If so, indicate their locations and extent.

b) Does the section of the dam and both the slopes appear structurally sound and stable?

c) Are any longitudinal or transverse cracks noticed in any part of the slopes?

d) Were 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 conditions of upstream pitching, downstream pitching / turfing and the rock toe.

e) Is there any profuse growth of bushes or weeds over any portion of the dam? If so, indicate the locations.

f) Do the upstream or downstream slopes show existence of crab holes or holes made by rodents or burrowing animals or anthills? If so, indicate the locations.

g) Are there any wet or slushy patches and 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 your findings.

h) Are all the rain cuts and erosion channels properly treated and made good?

Please indicate location of recurring damages, if any.

6. <u>Junction earth work with masonry / concrete dam sections and outlets</u>.

(a) 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.

(b) 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.

(c) Is there any tendency for surface erosion at the junctions?

(d) If the outlet conduit is located in the earth dam section, is the entire length of the conduit in perfect order & profile and free from off sets, open joints, cracks and leakage?

Examine the conduit carefully from the downstream or from inside, if possible, and indicate the deficiencies observed, if any.

(e) Check the conditions of the crest and slopes, especially in the zones adjacent concrete structures. Detect the deformations, settlements, cracks or other distress conditions caused by external erosion due to wind, rain, etc. Set up permanent observation system for the same at the places of occurrence. Seepage at junctions between earth dam and masonry concrete retaining wall or corch type junctions with concrete dams is a possible source of trouble and should be carefully watched.

7. Relief wells

(a) Are the relief wells in good working conditions and functioning well?

(b) Are the relief wells properly cleaned periodically?

(c) Please indicate the dates of last cleaning and the next cleaning due.

(d) Are the necessary plant & equipment for cleaning the relief walls available with the office.

8. Breaching section (if provided)

(a) Is the breaching section easily accessible?

(b) Is the condition of the breaching section satisfactory?

(c) Is the note of instructions as to when and how to operate the breaching section available on record?

(d) For reconstruction after the breach, are the following items decided in advance?

(i) Quarry for embankment material.

(ii) Suitable routes of access.

(iii) Agency, plant & machinery for its reconstruction.

(e) Is the maintenance staff fully aware of the instructions at (c) and (d) above?

(f) Ascertain and indicate the latest event of operation of breaching section and its performance.

(g) Is the surplus course from the breaching section acquired upto natural valley?

(h) Is the course formed?

~~638~~

(i) Is the surplus course assigned later as agriculture land or house site?

(j) If so, what steps are taken?

Note: For items pertaining to spillway, gates, sluices and outlets, etc., please refer points 4,5,6,7,8,9,11,12,13,14 under Masonry / Concrete dams.

~~640~~

PROFORMA FOR PERIODICAL INSPECTION OF DAMS

Inspection of dams and ancillary works

C. MASONRY / CONCRETE DAM

Item No.	Item of inspection	Observation & recommendations, if any, of the inspecting officer	Remarks of reviewing officer
(1)	(2)	(3)	(4)

1. Upstream and downstream faces

(a) Examine the monolith and construction joints for such defects as cracks, open joints, spalling, seepage, leaching, etc., and indicate the findings.

(b) Is the upstream face of the dam in good condition? If not, indicate the nature and extent of deficiency.

(c) Is any spalling or cracking observed on the downstream face, especially near the zone of concentration of stresses or location of abrupt change in geometry, or at the openings? If so, indicate the details of observations.

(d) (i) Is there excessive seepage / sweating at any location on the downstream face of the dam?

(ii) Whether the observations are analyzed and compared with the theoretical assumptions made in the design?

(iii) Remedial measures in case of large variations.

(e) Examine the roadway / top of the dam for offsets, opening of construction joints, condition of parapet wall, drainage, lighting, etc.

2. Drainage gallery

(a) General

(i) Is the drainage gallery easily accessible and does it have adequate lighting facilities with sufficient stand by units of lighting? If not, indicate the deficiencies.

(ii) Are proper arrangements made for the measurement of seepage into the gallery?

Is the seepage from

- Porous pipes
- Foundation drains
- Monolith joints
- Other seepage locations
- measured separately

(iii) Are the above arrangements satisfactory?

(b) Seepages from foundation

(i) If there has been a substantial reduction in the seepage through the foundations, is it due to chocking of the drain holes?

(ii) Are all the foundation holes periodically cleaned?

Indicate the last date of such cleaning and extent of variation

observed in the seepage discharge before and after the cleaning.

(iii) Are measurements of uplift pressures taken regularly? What was the uplift like at highest reservoir level during last season? Is observed uplift within design limits?

(iv) Are the seepage water and the deposit, if any, from the seepage being regularly examined for chemical composition?

If so, indicate the results and the probable source of dissolved salts, if any.

(v) Are any seepage water springs observed in the downstream area anywhere?

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 tests are made of water samples from such springs for dissolved salts.

(c) Seepage from body wall (dam and spillway)

(i) 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 (for the corresponding water level) when the reservoir was first filled?

(ii) If there has been a substantial reduction in this seepage, ascertain and indicate the probable reasons therefor.

643

(iii) Is a statement showing the surface area of the dam (water side) calculated block-wise for each metre of rise of water level available?

(iv) What was the total seepage per square metre of upstream face submerged during inspection?

(v) Is there any excessive seepage from any body drain or any other locations in the gallery?

(vi) What steps are being taken for regular periodical cleaning of the porous pipes?

(vii) Has there been a tendency for gradual reduction of drainage through pipes and progressive appearance of sweating on the downstream face of the dam?

(viii) Has there been considerable leaching from the seepage water and deposition of lime near the seepage exist spots?

(ix) Are the samples of the seepage water and the reservoir water being regularly tested for reactive and corrosive properties?

(x) Has the total leaching been estimated?

(xi) Is the seepage on the downstream face of the dam measured?

What was the seepage on the date of inspection? What was the maximum seepage during the past one year?

3. Structural performance

(a) Are there any signs of structural distress noticed in the dam, spillway and foundations in the form of:

(i) Excessive deflection

(ii) Tendency of gradual sliding.

(iii) Cracking and upheaval of 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.

(vi) Conspicuous weathering of materials or components in any portion of the body wall or the foundations.

4. Spillway gates

Spillway gates and other gates wherever applicable.

(a) Are the following documents available at site?

(i) A complete set of detailed design calculations together with the drawings of gates, gate grooves embedded parts, hoisting mechanism and controls, etc.

(ii) Designers operating criteria and / or detailed operating instructions for the various types of gates installed in the dam.

(iii) Maintenance schedules specifying each operation its frequency, and for due and done dates.

(iv) Operating instrumentation with "Dos and don'ts" for all operational units.

(b) Is the condition of the steel surfaces and the surface paint deteriorated?

(c) Are any connecting bolts of rubber seals loosened or damaged? If so, indicate the details of defects.

(d) What is the general condition of rubber seals? Do any of the rubber seals show signs of weathering, hardening, cracking or tearing and damage?

(e) Are the rubber seals of side and bottom touching uniformly all along the sealing surface?

(f) Do the rollers (wherever applicable) touch the track plates uniformly? Are the rollers well lubricated?

(g) Are the electrical meters, gear systems, limit switches, brakes, bush bearing, etc., of hoist mechanism well lubricated?

(h) Is the operation of the above, smooth and satisfactory? If not, list out individual results and observations.

(i) Are the embedded 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 observations, if any, regarding such defects.

(j) Check the following for structural soundness of all members and welded bolts and riveted connections, uneven wear, uneven bearing, cracking, chipping and dents and indicate the findings.

(i) Gate leaf and stiffeners
(ii) End arms
(iii) Trunnion girders
(iv) Stop logs
(v) Lifting beams
(vi) Gantry cranes
(vii) Tracks
(viii) Bridge structures

(k) Are the trunnion bearings of radial gates properly lubricated?

(l) Is there any damage or weathering caused to the seal plates? If so, indicate the nature of damage noticed.

(m) Is the full length of wire rope of the hoist in sound condition and free from broken strands?

(n) Is the electrical wiring in sound condition?

(o) Is the alternative power system for gate operation working properly?

Give details of generating sets and standby units and the time required to operate all gates on the alternative power system, on the basis of actual trial operation. Check for diesel stock for operation of generator, battery charger available. Battery in spare.

(p) Is the operation, which is a standby in case of electrical hoists, tried and found satisfactory? Please take test trial and ascertain.

(q) Are all the nuts of connecting bolts and anchorages properly tightened?

In case of trunnion girder anchorages tightening torque which is generally specified should be adhered to.

(Note: After inspection of the various items, it is necessary to draw up a list of actions needed to be taken and pursue matters with the concerned agency.)

(r) Are the hydraulic hoists working satisfactorily?

(s) Are the trunnion hub and the brackets well maintained?

(t) 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.

(u) Are any of the mechanical or structural components and fastening or seals subjected to excessive wear? If so, please give details. Is there any tendency for recurring damage to any particular components? If so, please give details.

~~646~~

(v) Is sufficient stock of spare which need frequent replacement maintained at the site?

(w) Is the staff posted at the site, maintenance and operation of gates, hoists, equipments and electrical installation well experienced, fully trained and conversant with the job requirements and responsibilities?

(x) What is the exercising frequency? When were the gates last exercised?

(y) Performance during inspection.

(z) Change over switches for main power supply to generator supply are provided.

5. Spillway bridge, hoist bridge catwalks, and other bridges where applicable.

(a) Are the decking, girders and structural supports of spillway bridge, hoist bridge and catwalks structurally sound?

(b) Is the floor of the bridge structurally sound and safe?

(c) Is there satisfactory arrangements to prevent unauthorized entry into the control structures and bridges?

(d) Are the structural members and joints sound and free from corrosion?

(e) When were the steel components painted last?

(f) Is the surface of steel work and paint satisfactory?

(g) Is the parapet or railing over the bridges sound and safe?

(h) Are all the bearings, bearing pads and pier caps structurally sound?

(i) Are all the track plates for gantry cranes laid over such bridges structurally sound and intact?

6. Energy dissipation arrangements

(a) Can the tail pond be drained easily for inspection of the stilling basin? If not, what are the short comings?

Please ascertain and indicate the last event of inspection of stilling basin.

(b) 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.

Indicate the extent and location of such erosion with reference to the various components of dam's spillway outlet, powerhouse, etc.

(c) Is the concrete surface of the stilling basin and apron 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.

(d) Is there any indication of abrasion and cavitation damage (pitting of concrete), especially at friction block, chute blocks the surface near the lower tangent point and the end sill?

~~650~~

If so, please give the details of nature and extent of the damage.

(e) Is the under-drainages of the stilling basin satisfactory?

Are all the open drain holes clear and functioning well?

7. Walls

Guide walls / divide walls, junction walls / return walls / spray walls, etc. (strike out whichever is not applicable)

(a) Are all the locations of such wall accessible for inspection, maintenance and repairs?

(b) Is the drainage of back sides of the walls (wherever applicable) from the weep holes satisfactory?

If not, indicate the nature of deficiencies.

(c) Is there any tendency for the water to undercut the ends of the walls?

If so, please give details of nature and extent of damage.

(d) 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.

(e) Is there any surface erosion / damage caused to face or body of such walls?

(f) Do any of the walls show symptoms of unequal settlement development of cracks and tilting?

If so, give details of the defects noticed.

(g) Is there any damage to guide bunds? If so, give details of the damage.

8. <u>End Weir</u>

(i) Is it accessible?

(ii) Is there any erosion pitting or spalling of the concrete or masonry surface? If so, give details.

(iii) Is there any scour noticed on the immediate downstream of such weir?

If so, give details of location and extent of such damage.

9. <u>Hydraulic performance of energy dissipation arrangements.</u>

(a) Do the flow conditions in the stilling basin have a tendency to draw rocky material into the bucket and cause its churning and abrasion damage to the surface of buckets, baffle blocks, apron and end sill?

(b) Is the hydraulic performance in proper agreement with the results of model studies?

Ascertain the performance from observed tail water rating curves and deficient observation, if any, such as weep outs and excessive erosion under plunge pools and location of secondary rollers and retrogression.

10. <u>Instruments installed and observations</u>

(a) Are all the instruments installed properly accessible?

Are all the locations properly lighted, ventilated and adequately protected from possibilities of damage?

(b) Are all the instruments in proper working order?

Ascertain the cases of instruments going out of order and indicate.

(c) Are all the registers of observations posted upto date? Please take test observations and initial the registers.

(d) Are all the plottings of the instruments data completed upto date?

(e) Are sufficient stocks of spares, gauges, master gauges, stationery items, etc., maintained at the site for uninterrupted data collection?

11. Outlet

(a) Is the air vent periodically cleaned?

(b) Are there any structural damage to the intake walls such as leakage noticed through walls?

(c) Is there any leakage observed through the conduit, concrete or masonry?

If so, give details of its location and extent.

(d) Is there any damage noticed to the conduit concrete, breast wall and gate slots?

(e) Is the by pass valve (wherever provided) operating satisfactorily?

(f) Take operating trials of the following as provided and record the observations and defects noticed, if any.

(i) Service - gate
(ii) Emergency - gate/s
(iii) Stop-log - gate/s
(iv) Sluice - valves

(g) Are the trash racks (wherever provided cleaned before monsoon?

(h) Are there vibration and noise noticed in operation of outlet gates at any time?

If so, are any periodical observations taken to ascertain their severity?

(i) Is the energy dissipation arrangement working satisfactorily for all discharges?

(j) Is there any structural damage to the energy dissipation structures? If so, give the details of nature and extent of the damage.

(k) Is the conduit structurally sound and reasonably leak proof?

If not, give details of nature and extent of the effects.

Is it possible to examine the conduit from inside?

(l) 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?

12. Outlet gates

a) Is the surface of gates and the paint deteriorated?

b) Are the connecting bolts of rubber seals loosened or damaged?

c) Do the rubber seals show signs of weathering & damage and need replacement?

d) Are the rubber seals of sides and bottom touching the bearing surface uniformly?

e) Do all the rollers touch the track plates?

f) Are the rollers well lubricated?

g) Is the operation of outlet gates smooth?

h) Are the stem rods for lifting the gates straight?

i) Are the actual operation of lifting and lowering of the gates and hoist mechanisms smooth and satisfactory?

j) Are all the gears and hoist mechanisms well lubricated?

k) Is the storing arrangement for emergency gate leaves and the stop logs in satisfactory condition?

l) Are the seal plates in sound condition?

If not, ascertain the type of damage and indicate.

m) Is the full length of wire rope (wherever applicable) of the hoist in serviceable condition and free from any broken strands?

n) Are all the nuts of connecting bolts and anchorage properly tightened?

o) Are all the lifting beams in proper order and sound condition?

If not, ascertain the nature and extent of damage and indicate.

p) Do any of the mechanical or structural parts of the gates, fasteners or hoists show signs of excessive wear? If so, please give details.

q) Is there any tendency for recurring damage to any particular component of components? If so, give details.

r) Is sufficient stock of spare which needs frequent replacement maintained at the site?

s) Whether hand cracks are kept under lock and key and not attached on hoist mechanism when operated by electrical energy?

t) Whether warning sign indicating "Danger, Do not switch on" is hung during maintenance?

u) Whether the operating crane is in "A" condition and the operators are instructed to lift the emergency gates / stop logs in a vertical direction so that allowable carrying capacity is not exceeded?

v) Whether there is a "standby" power supply?

w) The alternative sources of power

1. Is the generator in the working condition
2. Frequency of exercise
3. Is it developing full voltage.
4. Is the wiring intact and is the changeover switch in working condition?
5. Are the spares available at site?

13. River outlet / river sluice & gates

(a) Is the overall condition of river outlet works / river sluices satisfactory?

(b) Is the operation of the gate satisfactory as ascertained by taking an operating trial? If not, indicate the defects noticed.

(c) Are the trash rack (wherever provided) cleaned before monsoon?

(d) Is there excessive silting on the upstream of the sluice?

(e) When were the gates last opened for desilting, etc.?

(f) Please indicate the approximate quantity of the leakage through the gates, if any?

(g) Is there any seepage or leakage through the conduit surface?

(h) Is there any damage to the upstream and downstream conveyance structures of the conduit?

(i) Is the condition of energy dissipation arrangement satisfactory?

If not, indicate nature and extent of damage.

(j) Is there any retrogression noticed in the downstream channel?

If so, give details of nature and extent of damage.

14. Power outlet

(a) Is the overall condition of power outlet satisfactory?

(b) Is the operation of gates smooth and satisfactory as ascertained by taking operating trials?

If not, indicate the nature of the defects noticed.

(c) Are the trash racks cleaned before monsoon?

(d) Is there excessive silting in the approach channel on the upstream of power outlet?

(e) Is there any seepage through the conduit surfaces?

(f) Is there any cavitation damage to the inside of the conduit and penstock of the HRT and pressure shafts?

(g) Are all the valves functioning properly?

(h) Are there any vibrations induced into the dam and appurtenant works while the outlet is opened or the machines are running?

15. Emergency preparedness

(a) Are the project officers well conversant with the Emergency Action Plan, reporting procedures, warning procedures?

(b) When was the Emergency Action Plan last reviewed?

(c) Are the communication directories updated?

(d) Are the concerned authorities informed about the system of emergency reporting procedures and warning?

(e) Are the inundation maps updated?

(f) Are available safety spots on the downstream of the dam identified and made known to the concerned authorities?

(g) Is the communication system working satisfactorily?

(h) Are adequate warning devices and facilities provided at the dam?

(i) Is the downstream warning system operational?

(j) Are proper arrangements made for security of the dam and preventing cases of unauthorized trespass, vandalism and sabotage to the dam works?

(k) Is downstream warning system operatable on alternative power supply?

16. Access roads

(a) Is there a properly constructed and well maintained all-weather access road to the dam site?

(b) What is the type of pavement of the access road and its condition?

(c) Are there properly constructed and well maintained access roads arrangements to the following components for inspection, maintenance and repairs?

(i) Top of dam

(ii) Spillway

(ix) Gates and hoisting arrangement

(x) Drainage gallery

(xi) Bridge structure

(xii) Downstream stilling basin

(xiii) Junction and abutments

(xiv) Outlet control tower

(xv) Outlet gates

(xvi) Toe of earth dam downstream drainage arrangements and beams

(xvii) All saddle dams

(d) What is the general condition of all the structures on various access roads?

Are all the structures on the access roads adequately safe, for allowing passage of plant machinery for emergent repairs?

17. Communication facilities

(a) Are following facilities available at dam site?

(i) Wireless

(ii) Telephone

(iii) Telegraph

18. General assessment of condition of the dam

Please give general assessment of safety of dam for normal operation. Please enumerate all your observations which you feel are adverse to the safety of the dam for normal operation.

~~600~~

ANNEXURE- E6

TEESTA URJA LIMITED
(A GOVERNMENT OF SIKKIM ENTERPRISE)

REPORT OF EXPERT COMMITTEE

POST MONSOON INSPECTION – YEAR 2022 (Nov'2022)

PERIOD OF INSPECTION - 18.11.2022 TO 21.11.2022

~~681~~

REPORT ON POST MONSOON INSPECTION BY EXPERT COMMITTEE

1 INTRODUCTION

Teesta Urja Limited (A Government of Sikkim Enterprise) vide their letter no. TUL/PW/EC/2022-23/001 to 003 dated 11.11.22 engaged an Expert committee consisting of Sh. S C Gupta, (Construction Expert), Sh. B D Patni (Geo-technical Expert) and Sh. R K Mohapatra (E&M Expert) for post- monsoon inspection of the Teesta III Power station having an installed capacity of 1200 MW, housing six 200MW Generating Units driven by Pelton Type turbines, which was commissioned on 28th February 2017. The team was accompanied with MD-TUL, ED (Co-ordination & President), ED (Incharge) & President, ED (Projects & Contracts) & Chief O&M Consultant and officials of TUL during the visit.

MANDATE:

a) The Committee will carry out physical inspection of all the project components including gates namely Dam, Spillways, Power Intake, De-silting System, HRT, Surge Shaft, Pressure Shafts, Power House and Tailrace Tunnel :
b) To check the condition of the structures and monitor their behavior.
c) To investigate conditions that might cause distress to the structures.
d) To study the extent of deterioration based on which maintenance and repair can be planned.
e) The Committee will inspect Hydro-mechanical and Electro-mechanical Plant and review the performance. The Committee will also review the status of spares inventory and management.
f) To review the repair and maintenance works which have been carried out in the plant and submit broad guidelines for further improvements.
g) To review the works which were suggested in the earlier inspection report & its performance and suggest for any further improvements.
h) To review the issues faced in Transformer and the corrective actions taken by TUL and suggest further actions/ improvements.
i) The Committee will carry out inspection in coordination with the concerned engineers/Project team/agencies at site.
j) The Committee shall submit an inspection report of the all the Project Components and recommendations for repair if any shall be included in the report.

The members of committee as mentioned above, in accordance with the letter visited the project from 18.11.2022 to 21.11.2022. During the period of inspection, the committee members visited all plant locations for visual inspection of the components. The observations of the committee are summarized as under:

2 DAM COMPLEX

2.1 GENERAL

The maximum and minimum river discharge recorded in this year was 474cumecs on 12.10.2022 and 33.0 cumecs in Feb'2022. The project has been designed for a spillway capacity of 7000 cumecs with one gate inoperative condition.

2.2 CFRD

The concrete slab of CFRD is found intact above the reservoir level EL 1575m. However, no distress cracks were observed by site officials on the face slab of CFRD. There is no evidence of piping & subsidence along the downstream face & terminal reach of rock fill section of the Dam. The abutment slopes along the left bank of surface Spillway are stable and further downstream adjacent to the length of Spillway apron the hill slope appeared stable during visual inspection from dam top. No distress was observed along the back slope of Power Intake Structure. All vegetation growth have been removed by the project. At places, deep cavities/ hollow space was observed between the boulders of pitched area of the d/s of the dam. Enlargement of such cavities may pose instability in the d/s face of the dam.

Recommendation:

- The committee advised to fill the hollow space / cavities by boulders / rock fragments.
- In future, same procedure adopted in the past may be followed for removal of vegetation growth at the d/s face of the Dam.

2.3 CHUTE SPILLWAY

The chute spillway structure was visually inspected by the committee and found intact and stable. Downstream of the Chute Spillway Outfall Structure the river course has been widened as suggested in the earlier committee report.

Excessive rains in the project area are main cause of slides and instability of hill slopes even in adequately supported slide zones. The old slide zones just above the dam axis has already been supported by providing drift anchors and surface treatment. However, unprecedented rainfall may trigger the movement of hill slope due to marked reduction in shear strength parameters and lubrication along weak joints plane.

The committee noted that the channel connecting chute spillway & ST outlet is still not defined, this suggestion was made in the previous report also. The same needs to be attended by the project to address d/s side slope failures in the event of release of heavy discharges through chute spillway.

Recommendations:

- The landslide zone just above dam axis (EL: 1608 – 1740 m) left bank should be geotechnically examined and suitable defensive measures shall be decided based on the results of geological mapping and geo-technical assessment. This work may be carried out by the outside expert agency.
- Wherever there is vegetation growth in chute spillway area, same procedure adopted in the past for CFRD may be followed for removal of vegetation growth.
- The work of defined channel d/s of chute spillway needs to be taken up by identifying the most critical d/s reaches and providing gabions. This work needs to be taken up in such way that the whole d/s channel upto ST outlet becomes properly defined in next 3-4 years.

2.4 RIGHT BANK FLUSHING TUNNEL (RBFT):

The Expert Team also inspected the RBFT through outlet area and thoroughly inspected the invert, wall and crown portion of the tunnel. During the visit, it is observed that deep erosion and cavity formation was prominent in the curved area of right conventional side, however impact of boulder rolling was minimal in left conventional side. As noticed, Bottom sill beam of the radial gate found intact and observed as zero leakage through it. A few observations are enlisted below-

1. At the outfall structure of RBFT, abrasion of concrete surface in invert section has been observed.
2. At chainage 330 m and chainage 10 m of d/s of adit, 1m to 1.5m deep cavity was observed at right conventional side due to scouring and rock surface was exposed.
3. In u/s of the adit damages are minimal.
4. Committee was intimated that left pier of RBFT gate and concrete below sill beam is damaged and divers are currently working for the repair. Further, the committee noted that there is leakage to the tune 250-300 lit/s from RBFT.
5. The project intimated the committee that the nalah near the Tsoten village brought in huge quantum of debris during flash flood event in the nalah and the same got deposited at the flushing tunnel outlet area which led to the formation of pool at the outlet. However, the project saw no risk of blocking of flushing tunnel outlet mouth due to this event. The committee inspected the area and concurred with the observation of the project.
6. The project also intimated of the flash flood event in the ITPB nalah which damaged the road to FT outlet and brought in huge debris. The committee visited the area and inspected the extent of debris and concluded that no threat to plant operations or dam structures is visible due to these debris.

Recommendation:

- The leakages needs to be arrested and damaged gate seals need to be repaired/ replaced before commencing with repair activities in RBFT.
- Committee suggested to repair the u/s damage area of RBFT invert by providing M 50 fiber concrete.
- Committee suggested to repair the d/s damage area of RBFT by providing M20 SCC upto 300 mm below the final profile and the 300 mm thick M50 fiber concrete shall be placed upto final profile of the invert.
- Committee suggested to lower the level of final profile of invert by 100 mm to increase the flat area of invert.
- Wherever rock surface is exposed, committee suggested to properly dewater the area and clean the area and fill up the cavity with minimum design grade concrete.
- The committee recommends that the cladding wall on the left bank near the outlet be repaired and extended upto the nose of the hill.
- The committee recommends that a recce of the Tsoten village nalah and ITPB nalah to ascertain the quantum of debris deposited in the passage may be carried out by the project.

2.5 LEFT BANK SPILLWAY TUNNEL- 1:

1. Committee inspected the outlet structure of ST-01 and the structure found intact and in good shape.
2. The project officials informed that the LBST-01 has not suffered any major damages during this season including the goose neck. There are some minor pot holes in u/s from goose neck portion to chainage 200 m.

Recommendation:

1. The damaged area of invert in u/s may be repaired by providing M50 fiber concrete if the potholes are of depth 300 mm and more.
2. The energy dissipation arrangement of goose neck as per original design may be reviewed and it should be explored whether a pool formation can be made just downstream of goose neck. Model study of the energy dissipation arrangement for ST-01 is also recommended.

2.6 LEFT BANK SPILLWAY TUNNEL-2:

The committee discussed about the ongoing protection works being carried out by Maccaferri on the uphill slope above the ST-02 inlet. From the visual inspection, it is observed that at the toe of the slide area wide cracks/ openings are observed in few of the rock boulders which are unstable and may roll down due to lubrication along weak plane during rains.

Recommendation:

The committee advised for filling of all wide cracks in the rock boulders by cement slurry or thick grout mix, followed by installation of grouted anchors perpendicular to the boulder face. As suggested in the earlier committee report, installation of drapery system with rock anchors are in progress and the installation of steel girder at top of the ST-02 inlet is in progress. If possible, realistic geotechnical assessment may be carried out.

2.7 ACCESS TUNNELS IN DAM SITE:

Various access tunnels in left and right bank of dam site, found intact and stable. At places detachment of shotcrete blanket /deterioration was also noticed below spring level.

Recommendation:

As a preventive measures 300 mm thick & 1m high concrete wall may be provided in the affected area to avoid further deterioration. Wherever there is detachment in shotcrete layer above spring level, lattice mat with shotcrete may be provided as a protection measures.

2.8 DE-SILTING CHAMBERS:

Both the de-silting chambers are operative and are fully functional. The project is measuring the silt load on both u/s and d/s of de-silting chambers as well as downstream of RBFT on daily basis in order to determine the silt content and requirement of flushing and its duration. The committee inspected the downstream gate arrangement and noted that there are leakages from DC-02. The project showed photographs of the water jets emanating from invert of DC-01.

Recommendation:

- The committee suggested to dewater DC-01 first and carry out repair of seals in the d/s and thereafter dewater DC-02 and carry out repairs for controlling water leakage.
- As the project is emptying both the DCs it will be advisable and prudent to carry out survey of both the DCs for assessment of shotcrete & concrete. Further, geological assessment of the DCs may also be carried out. As informed by project major work is anticipated in DC-02, hence, the inspections may be concentrated to DC-02 this year.

2.9 RESERVOIR:

The committee inspected the reservoir RIM protection works and the same is found intact and in good shape. As suggested in earlier committee report, the protection & repair works have been carried out and found in order. The large size

boulders along Lachen river have been marked by different colour for monitoring the movement.

The project is suggested to carry out topographic survey (on suitable scale preferably 1: 5000) of the reservoir rim above FRL and also between the reservoir operating levels during this lean season.

No distress was observed in the support measures and adjacent slopes long both banks of Lachen and Lachung river except the gabion wall constructed below moonlight school from EL: 1567m – 1572 m. In this stretch, gabion wires are got damaged due to hitting of boulders and need to be repaired to arrest further damages.

Committee suggested to records the size & quantity and periodic movement of the trash and location of maximum accumulation. Based on the recorded data, the arrangement for removing trash may be explored and construction of log booms may be planned if required.

Recommendation:

1. Identification and classification of weak / landslide are in the upper catchment with geo-technical inputs. The catchment area map in the vicinity of reservoir, to start with upto 10 km from the reservoir tail, may be prepared in the scale of 1:10000 scale. This work may be expedited with the help of some outside agency. Based on the output of the catchment area survey, the vulnerable zones may be identified after detailed analysis. These zones may be further studied and monitored for future actions.
2. The gabion wall below moonlight school from EL: 1567 to EL: 1572 m shall be repaired by providing 300 mm thick concrete cladding from EL: 1567 – 1569m and 200 mm thick concrete cladding from EL: 1569 – 1572 m.

3.SEDIMENT MANAGEMENT:

The project team has been carrying out Silt depth measurement in front of RBFT, LBST-1, LBST-2, CHSP, junction of Lachen and Lachung river periodically. The depth of reservoir bed is being measured by eco sounding system based on established grid profile with the help of Motor Boat. Similarly silt analysis is being done by collecting samples from infront of Intake, Lachen and Lachung river, HRT U/S hinge Gate, HRT D/S hinge Gate. As suggested in the earlier report, the project informed that procurement of bathymetric survey equipment comprising of DGPS, depth sounder and contour generating software fitted on a motor boat is in progress.

The project informed the committee that the central government is stressing on implementation of autonomous early warning system for flood forecasting.

Recommendation:

The committee has stressed enough on the subject of sediment management and continuous monitoring and survey of the reservoir. The procurement of bathymetric survey equipment preferably autonomous may be expedited by the project.

4. HEAD RACE TUNNEL:

As informed by the project site, no seepage and distress noticed in the hill slope of these adits. As per the past practice daily monitoring of the seepage in all the adits be continued.

5. Instrumentation

Instrumentation in dam complex was discussed, the project recording the data of installed / working instrument on routine / weekly basis. The committee has already suggested to calibrate all the instruments in earlier visit and the same needs to be taken up at the earliest. Analysis and Interpretation of the recorded data needs to be carried out by the vendors/ Experts. At the same time all the working instruments shall be connected to a DAS System on real time basis which shall be installed in the Control room for regular monitoring.

The project has shown the instrumentation data to the committee. The record says that no significant movement observed in these instruments. The data should be collected regularly from the seismographs installed.

In power house area, only 2 extensometers are working.

Recommendation:

In addition to above, committee advised to install 4 nos extensometer (2 nos in u/s & 2 nos in d/s) for monitoring the deformation if any.

6. POWER HOUSE COMPLEX:

- The committee during earlier inspection reports has already recommended for immediate calibration of instruments. However, no distress and movement were noticed during the visit.
- The instrumentation wires should be collected kept in proper junction box for safety purposes.
- As per the available instrumentation data, there is no movement observed except Inspection Gallery – 1 which is within the limit.
- The Committee has earlier suggested that in-house team from different discipline may be formed for regular monitoring of the project components. A checklist to be prepared to cover all the parameters which are to be monitored. The team will monitor the project components at quarterly intervals and submit the report.

- At some locations telltale structures in the upstream wall of Power House are not installed along the cracks for monitoring the movement and the same may be installed as earlier as possible.

The committee also advised for immediate compliance on following unattended remedial measures as suggested in earlier reports:

i) The energy dissipation arrangement of goose neck as per original design may be reviewed and it should be explored whether a pool formation can be made just downstream of goose neck. Model study of the energy dissipation arrangement for ST-01 is also recommended.

ii) In access tunnel at EL: 1590 m, 300 mm thick & 1m high concrete wall may be provided in the affected area to avoid further deterioration. Wherever there is detachment in shotcrete layer above spring level, lattice mat with shotcrete may be provided as a protection measures.

iii) To carry out topographic survey (on suitable scale preferably 1: 5000) of the reservoir rim above FRL and also between the reservoir operating levels during this lean season.

iv) To calibrate all the instruments and analysis & Interpretation of the recorded data needs to be carried out by the vendors/ Experts. At the same time all the working instruments shall be connected to a DAS System on real time basis which shall be installed in the Control room for regular monitoring.

7. HYDRO MECHANICAL WORKS DAM COMPLEX:

Spillway Gates: There are five Spillway Gates in the Dam Complex to cater for Design Discharge of 7000 Cumecs with provision for one of the gates not operating due to any reason. The total capacity of all the five gates put together is 8400 Cumecs at FRL and will be even higher at Maximum Reservoir Level of 1588M.

OBSERVATION DURING POST MONSOON INSPECTION:

- Spillway Gates of LBST-1 and Chute Spillway are good working condition.
- LBST-2 Gate restoration done and operational.
- Leakage is observed from Spillway Gates of RBFT which the Project is attending to. Radial gate is closed condition and observed no leakage through sill beam, however, there is leakage from top seal & side seal which is being attended to.
- There is no issue with Power Tunnel Intake Gate, Feeder Tunnel and Link Tunnel Gates.
- Silt flushing tunnel gates are in closed condition and operative.
- As reported by the Project, both the Butter Fly Valves were in open position and no abnormalities found.

8. ELECTROMECHANICAL EQUIPMENT:

8.1 OPERATION OF GENERATING UNITS

The cumulative generation and running hours of Unit#1 to Unit#6 as on 31.10.2022 are tabulated below. Units have been running at its rated capacity and with the inflow increasing the station is being operated at 10% continuous overload.

Unit No	Total Running Hrs since COD	Generations during Monsoon		Total Running Hours		Running Hours on overload		Running hours at Overload in Monsoon (%)	
	(Upto Oct'22)	May'21-Sep'21	May'22-Sep'22	May'21-Sep'21	May'22-Sep'22	May'21-Sep'21	May'22-Sep'22	May'21-Sep'21	May'22-Sep'22
1	27726	710.3	683.4	3325	3259	2934	2207	88%	68%
2	28389	679.9	698.9	3274	3354	2897	2280	88%	68%
3	33621	711.5	718.8	3518	3526	3118	2280	89%	65%
4	27643	705.8	676.0	3292	3291	2936	2232	89%	63%
5	27789	709.2	650.5	3314	3123	2942	2039	89%	65%
6	33321	743.6	660.2	3546	3164	3146	2208	89%	70%

The maximum temperature observed in Turbine Guide Bearing and Upper Combined Guide Bearing are as under:

All temp in °C

Maximum Temperature										
Unit No	TGB		UCB		Generator Stator		Generator Transformer		Generator Transformer oil	
	Oct'21-Apr'22	May'22-Sep'22	Oct'21-Apr'22	May'22-Sep'22	Oct'21-Apr'22	May'22-Sep'22	Oct'21-Apr'22	May'22-Sep'22	Oct'21-Apr'22	May'22-Sep'22
1	74.0	55.0	59.9	76.0	81.4	84.0	65.7	77.0	52.2	64.0
2	75.7	64.0	70.2	78.0	76.8	82.0	61.9	70.0	51.3	59.0
3	74.4	69.0	57.5	76.0	77.0	81.0	64.8	77.0	43.6	57.0
4	78.6	55.0	58.0	79.0	79.6	84.0	69.0	71.0	55.9	66.0
5	76.5	59.0	70.9	78.0	78.2	84.0	67.0	74.0	57.8	60.0
6	75.3	52.0	73.6	77.0	82.3	86.0	67.0	70.0	52.6	56.0

The maximum vibration observed in Turbine Guide Bearing and Upper Combined Guide Bearing are as under:

Unit No.	Max Vibration in Microns			
	UCB (Any Axis)		TGB (Any axis)	
	Oct'21-Apr'22	May'22-Sep'22	Oct'21-Apr'22	May'22-Sep'22
1	143	129	92	79
2	105	135	102	98
3	115	132	51	51

~~670~~

Unit No.	Max Vibration in Microns			
	UCB (Any Axis)		TGB (Any axis)	
	Oct'21-Apr'22	May'22-Sep'22	Oct'21-Apr'22	May'22-Sep'22
4	117	108	124	117
5	131	153	80	77
6	92	95	110	62

The various parameters like maximum temperature of bearings, peak vibration at bearings, etc. for the period of operation from Oct-21 to Apr-22 and May-22 to Sep-22 were scrutinized to access the behavior of generating units. Unit wise observations are summarized as under:

The various parameters like maximum temperature of bearings, peak vibration at bearings, etc. for the last one month from 1-May-22 to 30-Sep-22 were also scrutinized to access the behavior of generating units.

It is also observed that the temperatures of unit#1 to unit#6 for the period from 1-May-22 to 30-Sep-22 that
Unit#1 Guide bearings pads temperatures vary from 45 to 62
Unit#2 Guide bearings pads temperatures vary from 49to 72
Unit#3 Guide bearings pads temperatures vary from 44 to 58
Unit#4 Guide bearings pads temperatures vary from 50 to 58
Unit#5 Guide bearings pads temperatures vary from 45 to 71
Unit#6 Guide bearings pads temperatures vary from 48 to 74
Unit#5 Thrust pads temperature vary from 57 to 76

The large variation in the guide bearing pads temperature of respective unit indicates that the guide bearing clearances are not uniform. There is a need to reset Guide bearing clearances of unit#1,2,5 and 6 to lower the temperature difference between the pads. All the RTDs may also be required to recalibrated during annual maintenance

Temperature variation in the thrust bearing pads of Unit#5 is around 19 deg C Thorough inspections and rectifications of the thrust bearing pads and verticality of machine should be carried out during annual maintenance.

Vibration Velocity probe installed on UCB housing on Unit#2 needs replacement/calibration.

~~67~~

8.2 REVIEW OF SPARES & MISCELLANEOUS ISSUES

It is recommended to procure an additional newly modified design nozzle set (5 nos.) for one more unit during next year in addition to two sets already procured.
It is also recommended to procure new modified guide housing and pistons along with the sealing arrangement for 6 sets of nozzles which are under operation.
It is also recommended that nozzle displacement sensors with integral long lead are procured and replaced in all existing old design nozzles at the earliest.
Non monsoon Runners (old design) are to be fixed in all the units and before next monsoon same needs to be replaced with Monsson runner (new design)
Monsoon Runners (being taken out during annual maintenance) are required to be refurbished within this ongoing maintenance schedule.
Additional spares for 400 KV GIS to be expedited
Procurement of Spare transformers and preparation for it's movement to site needs to be expedited.

8.4 OBSERVATIONS AND RECOMMENDATIONS REGARDING PERSISTING HIGH DGA READINGS EVEN AFTER BYPASSING OF BURNT OCTC LEADS AND REPLACING LT FLEXIBLES

There was reporting of violation of Dissolved Gas continuously from the Unit – 4 Y phase transformer and from the Unit – 5 B phase transformer . These violations were observed even after bypassing of burnt Off Load Tap Changer Leads and replacing LT bushing flexibles under supervision of OEM (M/s Toshiba erstwhile M/s Vijay Electricals Limited)

During the visit dissolved gas samples was taken once again drawn for both these transformers and 5 B transformer was back charged for 48 hours to observe the dissolved gas increase rates at no loads. Tank temperatures in order to locate any hot spot with thermos-vision camera was also carried out on both the transformer and analysis was made . A detailed report of the same is annexed.

On the basis of this report it is recommended to replace the unit 5B transformer with the spare transformer and it is recommended to un-tank this transformer at site after making suitable arrangements for further inspection of suspected winding to LT lead joints at the bottom of the transformer.
Unit 4Y is to be kept running with continued DGA monitoring for the time being.

It is also recommended to replace the LT flexibles and bypass all Off load tap changers of remaining transformers during the ongoing maintenance period.

SC Gupta	BD Patni	R.K.Mohapatra
(Construction Expert)	(Geotechnical Expert)	(E&M Expert)

~~672~~

CASE STUDY FOR 82 MVA 400 KV SINGLE PHASE

18 no 82 MVA 400 KV Single phase Transformer installed at TEESTA – substation making 6 units to evacuate power form 6 generating units of 200 MW each.

Rating of Transformer – 82 MVA Single Phase

HV Voltage – 400 kV

LV Voltage – 15 kV

Impedenec – 14.5 %

RATING AND DIAGRAM PLATE

TYPE			GENERATOR TRANSFORMER	YEAR OF MANUFACTURE			
CONFORMING TO			IS 2026	TRANSFORMER SERIAL NO.			
TYPE OF COOLING			ONWF	FREQUENCY		Hz	50
RATED POWER	kVA	HV	82000	NO OF PHASES			1
		LV	82000	VECTOR GROUP (AFTER BANK FORMATION)			YNd11
RATED VOLTAGE AT NO LOAD	kV	HV	420/√3	MAX. TEMPERATURE RISE	OIL	°C	55
		LV	15	MAX. TEMPERATURE RISE	WDG	°C	60
RATED LINE CURRENT	A	HV	338.16	MAX. TEMPERATURE	AMB	°C	40
		LV	9466.54	TOTAL MASS		kg	105700
			GUARANTEED / MEASURED	CORE & COIL MASS		kg	57800
% IMPEDANCE	MAX. TAP		14.0 + 15 %tol.	TRANSPORT MASS WITH N2 FILLED		kg	72000
	RATED TAP		14.5 + 15 %tol.	QUANTITY OF OIL		litres	28500
	MIN TAP		17.0 + 15 %tol.	INSULATION LEVEL	HV		IEC 1050-LI 1300 P.D AT 1.5P.U
					LV		LI 125 AC 50
					HVN		LI 125 AC 50

3 Single phase units are combined to make HV 420 kV STAR connected and LV 15 kV DELTA .

There was reporting of violation of Dissolved Gas continuously from the Unit – 4 Y phase transformers and from the Unit – 5 B phase transformer .

On reaching the site the dissolved gas was taken once again and the values were taken from both the transformer and analysis was made .

Generator Transformer Unit 4 Y

BOTTOM SAMPLE

	Unit - ppm	19/11/22	20/11/22
Oxygen	O_2	--	--
Nitrogen	N_2	--	--
Hydrogen	H_2	8	8
Methane	CH_4	22	18
Ethylene	C_2H_4	**110**	**113**
Ethane	C_2H_6	16	16
Acetylene	C_2H_2	5	5
Carbon Monoxide	CO	110	112
Carbon Dioxide	CO_2	**1502**	**1535**

As per Table -2 of the IEC 60599 , as per the dissolved gas concentration the transformer is in category of Condition 3 fault due to decomposition of material .

TABLE 2

Status	Dissolved key gas concentration limits [(µL/L (ppm)[a]]							
	Hydrogn (H_2)	Methane (CH_4)	Acetylene (C_2H_2)	Ethylene (C_2H_4)	Ethane (C_2H_6)	Carbon Monooxide (CO)	Carbon Dioxide (CO_2)	TDCG[b]
Condition 1	100	120	1	50	65	350	2500	720
Condition 2	101-700	121-400	2-9	51-100	66-100	351-570	2500-4000	721-1920
Condition 3	701-1800	401-1000	10-35	101-200	101-150	571-1400	4001-10000	1921-4630
Condition 4	>1800	>1000	>35	>200	>150	>1400	>10000	4630

NOTE 1 – Table 2 assumes that no previous tests on the transformer for dissolved gas analysis have been made or that no recent history exists. If a previous analysis exists, it should be reviewd to determine if the situation is stable or unstable.

NOTE 2 – An ASTM round-robin indicated variability in gas analysis between labs. This should be considered when having gas analysis made by different labs

- **Condition 1:** TDCG below this level indicates the transformer is operating **satisfactorily** (see Table 2). Any individual combustible gas exceeding specified levels should prompt additional investigation.
-
- – **Condition 2**: TDCG within this range indicates greater than normal combustible gas level. Any individual combustible gas exceeding specified levels should **prompt additional investigation.**
-
- – **Condition 3:** TDCG within this range indicates a high level of decomposition. Any individual combustible gas exceeding specified levels should **prompt additional investigation.**
-
- – **Condition 4:** TDCG exceeding this value indicates excessive decomposition. Continued operation could **result in failure of the transformer.** Proceed immediately and with caution.

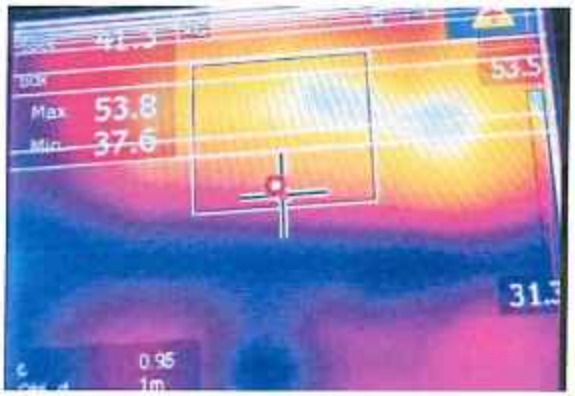
The implications of condition 3 fault calls for additional investigation

As a measure of additional investigation ,the tank wall temperature was measured .

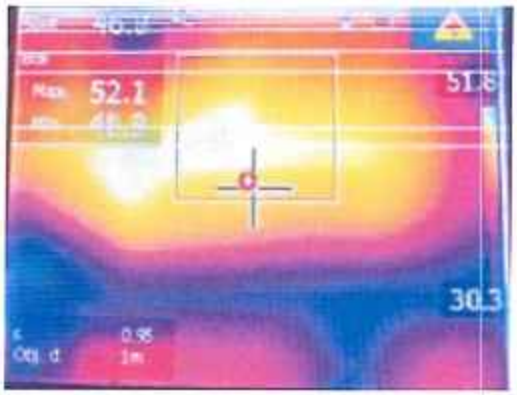
Measurement of Tank Wall Temperature

The transformer tank wall temperature was measured at all the sides using Thermo Vision Camera . At one location on LV side , few inches above the tank flange bottom the temperature found to be 53^0 C , approximately 20^0 C higher than other places .(Clip A and Clip B) .

From the internal layout drawing (fig.2) the location is found to be matching with **the location bottom lead of LV coil**



Clip – A



Clip - B

Fig 1 – Transformer LV side View

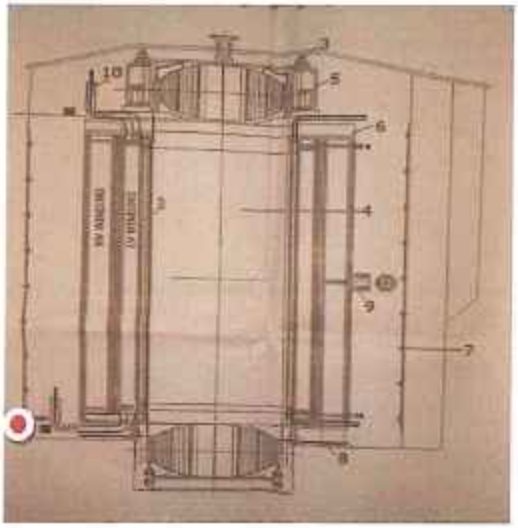


Fig 2 – Transformer Internal Layout

The gases were also analyzed using method prescribed in IEC 60599

This method is based on the use of three basic gas ratios:

1. C_2H_2/C_2H_4 (R_2) 2. CH_4/H_2 (R_1) 3. C_2H_4/C_2H_6 (R_5)

Abbreviations

PD	Partial discharges
D1	Discharges of low energy
D2	Discharges of high energy
T1	Thermal fault, t < 300°C
T2	Thermal fault, 300°C < t < 700°C
T3	Thermal fault, t > 700°C

Case	Characteristic Fault	C_2H_2/C_2H_4 (R_2)	CH_4/H_2 (R_1)	C_2H_4/C_2H_6 (R_5)
PD	Partial discharges (see notes 3 and 4)	NS[1]	<0.1	< 0.2
D1	Discharges of low energy	>1	0.1 – 0.5	>1
D2	Discharges of high energy	0.6 – 2.5	0.1 – 1	>2
T1	Thermal fault t < 300°C	NS[1]	> 1 but NS[1]	<1
T2	Thermal fault 300°C < t < 700°C	<0.1	> 1	1 – 4
T3	Thermal fault t > 700°C	<0.2[2]	> 1	> 4

The gas was analyzed using the analysis method given IEC 60599

$R_2 = C_2H_2/C_2H_4 = 5/113$ < 0.1

$R_1 = CH_4/H_2 = 18/8$ >1

$R_5 = C_2H_4/C_2H_6 = 113/16$ >4

This indicates Thermal Fault with local temperature > 700^0 C

Analysis was also done using Roger's Ratio method

ROGER'S Ratio Method

Case	R2 C_2H_2/C_2H_4	R1 CH_4/H_2	R5 C_2H_4/C_2H_6	Suggested fault diagnosis
0	<0.1	>0.1 to <1.0	<1.0	Unit normal
1	<0.1	<0.1	<1.0	Low-energy density arcing – PD[a]
2	0.1 to 3.0	0.1 to 1.0	>3.0	Arcing – High-energy discharge
3	<0.1	>0.1 to <1.0	1.0 to 3.0	Low temperature thermal
4	<0.1	>1.0	1.0 to 3.0	Thermal <700°C
5	<0.1	>1.0	>3.0	Thermal >700°C

The results of Roger's Ratio method matched with IEC method

~~676~~

Generator Transformer Unit 5 B

BOTTOM SAMPLE

Unit- 5 B Ph		Unit - ppm	
		19 Nov	22Nov
Oxygen	O_2	--	--
Water	N_2	14	15
Hydrogen	H_2	<5	<5
Methane	CH_4	50	51
Ethylene	C_2H_4	**143**	**149**
Ethane	C_2H_6	12	13
Acetylene	C_2H_2	12.8	13.4
Carbon Monoxide	CO	25	25
Carbon Dioxide	CO_2	**363**	**358**

As per Table -2 of the IEC 60599 , as per the dissolved gas concentration the transformer is in category of Condition 3 fault due to decomposition of material

TABLE 2

Status	Dissolved key gas concentration limits [(µL/L (ppm)][2]							
	Hydrogn (H_2)	Methane (CH_4)	Acetylene (C_2H_2)	Ethylene (C_2H_4)	Ethane (C_2H_6)	Carbon Monooxide (CO)	Carbon Dioxide (CO_2)	TDCG[3]
Condition 1	100	120	1	50	65	350	2500	720
Condition 2	101-700	121-400	2-9	51-100	66-100	351-570	2500-4000	721-1920
Condition 3	701-1800	401-1000	10-35	101-200	101-150	571-1400	4001-10000	1921-4630
Condition 4	>1800	>1000	>35	>200	>150	>1400	>10000	4630

NOTE 1 – Table 2 assumes that no previous tests on the transformer for dissolved gas analysis have been made or that no recent history exists. If a previous analysis exists, it should be reviewed to determine if the situation is stable or unstable.

NOTE 2 – An ASTM round-robin indicated variability in gas analysis between labs. This should be considered when having gas analysis made by different labs.

The transformer was found to be in Condition – 3

- **Condition 1:** TDCG below this level indicates the transformer is operating **satisfactorily** (see Table 2). Any individual combustible gas exceeding specified levels should prompt additional investigation.
- – **Condition 2**: TDCG within this range indicates greater than normal combustible gas level. Any individual combustible gas exceeding specified levels should **prompt additional investigation.**
- – **Condition 3:** TDCG within this range indicates a high level of decomposition. Any individual combustible gas exceeding specified levels should **prompt additional investigation.**
- – **Condition 4:** TDCG exceeding this value indicates excessive decomposition. Continued operation could **result in failure of the transformer**. Proceed immediately and with caution.

The implications of condition 3 fault calls for additional investigation

As a measure of additional investigation ,the tank wall temperature was measured .

Measurement of Tank Wall Temperature

The transformer tank wall temperature was measured at all the sides using Thermo Vision Camera .At one location on LV side , few inches above the tank flange bottom the temperature found to be 62^0 C , approximately 18^0 C higher than other places .(Clip C) .

From the internal layout drawing (fig.4) the location is found to be matching with **the location bottom lead of LV** coil

Clip - C

Fig – 3

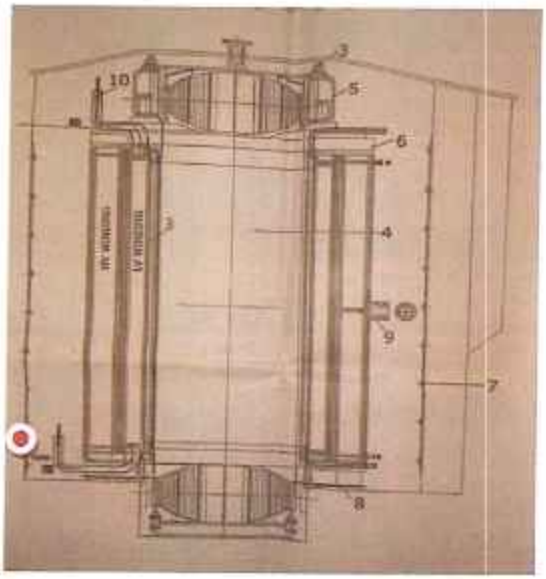


Fig - 4

~~684~~

The gases were also analyzed using method prescribed in IEC 60599

This method is based on the use of three basic gas ratios:

1. C_2H_2/C_2H_4 (R_2) 2. CH_4/H_2 (R_1) 3. C_2H_4/C_2H_6 (R_5)

Abbreviations

PD	Partial discharges
D1	Discharges of low energy
D2	Discharges of high energy
T1	Thermal fault, t < 300°C
T2	Thermal fault, 300°C < t < 700°C
T3	Thermal fault, t > 700°C

Case	Characteristic Fault	C_2H_2/C_2H_4 (R_2)	CH_4/H_2 (R_1)	C_2H_4/C_2H_6 (R_5)
PD	Partial discharges (see notes 3 and 4)	NS[1]	<0.1	< 0.2
D1	Discharges of low energy	>1	0.1 – 0.5	>1
D2	Discharges of high energy	0.6 – 2.5	0.1 – 1	>2
T1	Thermal fault t < 300°C	NS[1]	> 1 but NS[1]	<1
T2	Thermal fault 300°C < t < 700°C	<0.1	> 1	1 – 4
T3	Thermal fault t > 700°C	<0.2[2]	> 1	> 4

The gas was analyzed using the analysis method given IEC 60599

C2H2/C2H4 = 13.4/149 = 0.022 < 1

CH4/H2 = 51/5= 10.2 >1

C2H4/C2H6 = 149/13=11.46 >4

This indicates Thermal Fault with local temperature > 700^0 C

Analysis was also done using Roger's Ratio method

ROGER'S Ratio Method

Case	R2 C_2H_2/C_2H_4	R1 CH_4/H_2	R5 C_2H_4/C_2H_6	Suggested fault diagnosis
0	<0.1	>0.1 to <1.0	<1.0	Unit normal
1	<0.1	<0.1	<1.0	Low-energy density arcing – PD[a]
2	0.1 to 3.0	0.1 to 1.0	>3.0	Arcing – High-energy discharge
3	<0.1	>0.1 to <1.0	1.0 to 3.0	Low temperature thermal
4	<0.1	>1.0	1.0 to 3.0	Thermal <700°C
5	<0.1	>1.0	>3.0	Thermal >700°C

[a] There will be a tendency for the ratios R2 and R5 to increase to a ratio above 3 as the discharge develops in intensity.

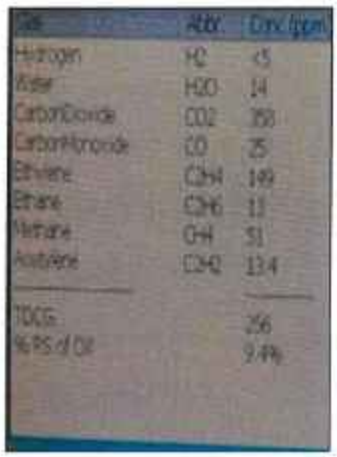
The results of Roger's Ratio method matched with IEC method

Since the Ethylene C_2H_4 content was high in Unit 5 B phase transformer , it is decided to verify the contribution of faults related to Voltage (no load condition) by Back Charging

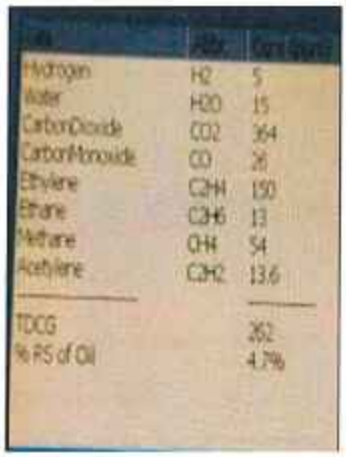
Back Carging of unit 5 – B (Additional Test)

In order to ascertain that there is no effect of voltage (Partial Discharge) it was decided to back charge the transformer 5 Y (having high CH_4 and low CO_2)

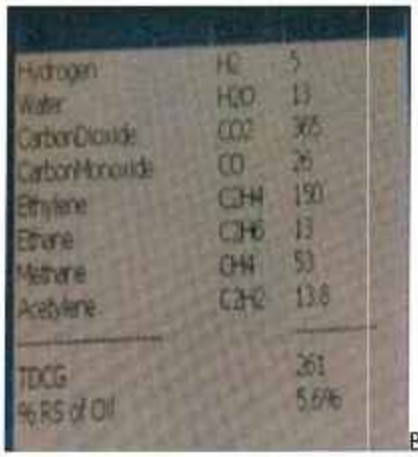
Back charging of Unit – 5 B



Start of Back charging



After 24 hr of Back charging



After 48 hr of Back charging

Before

		Before Start of Back charging	After 24 hr of Back charging from 400 kV side	After 48 hr of Back charging from 400 kV side	Increase after 48 hr
		22 Nov 2022	23 Nov 2022	24 Nov 2022	
Hydrogen	H_2	5	5	5	0
Water	H_2O	14	15	13	2
Carbon Dioxide	CO_2	358	364	365	6
Carbon Monoxide	CO	25	26	26	1
Ethylene	C_2H_4	149	150	150	1

~~685~~

Ethane	C_2H_6	13	13	13	0
Methane	CH_4	51	54	53	2
Acetylene	C_2H_2	13.4	13.6	13.8	<1
Total TDCG		256 (9.4 %)	262 (4.7 %)	261 (5.6%)	6
Inference	Back charging from 400 kV side with LV OPEN has **no contribution** towards gas geenration				

Conclusion :

From the investigation it is found that the gas generating are independent of voltage . The gas generation is due to flow of Load current . The heating appears at the vicinity of LV lead coming out from the LV winding. The heat generated could be due to proximity of LV lead or may be due to damage of LV leads at the point of bending .

Even if there is no immediate danger to these 2 Transformers as long as they are in Category 3 i.e and they can be run up to CH_4 level of 200 ppm , it is advisable to run the 2 transformers at as less load as possible till the rectification is done .

In both the cases the fault can be seen by lifting of the top tank cover by 300- 500 mm from Tank rim . In LV lead as it appears are to be repaired . In addition electromagnetic shielding will also be helpful at the LV lead taking out zones .

For transformer 5 B , the lead apparently have come closer to tank wall causing hating of tank wall and localized hot zone .

In transformer 4 Y , there is burning of paper which may be because of lead burning due to circulating current causing heavy temperature .

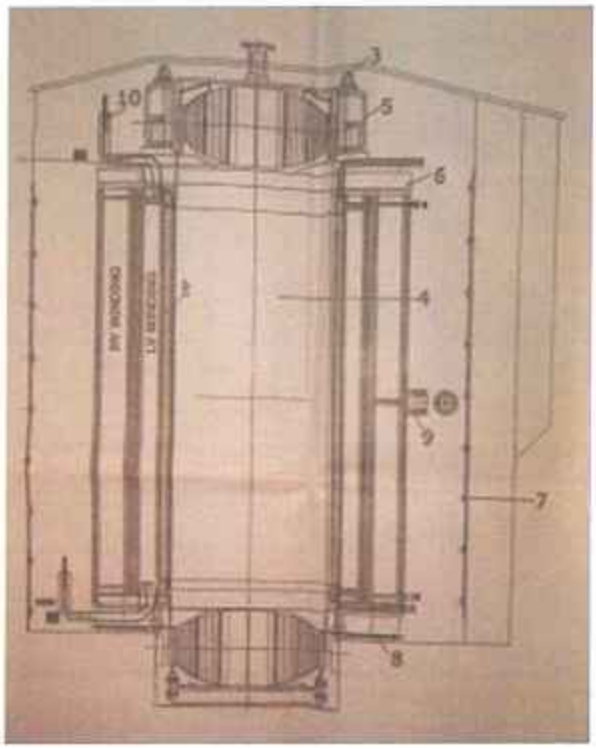
R.K. Mohapatra

(R K MOHAPATRA)

Site Repairing Procedure of 82 MVA 1 Phase Generator Transformer

The transformer has 2 coils High Voltage (HV) and Low Voltage coils .

Both the coils are cylindrical in shape placed concentrically to core LV winding being Inner and HV winding being Outer.

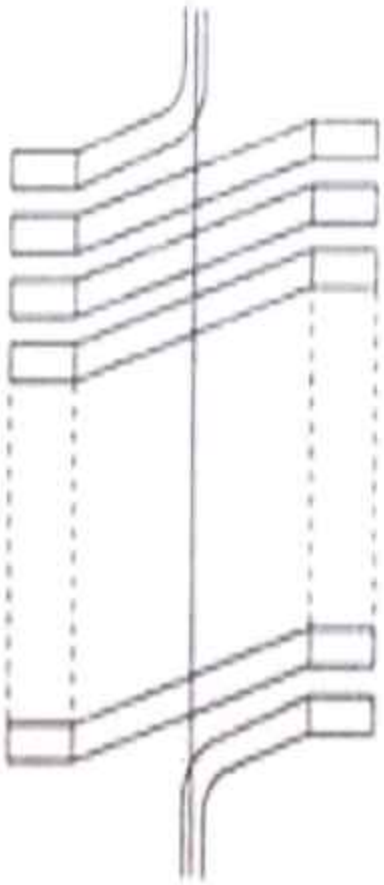


The Current in HV winding is 339 Ampere and current in LV winding is 5466 Ampere .

The Crosss sectional area of HV coil I = 112.49 sq.mm

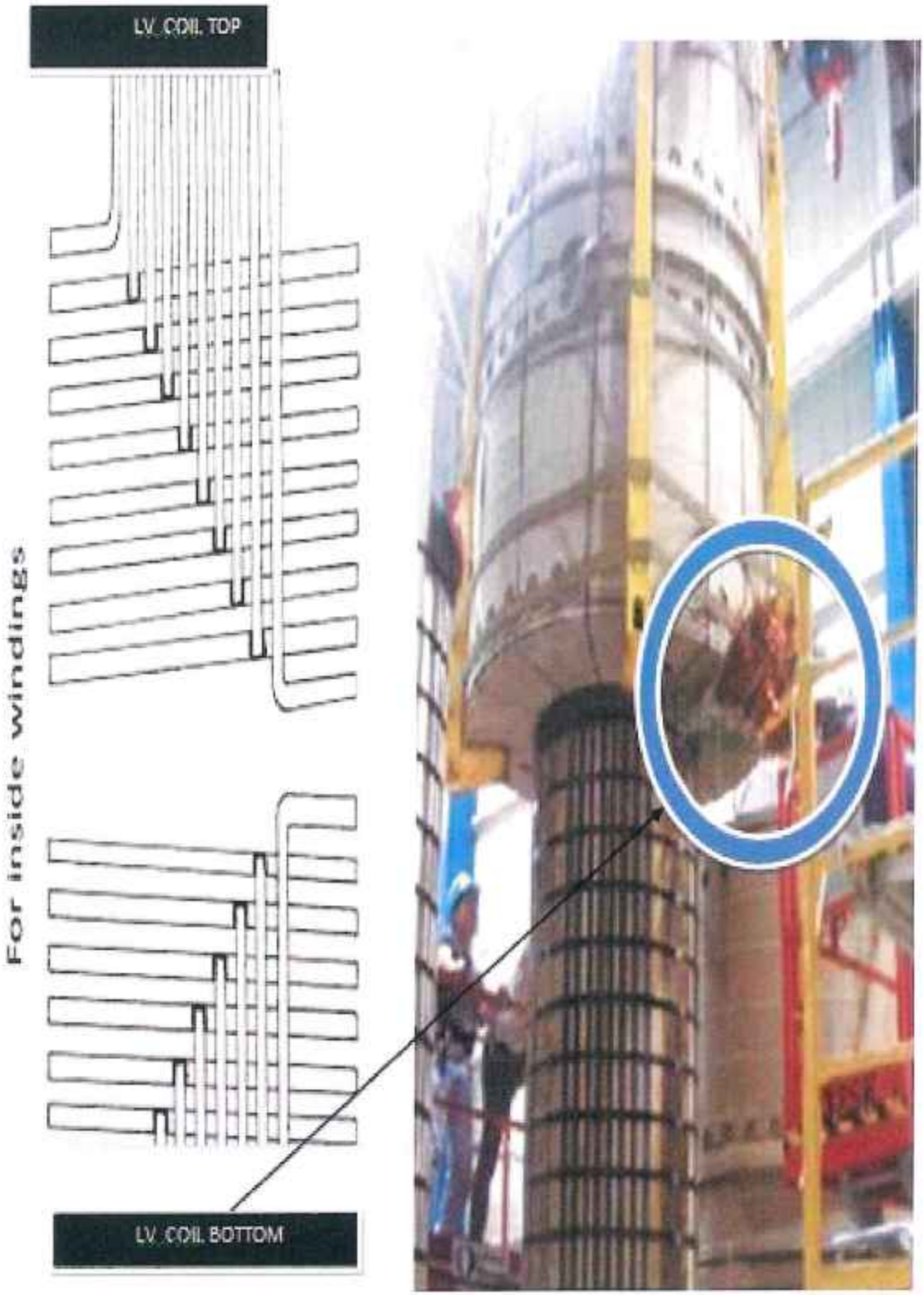
Cross sectional area of V coil = 1745.5 Sq.mm

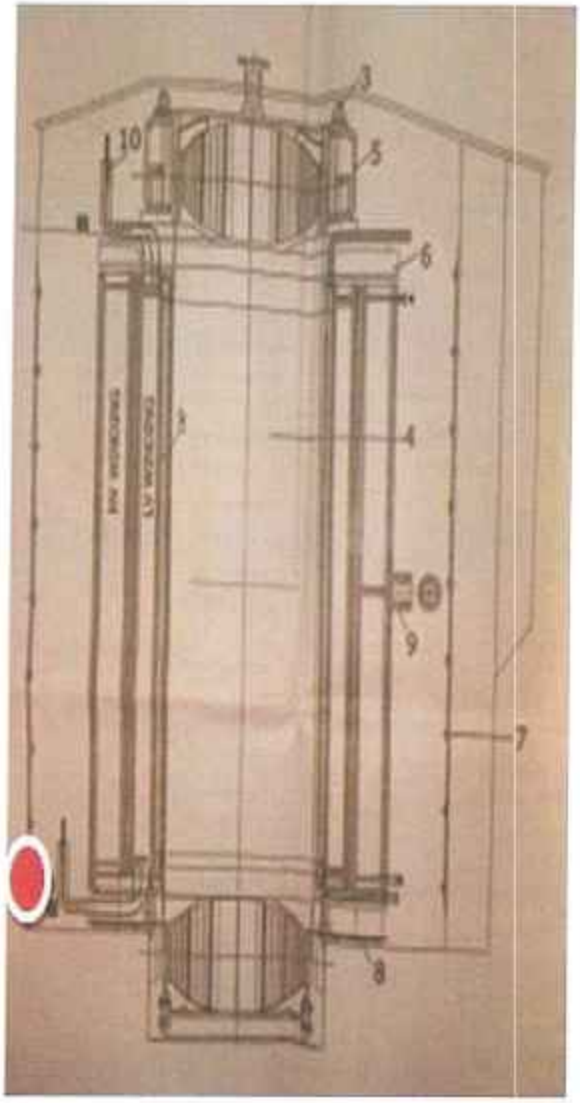
~~687~~



Single Layer Helical LV Coil

Continuously Transposed Cable(CTC) used for LV coil


LV COIL TOP
For inside windings
LV COIL BOTTOM


3
10
5
6
4
9
7
8

The Activity of Repairing activity involve :

1) Removal of al the fittings from he transformer

2) Dragging the transformer to a place having overhead crane of capacity atleast 20 Tonn

3) Surrounding the Transformer with Temporary tent

4) proving Halogen Lamps all around the tent external and internal

5) provision of Blowers for circulation of Hot Air from Halogen lamp

4) Removal of all the flange bolts

5) Lifting of the Top Tank by 500 mm

6) Observe the Lead insulation and extent of damage

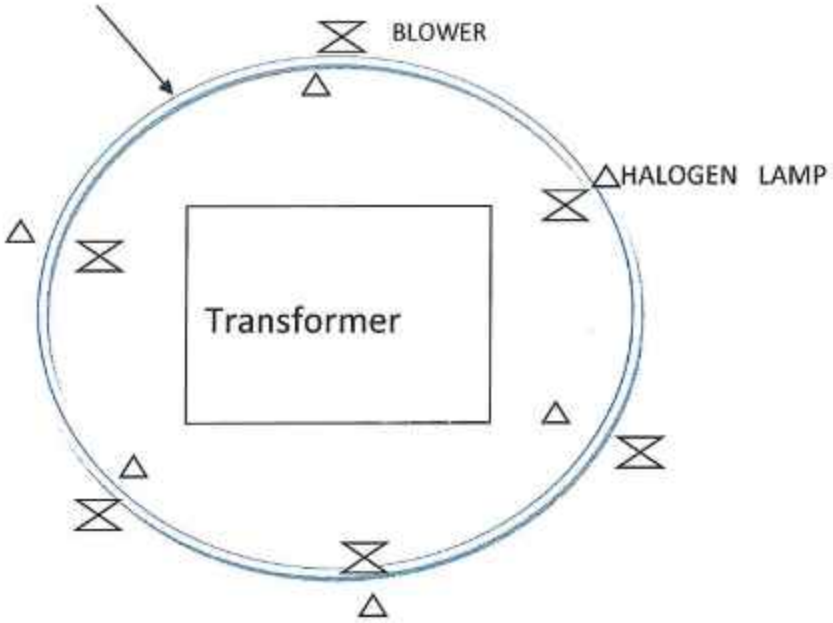
7) There could be 4 Bunches of CTC conductors each having 40 parallel strand

8) If possible a stainless steel or copper flat to be provided inside the tank wall at the location of the lead

9) After repairing cover to be put back and bolt to be tightened

10) Transformer to be taken out for Drying

Tarpaulin Tent without Cover



SIKKIM URJA LIMITED
(A GOVERNMENT OF SIKKIM ENTERPRISE)

REPORT OF EXPERT COMMITTEE

PRE MONSOON INSPECTION – YEAR 2023 (June'2023)

PERIOD OF INSPECTION - 05.06.2023 TO 08.06.2023

~~692~~

REPORT ON PRE MONSOON INSPECTION BY EXPERT COMMITTEE

1 INTRODUCTION

Sikkim Urja Limited (A Government of Sikkim Enterprise) vide their letter no. SUL/PW/EC/2023-24/001 to 003 dated 26.05.23 engaged an Expert committee consisting of Sh. S C Gupta, (Construction Expert), Sh. B D Patni (Geo-technical Expert) and Sh. H K sahu (H&M Expert) for pre- monsoon inspection of the Teesta III Power station having an installed capacity of 1200 MW, housing six 200MW Generating Units driven by Pelton Type turbines, which was commissioned on 28th February 2017. The team was accompanied with MD-SUL, MD-TPTL & Chief O&M Consultant and officials of SUL during the visit.

MANDATE:

a) The Committee will carry out physical inspection of all the project components including gates namely Dam, Spillways, Power Intake, De-silting System, HRT, Surge Shaft, Pressure Shafts, Power House and Tailrace Tunnel :
b) To check the condition of the structures and monitor their behavior.
c) To investigate conditions that might cause distress to the structures.
d) To study the extent of deterioration based on which maintenance and repair can be planned.
e) The Committee will inspect Hydro-mechanical and Electro-mechanical Plant and review the performance. The Committee will also review the status of spares inventory and management.
f) To review the repair and maintenance works which have been carried out in the plant and submit broad guidelines for further improvements.
g) To review the works which were suggested in the earlier inspection report & its performance and suggest for any further improvements.
h) To review the issues faced in Transformer and the corrective actions taken by SUL and suggest further actions/ improvements.
i) The Committee will carry out inspection in coordination with the concerned engineers/Project team/agencies at site.
j) The Committee shall submit an inspection report of the all the Project Components and recommendations for repair if any shall be included in the report.

The members of committee as mentioned above, in accordance with the letter visited the project from 05.06.2023 to 08.06.2023. During the period of inspection, the committee members visited all plant locations for visual inspection of the components. The observations of the committee are summarized as under:

2 DAM COMPLEX

2.1 GENERAL

The maximum and minimum river discharge recorded in this year was 474 cumecs on 12.10.2022 and 18 cumecs on 11.01.23 The project has been designed for a spillway capacity of 7000 cumecs with one gate inoperative condition.

2.2 CFRD

The u/s face of CFRD is found intact above the reservoir level EL 1574.5m. No distress/cracks were observed on the face slab of CFRD. There is no manifestations of piping & subsidence along the downstream face & terminal reach of rock fill section of the Dam. The abutment slopes along the left bank of surface Spillway are stable and further downstream adjacent to the length of Spillway apron. The right bank and left bank appeared stable during visual inspection from dam top. As suggested in the earlier report, cavities/ hollow space was filled by boulders in the rip rap area of d/s of the dam. No further vegetation growth was noticed.

2.3 CHUTE SPILLWAY

The chute spillway structure was visually inspected by the committee and found intact and stable. Downstream of the Chute Spillway Outfall Structure the river course has been widened as suggested in the earlier committee report.

The committee noted that the channel connecting chute spillway & ST outlet is still not defined. The same needs to be attended by the project to address d/s side slope failures in the event of release of heavy discharges through chute spillway.

The Committee observed heavy vegetation growth over the retaining structures/ cladding wall made along the chute spillway channel and it needs to be removed and properly monitored.

As suggested in earlier report, the project has removed nalah deposit brought out by ITBP nalah. The project has also constructed number of small check dams to the uphill side of ITBP nalah for retaining the silt load into spillway channel. However, the project has also informed that the ITBP nalah carried out immense quantity of slope wash material during rainy season and needs to be reclaimed every year.

Recommendations:

- During the visit, the Committee expressed their concern about the area between d/s of chute spillway and RBFT outlet. It is noticed that the discharge released through spillway, ST-01 & 02 and RBFT damaging the retaining structures and topography along the flanks of the river. In view

of that committee suggested to carry out detailed survey (geological & geotechnical) of the river channels, nalahs coming out from the uphill slope between chute spillway outlet to RBFT outlet. Accordingly, the project will prepare L-section & X- section of the river channel and nalahs between chute spillway d/s apron to RBFT outlet. The committee also stressed upon to carry out the detailed studies and characteristics of the material brings out by nalahs during heavy floods. Based on that the vulnerable areas in the uphill slope needs to be identified for further course of action.

- The committee also feels that the river bed level in both the banks should be same to prevent the scouring. Efforts should be made to maintain the original river bed level.
- The landslide zone just above dam axis (EL: 1608 – 1740 m) left bank is found intact with the existing adequate support measures. However, the area should be geotechnically examined and based on the results of geological mapping and geo-technical assessment, suitable defensive measures may be explored.
- Wherever there is vegetation growth in chute spillway area, same shall be removed and properly monitored.

2.4 RIGHT BANK FLUSHING TUNNEL (RBFT):

The Expert Team also inspected the RBFT and thoroughly inspected the invert, wall and crown portion of the tunnel. During the visit, it is observed that the invert was restored by filling of concrete as suggested in the earlier committee report.

The RBFT gate was first inspected from downstream of Radial gate. Water jet with high pressure was coming from right (Left side if we look in the direction of flow) bottom corner of the Radial gate. Bottom seal/side seal seem to be damaged at the corner. Some water is also falling directly on the left trunnion (Right side if we look in the direction of flow).

This location was also inspected from top wherefrom Bulkhead/Emergency gate could also be seen. Bulkhead was in good condition. Project reported that this gate is operating smoothly without any leakage, except when concrete (and sometimes sill beams also) in the sill beam area is damaged. Damage to the concrete is caused due to passing of big boulders at high velocity during monsoon season when whole area right from upstream of Bulk head sill beam to downstream of Radial gate sill beam is repeatedly damaged year after year. Repairs to the damaged sill beams and the concrete are carried out time to time as per requirement.

Recommendations:

- Damaged bottom and side seals of the Radial gate should be replaced lowering Bulkhead gate and raising the Radial gate.

- Trunnion should be protected against falling water on it, to avoid damage. Temporarily, a shed may be provided over the Trunnion, till the falling water is stopped from the source itself.
- Sill beams for Bulkhead and Radial gate need to be repaired / replaced as per the requirement.
- High performance concrete with minimum 150mm thickness with dowel bars should be laid in the whole damaged area right from upstream of Bulk head sill beam to downstream of Radial gate sill beam, after chipping off damaged concrete. Special care should be taken to ensure that the profile of concrete is flush with the sill beams without any undulations.

2.5 POWER INTAKE:

The committee inspected the power intake area and studied the detailed construction drawings. Committee observed that opening of intake is from EL: 1549m – EL: 1565m and the bottom sill level of ST-01 is EL: 1555 m. In the event of flash flood / major flood, ST-01 will act as flushing tunnel and due to silt load, the river bed level may raise upto bottom sill of ST-01 i.e EL: 1555m.

In view of this, the committee advised the Project to take up preliminary study/ investigation to modify the power intake opening for increasing the size of opening.

2.6 LEFT BANK SPILLWAY TUNNEL- 1:

Committee inspected the outlet structure of ST-01 and the structure found intact and in good shape. As suggested in the earlier committee, the project has completed the restoration work of the potholes by filling with concrete.

2.7 LEFT BANK SPILLWAY TUNNEL-2:

The committee observed that the installation of drapery works carried out by M/s Maccaferri has been completed and found satisfactory. As suggested in the earlier committee report, the wide opening of distressed rock mass has been filled with concrete and grout mix.

Recommendation:

- The vegetation cover above the retaining structures of outlet needs to be removed and properly monitored.
- The 20m stretch at the outlet area of ST-01 & St-02 along left bank may be protected by providing crate walls upto the height of 3-4 m.

~~696~~

2.8 ACCESS TUNNELS IN DAM SITE:

Various access tunnels in left and right bank of dam site, found intact and stable. At places detachment of shotcrete blanket /deterioration was also noticed below spring level.

Recommendation:

As recommended in the earlier report, construction of cladding wall is under progress and wherever there is detachment in shotcrete layer above spring level, shotcrete may be provided as a protection measures.

2.9 DE-SILTING CHAMBERS:

Both the de-silting chambers are operative and are fully functional. The project is measuring the silt load on both u/s and d/s of de-silting chambers as well as downstream of RBFT on daily basis in order to determine the silt content and requirement of flushing and its duration. The committee inspected the downstream gate arrangement and observed that there are leakages from DC-02. The project showed photographs of the water jets emanating from invert of DC-01.

Recommendation:

- As suggested in the earlier committee report, the DC-01 has been dewatered and the restoration works has also been completed and it is fully functional.
- The committee suggested that the DC-02 may also be dewatered and inspected thoroughly and if required the suitable restoration work may be carried out.

2.10 RESERVOIR:

As suggested in earlier report, the project has informed that the work of topographical survey is in he streamline and the work was awarded to M/s Aerialair, Mumbai to carry out topographical survey for 5 km reach and accordingly mobilization of team is under way.

No distress was observed in the support measures and adjacent slopes along both banks of Lachen and Lachung river.

As suggested in the earlier committee report, the movement of paint marked boulders is being maintained by the project.

The committee visited the Pincho nallah of reservoir u/s which is about 3-4 km from the tail end of the reservoir. A few marked boulders were noticed on the nalah bed. This nallah carries huge slope wash material with boulders during rainy season and it is in the close vicinity of the reservoir and is major source of the silt load. The Committee has earlier observed that the steep nallahs in the close vicinity of the reservoir which carry huge slope wash material & boulders poses risk to the reservoir in case of flash flood situation. Such an event could lead to a situation where the reservoir would get filled up with boulders and RBFT cannot be used for flushing. In such a scenario, ST-1 would require to be used as the main flushing outlet. The Committee is of the view that such a scenario calls for comprehensive

review of ST-1 and Intake structure to cater to such a change in operational regime of the reservoir and the downstream area.

Recommendation:

1. The catchment area map in the vicinity of reservoir for another 5 km i.e upto 10 km from the reservoir shall be prepared. Based on the output of the catchment area survey, the vulnerable zones may be identified after detailed analysis. These zones may be further studied and monitored for future actions.
2. The committee advised the Project to take up preliminary study/ investigation to modify the power intake opening for increasing the size of opening.
3. The committee once again advised to carry out the model study/ mathematical modelling of goose neck area to assess the movement of boulders in glacis portion and its impact area. Design modification based on the mathematical modelling results to be studied and further action to be taken accordingly. Further, creation of a plunge pool to be explored just downstream of goose neck for protection of the side walls and crown from boulders after rolling down from the goose neck. Committee has time and again made observation on the criticality of this structure for reservoir flushing in the event of a major floods and this study may be taken up on priority.
4. The work of defined channel d/s of chute spillway needs to be taken up by identifying the most critical d/s reaches and providing gabions. This work needs to be taken up in such way that the whole d/s channel upto ST outlet becomes properly defined. The river banks shall be protected by construction of gabion wall of height 4-5m depending upon the water level during discharge through spillway and may be cladded with concrete as per site specific conditions.

3.SEDIMENT MANAGEMENT:

The project team has been carrying out Silt depth measurement in front of RBFT, LBST-1, LBST-2, CHSP, junction of Lachen and Lachung river periodically. The depth of reservoir bed is being measured by eco sounding system based on established grid profile with the help of Motor Boat. Similarly silt analysis is being done by collecting samples from infront of Intake, Lachen and Lachung river, HRT U/S hinge Gate, HRT D/S hinge Gate. As suggested in the earlier report, the project informed that procurement of bathymetric survey equipment comprising of DGPS, depth sounder and contour generating software fitted on a motorboat is in progress.

The project informed the committee that the central government is stressing on implementation of autonomous early warning system in flood situation.

Recommendation:

- The committee suggested to expedite the procurement of bathymetric survey equipment for silt management studies at the earliest.

4. HEAD RACE TUNNEL:

As informed by the project site, no seepage and distress noticed in the hill slope of these adits. As per the past practice daily monitoring of the seepage in all the adits be continued.

5. Instrumentation

Instrumentation in dam complex was discussed, the project recording the data of installed / working instrument on routine / weekly basis. Analysis and Interpretation of the recorded data needs to be carried out by the vendors/ Experts. At the same time all the working instruments shall be connected to a DAS System on real time basis which shall be installed in the Control room for regular monitoring and the same needs to be expedited.

The project has shown the instrumentation data to the committee. The record says that no significant movement observed in these instruments.

The project officials informed that the seismograph installed at damsite are working properly and the readings are being collected regularly from the seismographs installed. As the seismographic instruments are digital instruments and the same shall be calibrated and connected to DAS on real time.

During the visit, the committee has also identified the location of borehole extensometer/ MPBX and load cells to be installed (**Annexure -1**). However, only 2 extensometers are working in power house area.

Recommendation:

It is advised to install the instruments in the location suggested by the committee including 4 nos extensometer at the location identified by the committee (2 nos in u/s & 2 nos in d/s) in power house area for monitoring the deformation if any.

6. SURGE SHAFT

As informed by the Project, no distress was observed in the surge shaft structure, however, the gantry at the top of the surge shaft is till non-operative. Again the Team stressed upon the maintenance of the gantry and advised to make it operative so that it could be used in case of any emergency. The project team informed that the process of procurement is in progress.

The committee was informed by the project that there is a water outflow near about 100 m u/s from the junction of surge shaft and HRT at the bottom level of surge shaft. No source of water from the uphill slope is visible. There is a substantial flow of water in this area and the water fall near Main Access Tunnel of Power House. It was also informed that the water outflow increases during the winter season.

Recommendation:
The quantity of water flow to be monitored continuously with respect to reservoir level. The water outflow area near the junction of surge shaft & HRT needs to be surveyed geologically and investigated. It is likely that the water may be escaping from the water conductor system or the surge shaft, therefore suitable mitigation measures should be taken to arrest the water leakage.

7. POWER HOUSE COMPLEX:

- No distress and movement were noticed during the visit.
- The instrumentation wires should be collected kept in proper junction box for safety purposes and it needs to be expedited.
- As per the available instrumentation data, there is no movement observed except Inspection Gallery – 1 which is within the limit.
- As suggested in the earlier report, the project formed the in-house team from different discipline for regular monitoring of the project components. A checklist prepared by the project is found in order.

8. HYDRO MECHANICAL WORKS DAM COMPLEX:

Spillway Gates: There are five Spillway Gates in the Dam Complex to cater for Design Discharge of 7000 cumecs with provision for one of the gates not operating due to any reason. The total capacity of all the five gates put together is 8400 Cumecs at FRL and will be even higher at Maximum Reservoir Level of 1588M.

OBSERVATION DURING PRE MONSOON INSPECTION:

- Spillway Gates of LBST-1 and Chute Spillway are good working condition.
- LBST-2 Gate restoration done and operational.
- Leakage is observed from Spillway Gates of RBFT which the Project is attending to. There is leakage from top seal & side seal which is being attended to.
- There is no issue with Power Tunnel Intake Gate, Feeder Tunnel and Link Tunnel Gates.
- Silt flushing tunnel gates are in closed condition and operative. There is water seepage in this area and needs to attend to.
- As reported by the Project, both the Butterfly Valves were in open position and no abnormalities found.

9. ELECTROMECHANICAL EQUIPMENT:

9.1 OPERATION OF GENERATING UNITS

The cumulative generation and running hours of Unit#1 to Unit#6 as on 30.04.2023 are tabulated below. Units have been running at its rated capacity and with the inflow increasing the station is being operated at 10% continuous overload.

Unit No	Total Running Hrs since COD	Generations in Mus		Total Running Hours		Running Hours on overload		Running hours at Overload in Monsoon (%)	
	(Upto Apr'23)	May'21-Sep'21	May'22-Sep'22	May'21-Sep'21	May'22-Sep'22	May'21-Sep'21	May'22-Sep'22	May'21-Sep'21	May'22-Sep'22
1	28439	710.3	683.42	3325	3609	2934	2207	88%	68%
2	29437	679.9	698.89	3274	3764	2897	2280	88%	68%
3	35403	711.5	718.83	3518	3932	3118	2280	89%	65%
4	28896	705.8	675.95	3292	3642	2936	2232	89%	63%
5	29283	709.2	650.51	3314	3536	2942	2039	89%	65%
6	35448	743.6	660.22	3546	3685	3146	2208	89%	70%

The maximum temperature observed in Turbine Guide Bearing and Upper Combined Guide Bearing are as under:

Maximum Temperature — All Temps. In °C

Unit No.	TGB		UCB		Generator Stator		Generator Transformer		Generator Transformer Oil	
	May'22 - Sep'22	Oct'22 - Apr'23	May'22 - Sep'22	Oct'22 - Apr'23	May'22 - Sep'22	Oct'22 - Apr'23	May'22 - Sep'22	Oct'22 - Apr'23	May'22 - Sep'22	Oct'22 - Apr'23
1	55	54.75	76	66.14	84	80.53	77	81.42	64	65.26
2	64	62.16	78	74.52	82	78.06	70	68.01	59	57.78
3	69	68.29	76	59.47	81	77.31	77	76.38	57	58.77
4	55	53.78	79	59.47	84	78.71	71	70.51	66	59.31
5	59	59.47	78	71.94	84	74.2	74	64.07	60	61.02
6	52	51.2	77	76.77	86	80.64	70	66.73	56	53.55

The maximum vibration observed in Turbine Guide Bearing and Upper Combined Guide Bearing are as under:

Unit No.	Max Vibration in Microns			
	UCB (Any Axis)		TGB (Any axis)	
	Oct'21-Sep'22	Oct'22 - Apr'23	Oct'21-Sep'22	Oct'22 - Apr'23
1	143	138.619	92	90.76
2	105	103.339	102	100.41
3	122	124.825	51	53.35
4	117	109.076	124	118.54
5	131	105.841	80	72.09
6	92	86.858	110	98.27

The various parameters like maximum temperature of bearings, peak vibration at bearings, etc. for the period of operation from Oct'21-Apr'22 , May'22 to Sep'22

and Oct-22 to Apr-23 were scrutinized to access the behavior of generating units. Unit wise observations are summarized as under:

It is also observed that the temperatures of unit#1 to unit#6 for the period from 1-May-23 to 07-June-23 that
Unit#1 Guide bearings pads temperatures vary from 47.3 to 50.4
Unit#2 Guide bearings pads temperatures vary from 49.6 to 58.6
Unit#3 Guide bearings pads temperatures vary from 51.7 to 65.8
Unit#4 Guide bearings pads temperatures vary from 48.4 to 48.6
Unit#5 Guide bearings pads temperatures vary from 57.0 to 58.3
Unit#6 Guide bearings pads temperatures vary from 45.6 to 49.2

The large variation in the maximum guide bearing pads of respective unit are normal.

9.2 REVIEW OF SPARES & MISCELLANEOUS ISSUES

- Feasibility of repair of all types of faulty cards to be explored.
- New Store yard which is being developing in Bend-21 needs to be shifted towards roadside by around 3-4m. Suitable arrangement for stacking and lifting to be made.
- Preparations for movement of spare transformer to desired location to be ensured.
- AMC may be provided to suitable agency for Oxygen Plant. Suitable back up power arrangement for Oxygen plant to be ensured.
- In the upcoming Annual Maintenance period, spring length of GIS breakers are to be measured and record to be maintained.
- Commissioning of Nitrogen Injection Fire extinguishing system for GTs to be expedited.

SC Gupta
(Construction Expert)

HK Sahu
(H&M Expert)

BD Patni
(Geotechnical Expert)

(RATISH KUMAR)

ANNEXURE- E8

Teesta Stage-III (1200 MW) HEP Project Mangan North Sikkim.

.

Project Teesta Stage-III Date:- 25/04/2023

- **Topic:-Cloud burst in Up Stream (Dam) Mock drill rehearsal**
- Flood mock drill rehearsal/ training program has been conducted at Teesta stage -111 project together (Dam &Powerhouse)
- Dated -25/04/2023 at 11:00 am to 13:00 pm.
- **OBSERVER**: Mr. VK.Pandey (DGM) Dam
- Mr.Ashok Kumar Sharma (GM) Powerhouse
- **PARTICIPANTS (Dam &PH)** :-Chief Incident controller Site incident controller, Work incident controller, Nodal officer and coordinator. Team operation control room.
- **Auxiliary Team:-Dam &Powerhouse**

1. Team Civil repairing and maintenance.
2. Team Electrical
3. Team H&M and mechanical
4. Team security .
5. Backup team
6. Team HR& Medical.
7. Team rescue, evacuation & searching

Agenda Point:

To educated the employee towards safety during flood emergency and check the availability/healthiness of resources.

Roll &Responsibility of Chief Incident Controller.
Roll &Responsibility of Site Incident Controller.
Roll &Responsibility of Work Incident Controller.
Roll &Responsibility of Coordinator

Roll &Responsibility of Control room &Assembly point in-charge.-

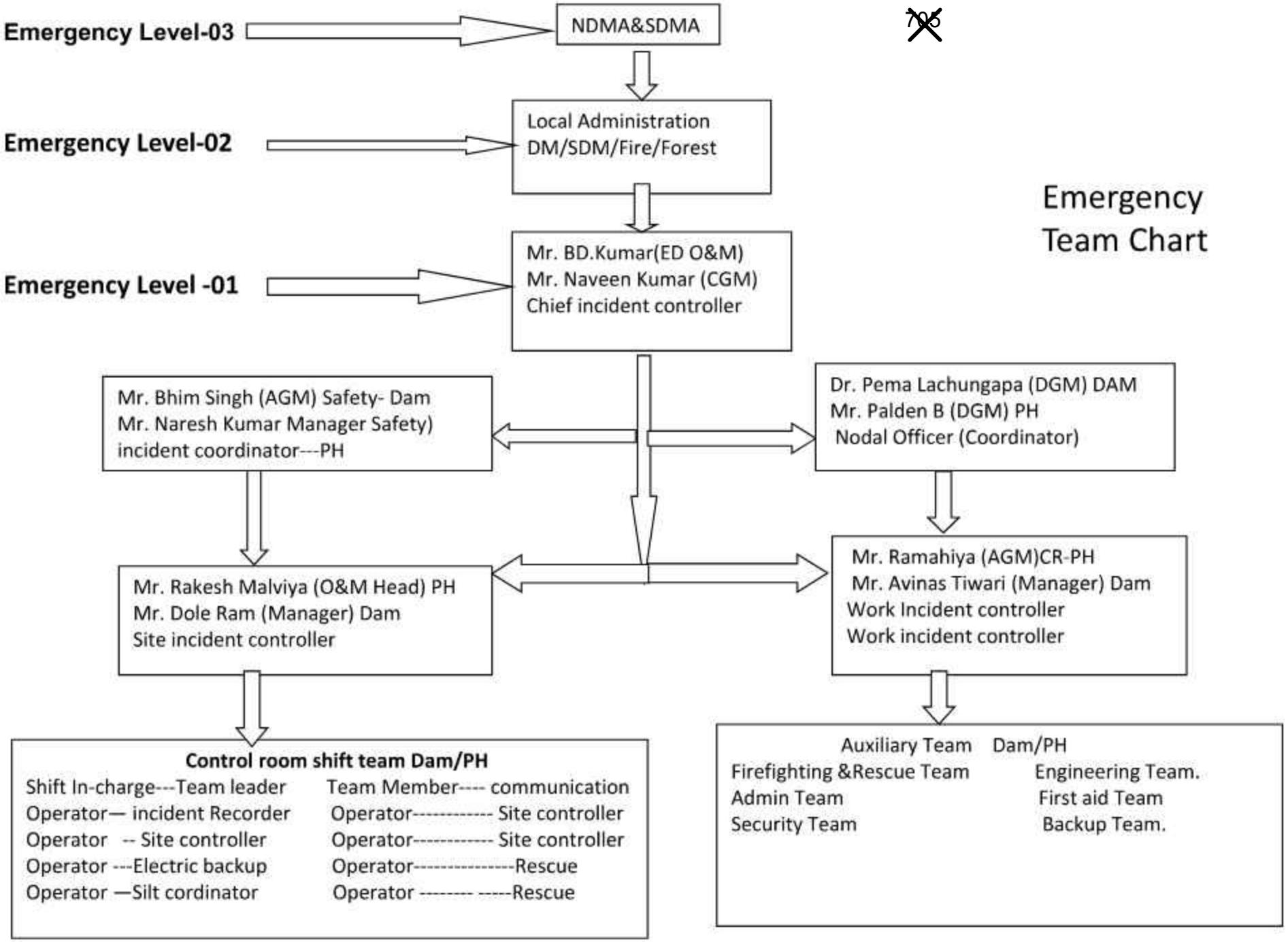
Roll of & Responsibility **of Auxiliary Teams**.
Firefighting Team &Rescue Team, First aid &Admin Team and Backup Team.

Rescue /evacuations plan.
Emergency equipment/Resources.
Assembly point and communication.
Reassemble or normalizes the situation.
Siren system
Recourses:- Motor boat, Siren, Emergency equipment's, Communication system

Situation of Mock drill action

- Today on 25/04/2023 at about **10:30 am flash flood reported from upstream Lachen to control Dam** and inflow level start increasing gradually.
- **Emergency action Team**:-Shift engineer Mr. KM Sharma(DM) inform to site in-charge that reservoir water level start rising quickly as information received from upstream flash flood. .
- QRT(on duty staff) Chute spillway ,ST-1&2 and Power intake, SFT gate alarted and reservoir level controlled by shift in-charge
- Desk operator control room Dam inform to Powerhouse , Mr. Naveen Kumar (CGM) –Chief Incident Controller,Nodal officer ,Coordinator after confirmation the site situation .
- Mr.Abisekh (Eng) (Silt manager) take report silt at control room for all silt lab,(Lachen Lab,Lachung Lab,Power intake Lab,Down Stream HRT Lab.

Emergency Team Chart



Roll &Responsibilities :-Management Team

Nodal officer:- Company Nodal officer designated to coordinate with the local administration, panchayat and authorities. Dr. Pema Lachungappa (DGM) ---9002360543

Chief incident controller :-Undertake a continuous review of possible developments and assess the magnitude of the situation and decide if staff needs to be evacuated at Assembly points to identified Shelter Place/Assembly point.

Safety Officers (Coordinator):-Upon getting the emergency message, he rush to the Emergency Control Center and arrange to activate all the systems. Arrange to establish the contact in between Site emergency function team and provide leadership.

Site Incident Controller:-When he hear the emergency and fire alarm according to the plan responsibilities along with auxiliary team, he actively participate in controlling the emergency and f try to reduce loss of personal, material damage.

Work Incident Controller:-take the overall charge including to the containment of emergency. On arrival, he will assess the scale of emergency and magnitude He direct to stop all activities within the affected area taking into consideration the priorities for safety of personnel; minimize further damage to the property and environment

Roles &Responsibilities of Auxiliary Teams

Operation in-charge Dam (Site incident controller) Mr. Dole Ram (Manager) Reached at Control room and takeover responsibility plant gate operation in emergency and powerhouse team set up a temporary control room at bend no.20 to coordinate to control room.

Control room Powerhouse desk operator inform to all site engineer to gather at assembly point for further action. He inform to **ERLDC, Rangpo Station ,Digchu Powerhouse and Teesta Stage –V NHPC Project.** and shut down machine in Powerhouse (T-3) a after confirmation from Site incident controller.

Dam Gate operation team and electric backup team reached at their designated area (OPU Room/DG Room for further action

Auxiliary Team:

Admin team:-Mr. Mon Kumar/Mr. Vinay Kumar (Executive HR) reached at assist to Site incident Controller.

First aid team:-First aid team reached at assembly point and establish first aid center they provide first aid to injured personal and sent to dispensary for further treatment.

Rescue team:-Mr. Avinas Tiwari (Dam)./Narender kumar Tiwari (PH) reached at assembly Point with equipment and start rescue people from PH and Dam Down stream and upstream colony they rescued the people at assembly point.

Security Team:- Team cordoned off all area to provide proper access and advised the designated teams and to keep away all the people from incident place.

Engineering team:-. The team shutdown their work and lockup their tool and tackle and all their personnel were shifted to a predetermined location called the assembly point.

BACKUP TEAM

Maintenance and Civil backup team reached at incident place to control the side situation at Dam top with heavy machinery/equipment to face the emergency situation..

- Emergency equipment use during emergency.
- 1.Mega phone.----------01
- 2.Nylon rope.----------400 mtr
- 3.Life buoy----------08
- 4.Whistle.----------04
- 5.Safety belt----------05
- 6.strechture.----------03
- 7.First aid kit.----------02
- 8.Emergency vehicle.----------01
- 9.Ambulance.----------01
- 10.Walki talky set.----------06
- 11.Breathing apparatus.---------02
- 12.Surch light/ torch.----------04
- 13.Life Jacket----------05
- 14. Loader----------01
- JCB----------01
- Life saving rescue boat----------02

Debriefing done at assembly point at 01:00pm

सत्यमेव जयते

भारत सरकार/ Government of India
पर्यावरण, वनएवंजलवायुपरिवर्तनमंत्रालय
Ministry of Environment, Forest & Climate Change
क्षेत्रीय कार्यालय, भुवनेश्वर/ Regional Office, Bhubaneswar
उप-कार्यालय, कोलकाता/ Sub-Office, Kolkata
IB-198, Sector – III, Salt Lake City, Kolkata-700106
Phone: 033-2335-0902, E-mail: iro.kolkata-mefcc@gov.in

LiFE Lifestyle for Environment

No. RO-NE/E/IA/SK/HEP/60/41 Date: 09.02.2024

To,

M/s. Teesta Urja Limited,
119, Jor Bagh, New Delhi- 110003.
(e-mail: kks@sikkimurjalimited.in,
pb@sikkimurjalimited.in , snsd@sikkimurjalimited.in)

Sub: Environmental Clearance for the Teesta Hydroelectric Project Stage-III (1200 MW) in North District, Sikkim by M/s. Teesta Urja Limited-reg.

Ref: 1. Ministry's letter no. L-11011/01/2024-IA-I(RV) dated 08.01.2024,
2. Ministry's EC letter no. J-12011/26/2006-IA-I dated 04.08.2006.

Sir,

I am directed to draw your kind attention to the subject and reference letter cited above and to state that the site inspection of the project (M/s. Teesta Urja Limited) was conducted by Dr. Shahida P. Quazi, Scientist 'E', Sub-office Kolkata, Regional Office Bhubaneswar on 16.01.2024 and 17.01.2024. The discussion was held with concerned officer on implementation of stipulated environmental condition. It was observed that the effective measures are required to be taken for following issues to ensure satisfactory compliance status:

J-12011/26/2006-IA.I dated 04.08.2006:

1. *PAs need to submit the certificate for utilization of funds deposited under CAT plan.* **(Specific Condition i)**

2. *PAs have not provided detailed compliance status with respect to the all the assurances/ commitments given by the project authority in the public Hearing.* **(Specific Condition vi)**

The action taken report on the above non-compliances should be submitted to the Regional Office within 30 days of issue of this letter.

Yours faithfully,

Q. Shahida Parvin

(डॉ. शाहिदा परवीन काज़ी/ Dr. Shahida Parvin Quazi)
वैज्ञानिक-ई / Scientist-E

Sikkim Urja Limited

ANNEXURE-11

[Formerly: Teesta Urja Limited | CIN: U31200DL2005SGC133875]
Government of Sikkim Enterprise
Registered Office: B2/1A Safdarjung Enclave, Africa Avenue, New Delhi 110029
E: contact@sikkimurjalimited.in | W: sikkimurjalimited.in

Ref. No. SUL/MoEFCC/2024/02 Date: 20.02.2024.

The Scientist – E
Ministry of Environment, Forest & Climate Change
Regional Office, Sub-Office
Kolkatta 700106

Kind attention – Dr. Shahida Parvin Quazi

Sub: Environment Clearance for the Teesta Hydro Electric Project Stage-III (1200 MW) in North District, Sikkim by M/s Sikkim Urja Limited (Formerly Teesta Urja Limited)-reg.

Madam,

In reference to your letter no. RO-NE/E/IA/SK/HEP/60/41 Dated: 09.02.2024. regarding submission of utilization certificate of the fund deposited for the CAT plan implementation and compliance of public hearing commitments, we are herewith kindly submitting the details as below.

1. PAs need to submit the certificate for utilization of funds deposited under CAT plan (Specific condition VI) – **Utilization statement received from Forest & Environment Department, Government of Sikkim is enclosed as Annexure-1.**

2. PAs have not provided detailed compliance status with respect to all the assurances / commitments given by the project authority in the public hearing (Specific Condition VO) – **Detailed compliance status report of the assurances given in the public hearing is enclosed as Annexure-2.**

Kindly submitted please.

Thanking You,

Yours Sincerely,
For **Sikkim Urja Limited**

SIKKIM URJA LIMITED

Authorized Signatory

GOVERNMENT OF SIKKIM
OFFICE OF THE SECRETARY
FORESTS AND ENVIRONMENT DEPARTMENT
FOREST SECRETARIAT, DEORALI, GANGTOK-737 102
[Email: pccf-fewd@sikkim.gov.inPhone: 03592 - 281261 (O) Fax: 03592 – 281778]

Ref. No. A-7/FCA/FEWMD/994 Date: 18-03-2023

To,

The Executive Director
Teesta Urja Pvt. Ltd.
Mangan District

Sub: **Utilization Statement of fund for various activities.**

Sir,

With reference to your Letter No. TUL/Forest/22-23/01 dated 22-06-2022, enclosed please find herewith fund utilization statement for implementation of different activities by the State CAMPA, Forest & Environment Department, Government of Sikkim till 28-02-2023, are as under.

(Amount in lakh)

Sl. No.	Name of activity	Fund deposited by User Agency	Fund utilized	Balance
1	Compensatory Afforestation	Rs. 215.40	Rs. 215.40	0
2	Catchment Area Treatment (CAT) Plan	Rs. 1002.70	Rs. 1002.96	Rs. 0.74
3	Forest Protection	Rs. 50.60	Rs. 50.60	0
4	Biodiversity Conservation Plan	Rs. 50.00	Rs. 50.00	0
5	Wildlife Habitat Mgmt. Plan	Rs. 114.70	Rs. 114.70	0

Submitted for information and further necessary action.

Yours sincerely,

18.03.2023
(Udai Gurung, IFS)
Chief Executive Officer
State Authority, CAMPA (Sikkim)

Udai Gurung, IFS
Chief Executive Officer
State Authority
CAMPA, Sikkim

989

STATEMENT OF FUND UTILIZED FOR IMPLEMENTATION OF "COMPENSATORY AFFORESTATION" STIPULATED FOR DIVERSION OF 83.0405 Ha OF FOREST LAND FOR CONSTRUCTION OF 1200 MW TEESTA STAGE III HYDRO ELECTRICT PROJECT IN NORTH DISTRICT OF SIKKIM TILL 28-02-2023

[Based on Forest Clearance granted by the Ministry vide Letter No 8-142/2006 FC Dt. 2/11/2007]

Implementing Division: **Territorial (North Division)**

(Amount in lakh)

Sl. No.	Item of works	Unit	Achievement		REMARKS
			Physical	Financial (In lakh)	
	Compensatory Afforestation (CA) Scheme				
1	PART "A" Chungthang Range	Ha.	67	215.40	Works completed
2	PART "B" Mangan Range	Ha.	40		
3	PART "C" Dzongu Range	Ha.	30		
	Total		**137**	**215.40**	

(Rupees two crores fifteen lakhs and forty thousand) only

Chief Exective Officer
State Authority, CAMPA (Sikkim)

Joint Chief Exective Officer
State Authority, CAMPA (Sikkim)

~~717~~

STATEMENT OF FUND UTILIZED FOR IMPLEMENTATION OF "CATCHMENT AREA TREATMENT PLAN" STIPULATED FOR DIVERSION OF 83.0405 Ha OF FOREST LAND FOR CONSTRUCTION OF 1200 MW TEESTA STAGE III HYDRO ELECTRICT PROJECT IN NORTH DISTRICT OF SIKKIM TILL 28-02-2023

[Based on Forest Clearance granted by the Ministry vide Letter No 8-142/2006 FC Dt. 2/11/2007]

Implementing Division: **Environment & Soil Conservation (North Division)** (Amount in lakh)

Sl. No.	Item of works	Unit	Achievement		REMARKS
			Physical	Financial	
	Catchment Area Treatment (CAT) Plan				
	Creation				
1	Creation of nursery	Ha. HA	10	20.15	
		Ha. LA		20.41	
2	Artificial Regenration	Ha. HA	752	55.91	
		Ha. LA		41.36	
3	Aided Natural Regeneration	Ha. HA		39.62	
		Ha. LA		30.37	
4	Pasture development	Ha. HA	538	30.97	
		Ha. LA		29.19	
5	Fodder plantation	Ha. HA	160	15.41	
		Ha. LA		12.52	
6	Small bamboo (pareng) plantation	Ha. HA	415	45.27	
		Ha. LA		31.72	
7	Broom grass plantation	Ha. LA	40	8.68	
8	B/Wwire fencing	Km, LA	22	43.97	
9	Watch & Ward	Mdys HA	3668	20.20	
		Mdys LA	3669	17.54	
10	Medicinal Plantation	Ha. HA	415	33.69	
		Ha. LA		26.79	
	Maintenance				
11	Artificial Regeneration	Ha. HA		33.10	
		Ha. LA		16.29	
12	Afforestation (2nd yr.)	Ha. HA		5.28	
		Ha. LA		3.11	
13	Afforestation (3rd yr.)	Ha. HA		8.38	
		Ha. LA		9.34	
14	Afforestation (4th yr.)	Ha. HA		1.54	
		Ha. LA		7.50	
15	Medicinal Plantation	Ha. HA		10.47	
		Ha. LA		4.90	
16	Medicinal Plantation (1st Year)	Ha. HA		0.83	
		Ha. LA		0.79	
17	Medicinal Plantation (2nd Yr.)	Ha. HA		8.16	
		Ha. LA		3.74	
18	Medicinal Plantation (3rd Yr.)	Ha. HA		2.60	
		Ha. LA		1.13	
19	Medicinal Plantation (4th Yr.)	Ha. HA		0.44	
		Ha. LA		0.00	
20	Pasture development	Ha. HA		14.11	
		Ha. LA		3.67	
21	Aided Natural Regeneration (1st Yr.)	HA		4.85	
		HA		3.25	
22	Aided Natural Regeneration (2nd Yr.)	HA		1.00	
		LA		0.67	
23	Aided Natural Regeneration (3rd Yr.)	Ha. HA		6.84	
		Ha. LA		4.78	
24	Aided Natural Regeneration (4th Yr.)	Ha. HA		5.97	
		Ha. LA		0.67	
25	Fuel/Fodder Plantation	Ha. HA		3.51	
		Ha. LA		3.39	

~~778~~

Sl. No.	Item of works	Unit	Achievement		REMARKS
			Physical	Financial	
26	Bamboo Plantation	Ha. HA		4.01	
		Ha. LA		2.81	
27	Bamboo Plantation (4th yr.)	Ha. HA		2.12	
		Ha. LA		0.70	
28	Broom Plantation	Ha. LA		1.07	
29	Artificial Regeneration (3rd yr.)	Ha. HA		0.95	
		Ha. LA		6.87	
30	Pasture development (3rd yr.)	Ha. HA		1.95	
		Ha. LA		1.29	
31	Pasture development (4th yr.)	Ha. HA		4.65	
		Ha. LA		2.83	
32	Watch & Ward	M/days		5.78	
		M/days		2.40	
33	Nursery Maintenance	Ha.	10	8.65	
	Engineering				
34	Contour bunding	Ha	49	60.17	
35	1:2:4 CRS Masonry	Cum.	75	5.37	
36	Dry Rubble Stone Masonry	Cum. HA		4.99	
		Cum. LA		2.49	
37	Step/Catch Water drain	Rmt HA	500	25.75	
		Rmt LA		18.01	
38	CCM Wall (1:4:8)	Cum. HA		17.55	
		Cum. LA		16.88	
39	Crate Wall (Sausage)	Cum. HA	0	18.23	
		Cum. LA		9.49	
40	Adm & Overhead cost	LS		20.78	
41	Monitoring & Evn.	LS		3.44	
42	Entry Point Activity	1 job		15.00	
43	Procurement of Vehicle			21.40	
44	Transfer of technoloy/Awareness/Training/workshop etc			14.78	
45	Labour camps/camp shifting			7.51	
	Total			**1001.96**	

(Rupees ten crores one lakh and ninety six thousand) only

Chief Exective Officer
State Authority, CAMPA (Sikkim)

Joint Chief Exective Officer
State Authority, CAMPA (Sikkim)

STATEMENT OF FUND UTILIZED FOR IMPLEMENTATION OF "FOREST PROTECTION" STIPULATED FOR DIVERSION OF 83.0405 Ha OF FOREST LAND FOR CONSTRUCTION OF 1200 MW TEESTA STAGE III HYDRO ELECTRICT PROJECT IN NORTH DISTRICT OF SIKKIM TILL 28-02-2023

[Based on Forest Clearance granted by the Ministry vide Letter No 8-142/2006 FC Dt. 2/11/2007]

(Amount in lakh)

Implementing Division: **North Territorial Division**

Item No.	Item of works	Unit/ Period	Year	Physical Target	ORIGINAL PROVISION As per EMP		ACHIEVEMENT		REMAKRS
					Rate	Amount	Phy	Fin	
1	2	3	4	5	6	7	8	9	10
A	**FOREST PROTECTION**	month							
1	Deployment of 8 Forest Guards @ 4000/month for 5 Yrs , 1x4000x12x5	12	5	8	4000	19.20	8	19.20	
2	Deployment of 1 Range Officer @ 9000/month for 5 Yrs, 1x9000x12x5	12	5	1	9000	5.40	1	5.40	
3	10% Increase cost on item No.1 and 2 above for 5years as per EMP					2.46		2.46	
	Sub-Total (A)					**27.06**		**27.06**	
B	**OTHER ACTIVITY**								
1	Contruction of Forest Check Post-with provision of arms etc	No		2	5,00,000	10.00	2	10.00	
2	Purchase of 2 Jeeps/Bolero for patrolling duty	No		2	5,00,000	10.00	2	10.00	
3	Communication system etc	LS				0.10		0.10	
4	Overhead/Office expenses/ TA&DA stationery, maintenance of vehicle & HSD/POL					3.44		3.44	
	Sub-Total (B)					**23.54**		**23.54**	
	Grand Total (A+B)					**50.60**		**50.60**	

(Rupees fifty lakhs and sixty thousand) only

Chief Exective Officer
State Authority, CAMPA (Sikkim)

Joint Chief Exective Officer
State Authority, CAMPA (Sikkim)

STATEMENT OF FUND UTILIZED FOR IMPLEMENTATION OF "BIO DIVERSITY CONSERVATION PLAN" STIPULATED FOR DIVERSION OF 83.0405 Ha OF FOREST LAND FOR CONSTRUCTION OF 1200 MW TEESTA STAGE III HYDRO ELECTRICT PROJECT IN NORTH DISTRICT OF SIKKIM TILL 28-02-2023

[Based on Forest Clearance granted by the Ministry vide Letter No 8-142/2006 FC Dt. 2/11/2007]

Implementing Division: **North Wildlife Division**

(Amount in lakh)

Item No.	Item of works	Unit	Physical Target	ORIGINAL PROVISION As per EMP		ACHIEVEMENT		REMAKRS
				Rate	Amount	Phy	Fin	
1	2	3	4	5	6	7	8	9
A	**BIO DIVERSITY CONSERVATION**							
1 (a)	Nursery creation by making bench terracing for growing of vulnerable /threatened species mainly of Hedychium spicatum in 1 Ha. nursery for 2 Yrs. HA		2	675000	13.50	675000.00	13.50	
	Soil & Moisture conservation works HA	Ha	10	81378	8.14	81378	8.14	
(b)	Planting of nursery grown Hedychium seedlings in subsequent Yrs of operation i/c soil and carriage charges etc complete	Ha	20	69236	13.85	69236	13.85	
2	Cost for growing of rare/endangered species of Cyathea spinulos	LS	5	30,000	1.50	30000	1.50	
3	Creation of Orchadarium by raising locally avilable Orchids like Dendrobium densiflorum, Arundina graminifolia, Coelogyne corymbosa etc	LS	1	10,00,000	10.00	1000000	10.00	
4	**Sub-Total (A)**				**46.99**		**46.99**	
(B)	**OVERHEAD EXPENSES/MONITORING & EVALUATION & CONTINGENCIES**							
i)	Overhead/Office expenses/stationery, HSD/maintenance of vehicles /TA/DA etc				2.01		2.01	
ii)	Monitoring & Evaluation @ 2%				1.00		1.00	
	Sub-Total (B)				**3.01**		**3.01**	
	Grand Total (A+B)				**50.00**		**50.00**	

(Rupees fifty lakhs) only

Chief Exective Officer
State Authority, CAMPA (Sikkim)

Joint Chief Exective Officer
State Authority, CAMPA (Sikkim)

STATEMENT OF FUND UTILIZED FOR IMPLEMENTATION OF "WILD LIFE HABITAT MANAGEMENT PLAN" STIPULATED FOR DIVERSION OF 83.0405 Ha OF FOREST LAND FOR CONSTRUCTION OF 1200 MW TEESTA STAGE III HYDRO ELECTRICT PROJECT IN NORTH DISTRICT OF SIKKIM TILL 28-02-2023

[Based on Forest Clearance granted by the Ministry vide Letter No 8-142/2006 FC Dt. 2/11/2007]

Implementing Division: **Khanchendzonga National Park (KNP) Division**

(Amount in lakh)

Item No.	Item of works	Unit	Physical Target	ORIGINAL PROVISION As per EMP		ACHIEVEMENT		REMAKRS
				Rate	Amount	Phy	Fin	
1	2	3	4	5	6	7	8	9
A	**WL/BIO DIVERSITY CONSERVATION**							
1	Habitat improvement	Ha	80	14950	11.96	80	11.96	
2	Construction of Watch Tower	No	3	250000	10.50	3	10.50	
3	Construction of Check Post	No	2	380000	7.60	2	7.60	
4	Improvement of foot path	km	3	350000	10.50	3	10.50	
5	Water holes/Check dam	Cum	900	968	8.71	900	8.71	
6	Estimate of wildlife	Ha	25	22200	5.55	25	5.55	
7	Immunization of wildlife	Head	800	500	4.00	800	4.00	
8	Conservation of vulnerable species	Ha	25	14950	3.74	25	3.74	
9	Control of forest fire	Ha	30	14950	4.49	30	4.49	
10	Patrolling & surveillance	Ha	50	12500	6.25	50	6.25	
11	Anti poaching	km	25	35000	8.75	25	8.75	
12	Eco-development	Ha	1.5	186000	2.79	1.5	2.79	
13	Enhancing wildlife diversity	Ha	15	20200	3.03	15	3.03	
14	Rehabilitation of displaced willdlife	Ha			3.00		3.00	
15	Awareness, education and training	No	4	80000	3.20	4	3.20	
16	Recruitment of field staff		6		5.40	6	5.40	
	Sub-Total				**99.46**		**99.46**	
17	Administrative expenses	12%			11.94		11.94	
18	Contingencies	3%			3.34		3.34	
	TOTAL				**114.74**		**114.74**	

(Rupees one crore fourteen lakhs and seventy four thousand) only

Chief Executive Officer
State Authority, CAMPA (Sikkim)

Joint Chief Executive Officer
State Authority, CAMPA (Sikkim)

COMPLIANCE STATUS OF DISCUSSION / COMMITMENTS MADE BY SPCB AND TUL DURING PUBLIC HEARING

Question by participant	Commitment made by SPCB, SPDC and TUL	Concern Deptt. to full fill this commitment	Compliance Status
Q.1 The project area lies in the protected and restricted areas and the previous projects of national interest involving armed forces and the Border Road Organization have had impact on the local demography, culture and environment and religion thereby endangering the survival of the local in their natural habitat. Shri Tseten Lepcha, Chungthang, North Sikkim.	**Ans.** Necessary arrangement to check the influx/the flow of labourers shall be made in co-ordination with the State Administration through Labour Deptt. Outside labour would be issued permits to stay only for the prescribed period and all steps shall be taken to ensure that labour would go back after the permitted period is completed. Shri JVSDP Raju. G.M, Teesta Urja Ltd.	**TUL**	To check the influx/the flow of labourers in the Project area, Protected Area Permits to the manpower engaged in the construction of the project were issued from the District Collectorate and same were regulated through Toong & Snagkalang Police Check posts. With the completion of the project components, the workers were returned back in phased manner. A sample copy of the issued permit is attached as **Annexure-2A.**
Q.2. The locals feel that the people of this project area will have to face the hardship faced by the displaced people of the Teesta hydro-electric project, Stage-V, and Rangit hydro-electric project in connection to job opportunities, rehabilitation, health problems etc. Shri Tseten Lepcha, Chungthang, North Sikkim.	**Ans.** Considering all this fear, the Govt. of Sikkim has made necessary provisions for safeguarding the local interest and this have been included in the Agreement signed between the project proponent and the State Government. Shri. Pema Wangchen, Chief Engineer-cum-Managing Director, SPDC.	**SPDC**	There was no involvement of displacement due to any of the project component and economic & job opportunities to the local people were provided by the project during the period of entire project construction. During the construction stage, employment to about 299 local people were provided and after the commission of the project, employment to about 425 local people have been provided.
Q.3. What will be the impact on the religion, law and order and cultural identity of the locals?	**Ans.** The places of the religious interest will remain untouched. Further for the law and order problem necessary arrangements will be made by the Sate	**GoS**	Complied the comments of the Honorable Minister. No places of religious interest have been

Question by participant	Commitment made by SPCB, SPDC and TUL	Concern Deptt. to full fill this commitment	Compliance Status
Shri Tseten Lepcha, Chungthang, North Sikkim.	Government. The outside labourers after completion of the project will be moved out of the restricted and protected areas. Shri Hissay Lachungpa, Hon'ble Minister.		touched and outsider labourers after completion of the project deported.
Q.4. What will be the environmental impact from the project? Shri Tseten Lepcha, Chungthang, North Sikkim.	**Ans.** Necessary steps shall be taken to minimize the environmental impact during the construction and operation phase. Shri JVSDP Raju G.M, Teesta Urja Ltd.	**TUL**	A detailed EIA study was conducted by the independent consultant (WAPCOS) covering all environmental and social aspects associated with hydro power project and on the basis of impact identified various environmental management plans were prepared which have been implemented. These plans are Management in Road Construction, Control of Pollution for labour camp, Restoration and landscaping of Project Quarry Site, Green Belt Development, Biodiversity Conservation Plan, Wildlife Management plan, Fish Management Plan, Public Health Delivery System, Road- Side Plantation, Control of Air Pollution, Control of water pollution, Compensatory Afforestation, R&R Plan, DMP etc. Further, the project had complied all the conditions as stipulated in environmental

Question by participant	Commitment made by SPCB, SPDC and TUL	Concern Deptt. to full fill this commitment	Compliance Status
			clearance letter to minimize the environmental impacts.
Q.5. According to EIA report page no. 5-3 "Ethnographic Aspect" here is no tribal, it is true and many more intolerable sentence are written, which may cause disputes. Shri Tseten Lepcha, Chungthang, North Sikkim	Ans. I apologized and assure that whatever hurting sentence written in project report shall be deleted from the report immediately. Shri JVSDP Raju G.M, Teesta Urja Ltd.	**TUL**	The EIA report was suitable modified after the concerns raised during the public hearing and after the corrections, the communications to the concern stake holders were made and same are enclosed as **Annexure:2B**
Q: 6. a) Construction of (i) multi-purpose ground and (ii) school building at Naga Mangor. b) Providing job opportunities such as contract work to the residents of the affected area. - Toong Naga Panchayat and Villagers (68 in number)	**Ans:** The efforts of the State Government in this regard would be supplemented by TUL as a part of Local Area Development Programme. b) Preference would be given to affected and local residents of the project area with regard to jobs and contract opportunities subject to suitability of skills and competence. - Shri Raju, GM M/s Teesta Urja Limited	**TUL**	Implementation of Local area development program was carried out through R & R Committee. The LADP programs mainly focused on Public Health Care system, education, infrastructural development, livelihood & social developmental activities.
Q.7. The tribal lands are likely be taken over by the companies. Shri Athup Lepcha & party.	**Ans.** The land owners will be suitably compensated. Shri JVSDP Raju G.M, Teesta Urja Ltd.	**TUL**	130.8456 HA Private land was acquired for the project by the State Government in accordance with provision of Land Acquisition Act. None of 265 project affected family was displaced. The land owners were suitably compensated. In addition to land compensation, rehabilitation and tribal grant of Rs.1.86 crore was also disbursed to PAFs through district authority. R&R

Question by participant	Commitment made by SPCB, SPDC and TUL	Concern Deptt. to full fill this commitment	Compliance Status
			committee was constituted by State Government as per NPRR 2003 to oversee the implementation of R&R plan and various developmental activities in the sector of health care, livelihood, education, social development and other infrastructure facilities in 9 affected villages have been implemented.
Q.8. The EIA produced by the company is biased. Shri Athup Lepcha & party.	**Ans.** The EIA was carried out by WAPCOS an independent organization of the Govt. of India. Shri JVSDP Raju G.M, Teesta Urja Ltd.		The EIA/EMP report had been prepared by the independent consultant as per the guidelines of MOEFCC for the river valley project. The EIA & EMP along with public hearing report after incorporating the suggestions of the public have been submitted to MOEFCC which were duly appraised and critically examined by the EAC of MOEFCC Based on their recommendation, Environment Clearance was accorded by the MOEFCC
Q.9. We welcome the project whole heartedly however, we demand free electricity for the entire resident of North Sikkim. Shri Tshering Wangdi, Zilla Member	**Ans.** The proposal may be placed to the State Government. We thank for your support however. Shri JVSDP Raju G.M, Teesta Urja Ltd	**TUL**	As per the agreement between Project proponent & GoS, Company will provide 12% of free electricity for first 15 years and 15% up to 35 years. It was implemented since the project date of

Question by participant	Commitment made by SPCB, SPDC and TUL	Concern Deptt. to full fill this commitment	Compliance Status
			commercial operation (COD).
Q.10. Sufficient fund for environmental conservation should be made available. Shri Tshering Wangdi, Zilla Member	**Ans.** Sufficient provision for environmental conservation has been set aside. Shri JVSDP Raju G.M, Teesta Urja Ltd	**TUL**	The budget to implement the EMP was earmarked with Rs. 140.568 crore which was further raised to 238 Crores.
Q.11. Environmental risks and seismic impact have not been dealt adequately. - Shri Tseten Lepcha, Chungthang, North Sikkim	**Ans:** The EIA/EMP Report have been prepared taking into account assessment of all possible environmental impacts due construction of the project and suggested suitable mitigative measures as a part of EMP. However, the suggestions would considered and necessary additions, wherever required would be incorporated in the EIA/EMP Report. - Shri Raju, GM M/s Teesta Urja Limited	**TUL**	Seismic Design Parameters for Teesta-III HEP has been approved by NCSDP in its XIXth meeting held on 11th April 2008 at CWC, New Delhi. Based on their recommendation, seismic design parameters were incorporated for the design of Dam and other related structures.
Q.12. a) Complete health screening be made mandatory before issuing permits to outside labour. b) Large scale influx of outside labour could dilute the culture and traditions of the local community. - Shri Tseten Lepcha, Chungthang, North Sikkim	a) Complete health screening of labour would be carried out before their deployment by the company and its contractors. b) Outside labour would be sensitized about the culture and traditions of the local community before inducting them to the project execution. Labour would be staying at designated labour colonies and would be commuting to the work site. Their interaction and interference with the local community and environment would be kept to the possible minimum level. - Shri Raju, GM M/s Teesta Urja Limited	**TUL**	The health screening of each and every labour was carried out by medical division of the project. Labour colonies were established in the designated site where their deployment was required and there was no interaction & interference with the local community.
Q.13. Permanent Settlement of outside work force could affect the social/economic and political balance of the state. - Shri Tseten Lepcha, Chungthang, North Sikkim	**Ans:** With regard to the outside work force the conditions of the work permits would be complied strictly and the work force would be moved out of the project area after completion of the execution of the project. - Shri Raju, GM M/s Teesta Urja Limited	**TUL**	All the construction employees, workers & labours were issued the permit from the administration and had been withdrawn all the manpower from the site when construction work

Question by participant	Commitment made by SPCB, SPDC and TUL	Concern Deptt. to full fill this commitment	Compliance Status
			was over.
Q:14. As most of the river Teesta would flow underground for long stretches, it would impact riverine ecology and agriculture in the river valley. - Shri Tseten Lepcha, Chungthang, North Sikkim	**Ans:** Minimum flow would be released downstream of the dam to ensure sustenance of the aquatic ecology and also to meet the needs of other agencies. This would be in addition to the flows the river gets from the intermittent catchment. - Shri Raju, GM M/s Teesta Urja Limited	**TUL**	The EC stipulation in this regard was complied and required e-flow as per EC & NGT orders have been maintained in the downstream for the sustenance of aquatic life. Fish hatchery was also established for the sustenance of fishes.
Q:15. Does the population of Chungthang are recommended to use ear plugs/muff during construction of the project. - Shri Tseten Lepcha, Chungthang, North Sikkim	**Ans:** Provision of ear plug/muff is being recommended for the labour involved in the project construction to reduce the impact due to noise, if any. The study has revealed that the project construction activities with suggested measures would keep the noise pollution within the permissible limits in the project area including that of Chungthang. - Shri Raju, GM M/s Teesta Urja Limited	**TUL**	There was no report of noise pollution in and around the project including Chungthang during the construction stage. Ear plugs / muff were provided to the labour and other employees only who were at construction site.
Q:16. Land slides due to construction of tunnel and roads would cause environmental hazard to the near by villages. - Shri Tseten Lepcha, Chungthang, North Sikkim	**Ans:** Adequate engineering measures would be taken to prevent land slides in the project area. Comprehensive Muck Management Plan has been prepared and the same would be implemented in letter and spirit to avoid any adverse environmental impact due to muck generated during the project execution. - Shri Raju, GM M/s Teesta Urja Limited	**TUL**	Tunneling work was executed by controlled blasting method. Monitoring of the blasting had been duly conducted by expert so as to keep the impact of vibration in the desired boundary. Muck dumping sites were treated with adequate engineering & biological measures. No such landslide was noticed in an around the project site.
Q:17. The proximity of the KNP and measures for wild life protection not adequately covered in the EMP. - Shri Tseten Lepcha, Chungthang, North Sikkim	**Ans:** A comprehensive Wild Life Conservation Plan costing about Rs. 1.14 crores has been finalized in consultation with the Forest Department as a part of EMP. - Shri Raju, GM M/s Teesta Urja Limited	**TUL**	Wildlife Management Plan is a part of EMP and it has been implemented by the KNP division of Forest Department, GoS at an estimated cost of Rs. 1.14

Question by participant	Commitment made by SPCB, SPDC and TUL	Concern Deptt. to full fill this commitment	Compliance Status
			crores.
Q: 18. Keeping in view of the "Green Mission" programme of the State government, avenue plantation with ornamental & flowering plants suitable for that area can be incorporated in the work programme. List of suitable sps. recommended for various plantation schemes should be provided. -FEWMD, Govt. of Sikkim	**Ans:** The details of Road side Plantation and Green belt development has been provided as a part of EMP. -M/s Teesta Urja Limited	**TUL**	Road side plantation and Green belt development was implemented as per the EMP of the Project.
Q: 19. Out of the total area of 7469 (h) under High, Very high and Medium, only 1485 (h) has been taken for treatment. More area needs to be taken under treatment works. -FEWMD, Govt. of Sikkim	**Ans:** As a part of CAT Plan, most of the high and very high erosion areas that could be treated have been covered treatment measures. CAT Plan, has been suggested for catchment area of 1953.3 ha, which is roughly 29.55% of the area under very high and high erosion categories. The balance area is under forest, pasture or water bodies, for which biological treatment measures cannot be suggested. However, for these areas, Engineering measures in the form of step drain and stone masonry have been suggested. -M/s Teesta Urja Limited	**TUL**	CAT Plan was implemented by Environment & Soil Conservation Division Forest Department, Gos. The utilization certificate and progress report are enclosed.
Q: 20. Provision for purchase of vehicles for execution of above work is also suggested. -FEWMD, Govt. of Sikkim	**Ans:** As suggested purchase of two vehicles for Executives manning the CAT Plan would be provided at a cost of Rs. 10 lacs. -M/s Teesta Urja Limited	**TUL**	Part of CAT Plan
Q: 21. As in the case of other such Mega Hydel project, provision should also be made in the CAT Plan of Teesta Stage III. -FEWMD, Govt. of Sikkim	**Ans:** The cost estimate for CAT plan are mentioned in EMP report. It may be seen that a provision of 16% towards the above administrative expenses have been provided. However, as suggested the same is being revised to 25%. -M/s Teesta Urja Limited	**TUL**	Administrative expenses revised from 16% to 25%. Page No. 7-18 of EMP.
Q: 22. The rate for the items of work is not realistic and does not tally with the State Forest Department	**Ans:** It may be seen that the cost of Afforestation has been provided 3-4 times the prevailing rates of the State Forest Department. This excess amount could be adjusted against any possible increase in the other items of the work by the Forest Department during	**TUL**	Part of CAT Plan

Question by participant	Commitment made by SPCB, SPDC and TUL	Concern Deptt. to full fill this commitment	Compliance Status
-FEWMD, Govt. of Sikkim	implementation of the CAT Plan. -M/s Teesta Urja Limited		
Reservoir Rim Treatment Plan **Q:23.** The above plan has not been prepared and submitted. The plan is essential due to following reasons: 1. Due to the construction of dam in the river, a large chunk of land in the upstream side comes under submergence. a. Height of Dam-60 mts. b. Gross storage at Flood Rise Level5.08 Mm3. c. Length of Dam at top with 10 m width: 273 mts. To be precise the submergence area at FRL is about 22 ha 2. Due to submergence, the land at the periphery of the impounded water gets loosen and landslides/slips are activated. The Reservoir Rim Treatment is necessary for the following reason:- To check erosion of soil, landslip, landslide at the periphery of reservoir. To create footpath & parks all around the reservoir with iron fencing To conserve and propagate all the floral species that is lost due to the submergence of land To make a tourist spot Socio-economic development of the affected people required proper address. Measures to be adopted: **Measures to be adopted** Appropriate engineering measures for protection of peripheral land mass Biological measures with ornamental plants & soil binding species Fencing and street light all around the reservoir Rejuvenation of lost plants of the submergence area at all along the periphery of reservoir. Guards & Patrolling 24 hours. -FEWMD, Govt. of Sikkim	**Ans:** As suggested Rim Treatment Plan has been prepared and shall be incorporated in the revised EMP. -M/s Teesta Urja Limited.	**TUL**	Reservoir Rim Treatment Plan was implemented before the commissioning of the project. Slope of reservoir RIM of Teesta-III HEP was supported by specialized engineering materials supplied by M/s Maccaferri Environmental Solutions like terramesh, paralink, geotextile and erosion control blankets. Hill slopes are also protected by construction of RCC grid beams of 3x3 m grid and anchored to the hill slopes with 9m and 12m Self drilling anchors. The grid space was filled with boulders and protected by terramesh netting and geotextile.

Question by participant	Commitment made by SPCB, SPDC and TUL	Concern Deptt. to full fill this commitment	Compliance Status
Q: 24. Due to the submergence, the flora and fauns of the area is likely to be depleted forever. Note: A survey of the flora & fauna and its population needs to be carried out. A checklist of the species to be prepared. -FEWMD, Govt. of Sikkim	**Ans:** As a part of field studies for the project, Terrestrial Ecological survey was conducted for three seasons namely Winter, Summer, Post-monsoon and Monsoon. The results are summarized in EIA report. -M/s Teesta Urja Limited	**TUL**	Prepared and incorporated in EIA report of the project.
Forest Protection Plan **Q: 25.** The above plan has not been made The above plan is necessary due to following reasons: 1. During the construction period a large no. of labourers are engaged in the project areas spreading at different locations such as Dam site, Dam site colony, desilting chamber site, Adit sites, Quarry sites, Labourer camps, muck disposal areas, surge shaft & pen stock sites, power house, power colony area etc. The total length of Head race tunnel is 12.5 km. A huge no. of labourers shall remain in the project area during the whole construction time for 8 to 10 years. Therefore, these labourers shall depend on nearby forest for firewood, small timber, fodder and even for construction materials for their labour huts, which may cause serious damages to the forest. Some of the labourers may involve in illicit felling of trees which cannot be ruled out in such circumstances. **Mitigative measures suggested** 1. To provide labour camps in specific locations preferably with community kitchen. 2. Supply of kerosene, LPG or electricity in free of cost or subsidized rate. 3. Creation of LPG or Kerosene depots in the project area.	**Ans:** Forest Protection Plan including provision of free fuel to the labour costing above Rs. 1.6 crore has been adopted costing as part of the Environment Management Plan. -M/s Teesta Urja Limited.	**TUL**	1. During the construction stage, workers were provided with community kitchen supported by Diesel Bhattis & LPG gas cylinders. 2. Around the project there were about 27 labour community kitchens operated in close monitoring of the project authority & forest department, as usage of firewood was completely restricted. 3. Project had taken about 850 LPG connections from IOCL and were regularly refilled through a centralized store maintained at Adit-II area at Theng village.
4. To construct as many as F.G. huts at different strategic locations in the project area and posting of FGs. 5. To appoint sufficient nos. of forest chowkidars to assist the FG & Forest	**Ans:** These being attended as a part of the Forest Protection Plan of	**TUL**	Three forest check posts have been constructed by the project proponent at Chungthang, Theng &

Question by participant	Commitment made by SPCB, SPDC and TUL	Concern Deptt. to full fill this commitment	Compliance Status
staffs, for patrolling & checking of forest produce. 6. To provide W/T sets for these forests field staff. 7. To provide one patrolling vehicle for the field staff. 8. B/W fencing of all the venerable forest areas near to the project site. 9. Purchase of forest fire fighting equipments. 10. Provide training & awareness programme 11. To avoid further encroachment of forest land, boundary pillars are necessary to be erected, especially to those areas which are likely to be encroached and such areas where the forest land is diverted for the project. 12. If necessary fire arms may also be provided to the field staffs. 13. In the fire prone areas, small rain water harvesting structures can be suggested for emergency use during forest fire which shall also serve as water hole for the wildlife. 14. If necessary few watch towers can also be suggested. 15. All the expenditure for the above works should be form by the project. -FEWMD, Govt. of Sikkim	the Environment Management Plan. -M/s Teesta Urja Limited		Mangan and handed over to Forest Department.
Compensatory Afforestation Plan **Q 26.** As per the forest conservation Act 1980, the equivalent non-forest land should be identified for the purposes and to be transferred to State Forest Department for raising plantation to minimize the adverse impacts on ecology. The details of non-forest land for compensatory Afforestation Scheme are not furnished. Efforts has to be made to identify any non-forest land for C.A. Scheme. -FEWMD, Govt of Sikkim	**Ans:** As suggested efforts would be made to identify non-forest land for Compensatory Afforestation. -M/s Teesta Urja Limited	**TUL**	In lieu of 68.3130 HA of surface forest land excluding 14.7275 HA of underground land for the construction of the project, a compensatory afforestation scheme over 137 HA of degraded forest land has been done which is twice area in extent to forest area that diverted as per provision of the guidelines.
Wildlife Conservation Plan **Q: 27.** Only some protection aspects has been suggested in the plan. Programmes like wildlife habitat management, has been completely ignored schemes like trap demolition, salt licks, water holes etc. need to be put in place in the plan. A detail Wildlife	**Ans:** Wildlife Conservation Plan has been prepared and shall be provided in the revised EMP.	**TUL**	Wildlife Management Plan is prepared and provided in a part of EMP which has been implemented.

Question by participant	Commitment made by SPCB, SPDC and TUL	Concern Deptt. to full fill this commitment	Compliance Status
Management Plan for conservation of wildlife is a mandatory and should be a part of Environmental Management Plan -FEWMD, Govt. of Sikkim	-M/s Teesta Urja Limited		
Q: 28. Detailed study of flora & fauna of all the diverted forest land required for dam construction, colony sites, quarry sites, muck disposal area & submergence area has to be done and check lists of spp found in these areas to be prepared. -FEWMD, Govt. of Sikkim	**Ans:** A detailed study of flora & fauna of all the diverted forest land required for dam construction, colony sites, quarry sites, muck disposal area & submergence area and check lists of spp. found in these areas are provided to the Department. -M/s Teesta Urja Limited	**TUL**	Part of EIA & EMP.
Q: 29. The forest and vegetation type of the catchment area is not mentioned /described- -FEWMD, Govt. of Sikkim	**Ans:** As per the available data the details of major vegetation in the Reserved Forest blocks in the study area including directly draining catchment area is given in EIA Report. -M/s Teesta Urja Limited	**TUL**	Part of EIA, PP3-55 to 3-77
Q: 30 (a. Forest density map & Forest type map of the catchment with its area statistics has not been provided. Q: b. In absence of above, the health status of forest of the Catchment area and its problems were not known properly. As a result of which the correct mitigation measures can't be suggested. -FEWMD, Govt. of Sikkim	**Ans:** The land use pattern map of the catchment area indicates forest density is enclosed as a part of the EMP Report. The land use pattern of the catchment area as per the satellite data is enclosed in EMP report -M/s Teesta Urja Limited	**TUL**	Part of CAT plan of EMP. Reference Fig: 7.2
Q: 31 The Land Use Map of the catchment area with its area statistics also must be provided, so that suitable biological or engineering measures can be suggested for different kinds of land use such as forest land, waste land (i.e. Khasmal & Gaucharan Land) and Agricultural land. -FEWMD, Govt. of Sikkim	**Ans:** The land use pattern map of the catchment area is enclosed as a part of the EMP Report. The land use pattern of the catchment area as per the satellite data is enclosed in EMP report. -M/s Teesta Urja Limited	**TUL**	Part of CAT plan of EMP. Reference Fig: 7.2
Q: 32 A large chunk of forest land comes under Alpine pasture (1249.829	**Ans:** As a part of Biological Measures of CAT plan, Pasture	**TUL**	Part of CAT plan of EMP. Reference

Palden

Question by participant	Commitment made by SPCB, SPDC and TUL	Concern Deptt. to full fill this commitment	Compliance Status
(ha) to be precise. Schemes such as pasture development or silvi-pasture development could be suggested in such land -FEWMD, Govt. of Sikkim	development, Plantation for Fuel wood has been provided in the revised EMP. -M/s Teesta Urja Limited		Table: 7.6
Q: 33 Though there is considerably very small area under agriculture, it is a main source of soil erosion due to continuous tillage operation. Schemes such as horticulture, floriculture, fodder development, agro-forestry and contour bunds, protective walls etc. could have been suggested adequately. -FEWMD, Govt. of Sikkim	**Ans:** Contour bunding over an agricultural area of 49 ha lying within high and very high erosion categories has been recommended in Table-7.6 of the EMP report. In addition to the above, as suggested measures such as horticulture, floriculture, fodder development and agro-forestry would be adopted for agriculture land. -Teesta Urja Limited	**TUL**	The contour bunding was provided under CAT plan to check the soil erosion. Further, other engineering work viz CRS masonry, dry rubble, masonry, catch water drain, crate wall, CCM, had also been constructed in the catchment area to check the soil erosion.
Q: 34 The catchment area is very important from the medicinal plants point of view. Adequate in-situ and ex-situ conservation & propagation measures should be suggested as many of them are rare and endangered. -FEWMD, Govt. of Sikkim	**Ans:** The details of medicinal plants available in the project area and catchment area are provided along with their conservation measures. -M/s Teesta Urja Limited	**TUL**	Complied
Q:35. No information has been made for the major landslides/slips found in the catchment area. These landslides & slips need special attention for treatment. -FEWMD, Govt. of Sikkim	**Ans:** The information on landslides has been provided in revised EMP. -M/s Teesta Urja Limited	**TUL**	The EIA report has enumerated the landslide zones of the North Sikkim and these sliding areas are away from the project area. Though small landslip areas in the catchment section of the project was attained under CAT plan being implemented by State Forest Department.
Q:36 Surprisingly, there is no provision for maintenance for plantation, barbed wire fencing and other works. Without maintenance for plantations are bound to be failure. At least two or three years of maintenance must be provided.	**Ans:** The provision for maintenance for plantation, barbed wire fencing, etc. has been outlined in EMP Report. As a part of the CAT Plan, provisions for the following have been made: • Nursery development • Maintenance of nursery	**TUL**	Prepared as part of CAT Plan of EMP.

Question by participant	Commitment made by SPCB, SPDC and TUL	Concern Deptt. to full fill this commitment	Compliance Status
-FEWMD, Govt. of Sikkim	• Barbed wire fencing • Watch and ward for 3 years for 10 persons. -M/s Teesta Urja Limited		
Q:37. The Action Plan is phased for three years only which should have been at least for seven years. This is because that the seedlings required for plantation take at least one to two years to grow in the nurseries and during this seedlings preparation time all the engineering & fencing works can be completed i.e. in the 1st and 2nd year. The seedlings which will be ready for plantation during two years time can be planted in the 3rd and 4th year followed by its maintenance upto 5th, 6th and 7th year. It will ensure the full success of plantation. -FEWMD, Govt. of Sikkim	**Ans:** As per the discussions during Appraisal Committee meeting at MoEF for various hydroelectric projects, the catchment area treatment has to be completed before the construction period. As the construction period of the project is 5 years, the catchment area treatment has been proposed to be completed over a period of three years. However, as suggested maintenance upto 7th year of plantation would be borne as a part of Catchment Area Treatment Plan. -M/s Teesta Urja Limited	**TUL**	Prepared as part of CAT Plan of EMP. (Chapter 7) The cost of the CAT plan, also includes 4 years for the plantation and 3 years of maintenance. (7.6 of EMP chapter)

~~737~~

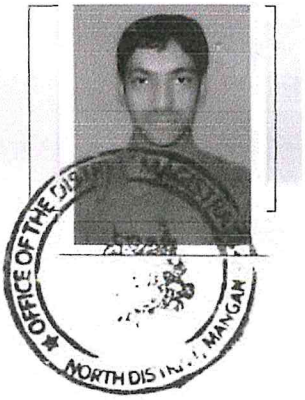
ANNEXURE – 2A (Colly)

(To be filled in duplicate)

(Application Form for the Issue of Entry Permit to Restricted / Protected Area)

To,
The District Collector
DAC, North Sikkim,
Pentok, Mangan.

Date: 12.09.13



Sir,

Kindly issue permission to visit : **Sangkalang / Safoo/ Chungthang**

The details of applicant/applicants is/are as follows:

Name/Names: Mr.Arpan Hazra
Father's Name: Sh. Madan Mohan Hazra
Full Address : Nasigram, Bhatar Burdwan-713165.
Name & Address of tour operator/Sponsor: **Abir Infrastructure Pvt. Ltd.**
Teesta Stage -3 H.E Project, Mangan (Post), North District, 737116.

Duration From: **12.09.2013 to 31.12.2013**

1. Copy of ILP & Passport to be enclosed with the application in case of foreign tourist.
2. Application for more than one person, an annexure with full details and photographs to be attached with the application.
3 For other applicants a copy of COI/SSC/EPIC etc to be enclosed for easy identification.

Name &Signature of the Applicant

FOR OFFICIAL USE

Permit is allowed for crossing **Toong / Sangkalang / Phidang** on the following conditions.

1 This entry permit will be cancelled if the permit holder/holders contrivances, the provisions of the rules and regulations in forces or in case of any offence involved breach of public order.
2 This entry permit will be cancelled if the permit holder/holders is/are engaged in any other activity other than for which the permission is granted.
3 This permit is granted for visiting the place as requested only

Sub -Divisional Officer
North District, Mangan

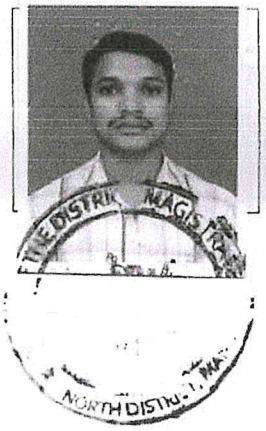
D.C (N)/A.D.C. (N)/S.D.M. (N)

~~786~~ (To be filled in duplicate)

(Application Form for the Issue of Entry Permit to Restricted / Protected Area)

To,
The District Collector
DAC, North Sikkim,
Pentok, Mangan.

Date: 12.09.13



Sir,

Kindly issue permission to visit : **Sangkalang / Safoo/ Chungthang**

The details of applicant/applicants is/are as follows:

Name/Names: Mr.Chiranjeevi Rajavarapu
Father's Name: Sh. Ankarao Rajavarapu
Full Address : 4-234/2 Salivahana Nagar, Guntur-522647.

Name & Address of tour operator/Sponsor: **Abir Infrastructure Pvt. Ltd.**
Teesta Stage -3 H.E Project, Mangan (Post), North District, 737116.

Duration From: **12.09.2013 to 31.12.2013**

1. Copy of ILP & Passport to be enclosed with the application in case of foreign tourist.
2. Application for more than one person, an annexure with full details and photographs to be attached with the application.
3 For other applicants a copy of COI/SSC/EPIC etc to be enclosed for easy identification.

Name &Signature of the Applicant

FOR OFFICIAL USE

Permit is allowed for crossing **Toong / Sangkalang / Phidang** on the following conditions.

1 This entry permit will be cancelled if the permit holder/holders contrivances, the provisions of the rules and regulations in forces or in case of any offence involved breach of public order.
2 This entry permit will be cancelled if the permit holder/holders is/are engaged in any other activity other than for which the permission is granted.
3 This permit is granted for visiting the place as requested only.

Sub -Divisional Officer
North District, Mangan

D.C (N)/A.D.C. (N)/S.D.M. (N)

~~ILP~~ (To be filled in duplicate)

(Application Form for the Issue of Entry Permit to Restricted / Protected Area)

To,
The District Collector
DAC, North Sikkim,
Pentok, Mangan.

Date: 12.09.13

Sir,

Kindly issue permission to visit : **Sangkalang / Safoo/ Chungthang**

The details of applicant/applicants is/are as follows:

Name/Names: Mr.Rajesh
Father's Name: Sh. Ramanand
Full Address : Vill- Jaimohara, Tehsil- Rarbatsaganj, Dist- Sonbhadra U.P.
Name & Address of tour operator/Sponsor: **Abir Infrastructure Pvt. Ltd.**
Teesta Stage -3 H.E Project, Mangan (Post), North District, 737116.

Duration From: **12.09.2013 to 31.12.2013**

1. Copy of ILP & Passport to be enclosed with the application in case of foreign tourist.
2. Application for more than one person. an annexure with full details and photographs to be attached with the application.
3 For other applicants a copy of COI/SSC/EPIC etc to be enclosed for easy identification.

Name &Signature of the Applicant

FOR OFFICIAL USE

Permit is allowed for crossing **Toong / Sangkalang / Phidang** on the following conditions.

1 This entry permit will be cancelled if the permit holder/holders contrivances, the provisions of the rules and regulations in forces or in case of any offence involved breach of public order.
2 This entry permit will be cancelled if the permit holder/holders is/are engaged in any other activity other than for which the permission is granted.
3 This permit is granted for visiting the place as requested only

Sub-Divisional Officer
North District, Mangan

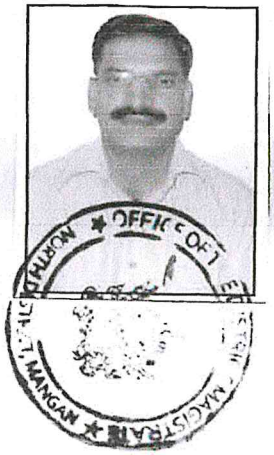
D.C (N)/A.D.C. (N)/S.D.M. (N)

~~788~~ (To be filled in duplicate)

(Application Form for the Issue of Entry Permit to Restricted / Protected Area)

To,
The District Collector
DAC, North Sikkim,
Pentok, Mangan.

Date: 12.09.13



Sir,

Kindly issue permission to visit : **Sangkalang / Safoo/ Chungthang**

The details of applicant/applicants is/are as follows:

Name/Names: Mr.Sunil Dutt
Father's Name: Sh. Om Dutt
Full Address : Japgampartly, P.o - Kishtwat.

Name & Address of tour operator/Sponsor: **Abir Infrastructure Pvt. Ltd.**
Teesta Stage -3 H.E Project, Mangan (Post), North District, 737116.

Duration From: **12.09.2013 to 31.12.2013**

1. Copy of ILP & Passport to be enclosed with the application in case of foreign tourist.
2. Application for more than one person, an annexure with full details and photographs to be attached with the application.
3 For other applicants a copy of COI/SSC/EPIC etc to be enclosed for easy identification.

Name &Signature of the Applicant

FOR OFFICIAL USE

Permit is allowed for crossing **Toong / ~~Sangkalang~~ / ~~Phidang~~** on the following conditions.

1 This entry permit will be cancelled if the permit holder/holders contrivances, the provisions of the rules and regulations in forces or in case of any offence involved breach of public order.
2 This entry permit will be cancelled if the permit holder/holders is/are engaged in any other activity other than for which the permission is granted.
3 This permit is granted for visiting the place as requested only

Sub -Divisional Officer
North District, Mangan

D.C (N)/A.D.C. (N)/S.D.M. (N)

~~789~~ (To be filled in duplicate)

(Application Form for the Issue of Entry Permit to Restricted / Protected Area)

To,
The District Collector
DAC, North Sikkim,
Pentok, Mangan.

Date: 12.09.13

Sir,

Kindly issue permission to visit : **Sangkalang / Safoo/ Chungthang**

The details of applicant/applicants is/are as follows:

Name/Names: Mr.Vijay Shridhar Nair
Father's Name: Sh. Shridhar Nair
Full Address : Navin S.T. Stand Parisar, Kadeganv Gram, Dist- Sangli-415304

Name & Address of tour operator/Sponsor: **Abir Infrastructure Pvt. Ltd.**
Teesta Stage -3 H.E Project, Mangan (Post), North District, 737116.

Duration From: **12.09.2013 to 31.12.2013**

1. Copy of ILP & Passport to be enclosed with the application in case of foreign tourist.
2. Application for more than one person, an annexure with full details and photographs to be attached with the application.
3 For other applicants a copy of COI/SSC/EPIC etc to be enclosed for easy identification.

Name &Signature of the Applicant

FOR OFFICIAL USE

Permit is allowed for crossing **Toong / Sangkalang / Phidang** on the following conditions.

1 This entry permit will be cancelled if the permit holder/holders contrivances, the provisions of the rules and regulations in forces or in case of any offence involved breach of public order.
2 This entry permit will be cancelled if the permit holder/holders is/are engaged in any other activity other than for which the permission is granted.
3 This permit is granted for visiting the place as requested only.

Sub -Divisional Officer
North District, Mangan

D.C (N)/A.D.C. (N)/S.D.M. (N)

~~730~~

(To be filled in duplicate)

(Application Form for the Issue of Entry Permit to Restricted / Protected Area)

To,
The District Collector
DAC, North Sikkim,
Pentok, Mangan.

Date: 12.09.13

Sir,

Kindly issue permission to visit : **Sangkalang / Safoo/ Chungthang**

The details of applicant/applicants is/are as follows:

Name/Names: Mr.Ajay Rana
Father's Name: Sh. K.R.Rana
Full Address : Vill- Moltari Block. Balijuri, Dist.- Sonitpur (Arunachal Pradesh)
Name & Address of tour operator/Sponsor: **Abir Infrastructure Pvt. Ltd.**
Teesta Stage -3 H.E Project, Mangan (Post), North District, 737116.

Duration From: **12.09.2013 to 31.12.2013**

1. Copy of ILP & Passport to be enclosed with the application in case of foreign tourist.
2. Application for more than one person, an annexure with full details and photographs to be attached with the application.
3 For other applicants a copy of COI/SSC/EPIC etc to be enclosed for easy identification.

Name &Signature of the Applicant

FOR OFFICIAL USE

Permit is allowed for crossing **Toong / ~~Sangkalang~~ / ~~Phidang~~** on the following conditions.

1 This entry permit will be cancelled if the permit holder/holders contrivances, the provisions of the rules and regulations in forces or in case of any offence involved breach of public order.
2 This entry permit will be cancelled if the permit holder/holders is/are engaged in any other activity other than for which the permission is granted.
3 This permit is granted for visiting the place as requested only

Sub -Divisional Officer
North District, Mangan

D.C (N)/A.D.C. (N)/S.D.M. (N)

~~A1~~

(To be filled in duplicate)

(Application Form for the Issue of Entry Permit to Restricted / Protected Area)

To,
The District Collector
DAC, North Sikkim,
Pentok, Mangan.

Date: 13.09.2013

Sir,

Kindly issue permission to visit **Chungthang, Safoo, Theng Via Toong.**

The details of applicant/applicants is/are as follows:

Name/Names : Tamang Buddha
S/o : Kalu Tamang
Full Address : Panjora Forest Basti,Upper Tandu Renj
Nagrakata, WB

Name & Address of tour operator/Sponsor: **Abir Infrastructure Pvt Ltd.**
Duration From: **13.09.2013 to 31.12.2013**

1 Copy of ILP & Passport to be enclosed with the application in case of foreign tourist.

2 Application for more than one person, an annexure with full details and photographs to be attached with the application.

3 For other applicants a copy of COI/SSC/EPIC etc to be enclosed for easy identification.

Name &Signature of the Applicant (Authority Signature)

FOR OFFICIAL USE

Permit is allowed for crossing **Toong / Sangkalang / Phidang** on the following conditions.

1 This entry permit will be cancelled if the permit holder/holders contrivances, the provisions of the rules and regulations in forces or in case of any offence involved breach of public order.
2 This entry permit will be cancelled if the permit holder/holders is/are engaged in any other activity other than for which the permission is granted.
3 This permit is granted for visiting the place as requested only.

Sub-Divisional Officer
North District, Mangan

D.C.(N)/A.D.C.(N)/S.D.M.(M).

~~702~~

(To be filled in duplicate)

(Application Form for the Issue of Entry Permit to Restricted / Protected Area)

To,
The District Collector
DAC, North Sikkim,
Pentok, Mangan.

Date: 13.09.2013

Sir,

Kindly issue permission to visit **Chungthang, Safoo, Theng Via Toong.**

The details of applicant/applicants is/are as follows:

Name/Names : Lama Amrit
S/o : Jeytha Lama
Full Address : Idng Forest Basti, Upper Tandu Renj
Nagrakata, WB

Name & Address of tour operator/Sponsor: **Abir Infrastructure Pvt Ltd.**
Duration From: **13.09.2013 to 31.12.2013**

1 Copy of ILP & Passport to be enclosed with the application in case of foreign tourist.

2 Application for more than one person, an annexure with full details and photographs to be attached with the application.

3 For other applicants a copy of COI/SSC/EPIC etc to be enclosed for easy identification.

Name &Signature of the Applicant (Authority Signature)

FOR OFFICIAL USE

Permit is allowed for crossing **Toong / Sangkalang / Phidang** on the following conditions.

1 This entry permit will be cancelled if the permit holder/holders contrivances, the provisions of the rules and regulations in forces or in case of any offence involved breach of public order.
2 This entry permit will be cancelled if the permit holder/holders is/are engaged in any other activity other than for which the permission is granted.
3 This permit is granted for visiting the place as requested only.

Sub-Divisional Officer
North District, Mangan
D.C.(N)/A.D.C.(N)/S.D.M.(M).

~~743~~

ANNEXURE - 2 B

Teesta III

No.TUL/GM/ENV./2006-10

To

Dt.11.08.2006

The Panchayat President
Singtam, Sikkim

Sub: Teesta Hydro-Electric Project Stage-III - regarding Environmental clearance

Sir,

We would like to bring to your kind information that the Environmental clearance for the Teesta Hydro-electric Project stage-III has been issued by the Ministry of Environment and Forests vide No.J-12011/26/2006.IA.I dt.4th Aug. 2006. A copy of the same is enclosed herewith for your kind information.

In this respect, we would also like to bring to your information that the EIA & EMP Reports prepared by us in consultation with our consultants, prior to the public hearing have been suitably revised / modified by us after attending to the various observations made by various respectable individuals during the public hearing as well as by concerned State Government agencies. We reiterate that the project / company have very high regards for the local people, the local culture, customs and traditions and also huge concern for the environment and ecology and hereby reaffirm that our commitments / assurances would be honoured in letter and spirit.

Thanking you,

Yours faithfully,

General Manager

TEESTA URJA LIMITED
Site Office : Near Power Colony, Mangan (P.O.), North Sikkim, 737 116, Sikkim
Tel. : +91-3592-234022 Telefax : +91-3592-234275
Gangtok Office : Bashista Niwas, Shyari, P.O. Deorali Bazar, Gangtok 737 102, Sikkim
Tel : +91-3592-281717 Telefax : +91-3592-280081
Gurgaon Office : A-297, Sushant Lok Phase-I, Gurgaon-122002, Haryana
Tel. : +91-124-4356720 Fax :+91-124-4356757

Teesta III

No.TUL/GM/ENV./2006-10

Dt.11.08.2006

To

The Zilla Member
Singhik, Sentam

Sub: Teesta Hydro-Electric Project Stage-III - regarding Environmental clearance

Sir,

We would like to bring to your kind information that the Environmental clearance for the Teesta Hydro-electric Project stage-III has been issued by the Ministry of Environment and Forests vide No.J-12011/26/2006.IA.I dt.4th Aug. 2006. A copy of the same is enclosed herewith for your kind information.

In this respect, we would also like to bring to your information that the EIA & EMP Reports prepared by us in consultation with our consultants, prior to the public hearing have been suitably revised / modified by us after attending to the various observations made by various respectable individuals during the public hearing as well as by concerned State Government agencies. We reiterate that the project / company have very high regards for the local people, the local culture, customs and traditions and also huge concern for the environment and ecology and hereby reaffirm that our commitments / assurances would be honoured in letter and spirit.

Thanking you,

Yours faithfully,

General Manager

Recieved
13/08/06.

TEESTA URJA LIMITED
Site Office : Near Power Colony, Mangan (P.O.), North Sikkim, 737 116, Sikkim
Tel. : +91-3592-234022 Telefax : +91-3592-234275
Gangtok Office : Bashista Niwas, Shyari, P.O. Deorali Bazar, Gangtok 737 102, Sikkim
Tel: +91-3592-281717 Telefax : +91-3592-280081
Gurgaon Office : A-297, Sushant Lok Phase-I, Gurgaon-122002, Haryana
Tel. : +91-124-4356720 Fax : +91-124-4356757

~~145~~

Teesta III

No.TUL/GM/ENV./2006-10

To

Dt.11.08.2006

Sh. Pemzang Tenzing,
Mangan,
North Sikkim – 737116.

Sub: Teesta Hydro-Electric Project Stage-III - regarding Environmental clearance

Sir,

We would like to bring to your kind information that the Environmental clearance for the Teesta Hydro-electric Project stage-III has been issued by the Ministry of Environment and Forests vide No.J-12011/26/2006.IA.I dt.4th Aug. 2006. A copy of the same is enclosed herewith for your kind information.

In this respect, we would also like to bring to your information that the EIA & EMP Reports prepared by us in consultation with our consultants, prior to the public hearing have been suitably revised / modified by us after attending to the various observations made by various respectable individuals during the public hearing as well as by concerned State Government agencies. We reiterate that the project / company have very high regards for the local people, the local culture, customs and traditions and also huge concern for the environment and ecology and hereby reaffirm that our commitments / assurances would be honoured in letter and spirit.

It is our genuine endeavor to develop the project in a highly beneficial manner to the local people with utmost care to the local sentiments and apprehensions. In this regard we request for your valuable guidance and suggestions to augment our efforts and we shall remain obliged for the same.

Thanking you,

Yours faithfully,

General Manager

Received

TEESTA URJA LIMITED
Site Office : Near Power Colony, Mangan (P.O.), North Sikkim, 737 116, Sikkim
Tel. : +91-3592-234022 Telefax : +91-3592-234275
Gangtok Office : Bashista Niwas, Shyari, P.O. Deorali Bazar, Gangtok 737 102, Sikkim
Tel : +91-3592-281717 Telefax : +91-3592-280081
Gurgaon Office : A-297, Sushant Lok Phase-I, Gurgaon-122002, Haryana
Tel. : +91-124-4356720 Fax : +91-124-4356757

~~116~~

Teesta III

No.TUL/GM/ENV./2006-10

Dt.11.08.2006

To

Sh. Tseten Lepcha,
Chungthang,
North Sikkim.

Sub: Teesta Hydro-Electric Project Stage-III - regarding Environmental clearance

Sir,

We would like to bring to your kind information that the Environmental clearance for the Teesta Hydro-electric Project stage-III has been issued by the Ministry of Environment and Forests vide No.J-12011/26/2006.IA.I dt.4th Aug. 2006. A copy of the same is enclosed herewith for your kind information.

In this respect, we would also like to bring to your information that the EIA & EMP Reports prepared by us in consultation with our consultants, prior to the public hearing have been suitably revised / modified by us after attending to the various observations made by various respectable individuals during the public hearing as well as by concerned State Government agencies. We reiterate that the project / company have very high regards for the local people, the local culture, customs and traditions and also huge concern for the environment and ecology and hereby reaffirm that our commitments / assurances would be honoured in letter and spirit.

It is our genuine endeavor to develop the project in a highly beneficial manner to the local people with utmost care to the local sentiments and apprehensions. In this regard we request for your valuable guidance and suggestions to augment our efforts and we shall remain obliged for the same.

Thanking you,

Yours faithfully,

General Manager

Tseten Lepcha 13/8/06

TEESTA URJA LIMITED
Site Office : Near Power Colony, Mangan (P.O.), North Sikkim, 737 116, Sikkim
Tel. : +91-3592-234022 Telefax : +91-3592-234275
Gangtok Office : Bashista Niwas, Shyari, P.O. Deorali Bazar, Gangtok 737 102, Sikkim
Tel : +91-3592-281717 Telefax : +91-3592-280081
Gurgaon Office : A-297, Sushant Lok Phase-I, Gurgaon-122002, Haryana
Tel. : +91-124-4356720 Fax :+91-124-4356757

747

ANNEXURE-IV

Teesta III

No.TUL/GM/ENV./2006-10

Dt.11.08.2006

To

Sh. Athup Lepcha,
Ex- Minister,
Lingthem,
P/O- Passingdong
Upper Dzongu,

Sub: Teesta Hydro-Electric Project Stage-III - regarding Environmental clearance

Sir,

We would like to bring to your kind information that the Environmental clearance for the Teesta Hydro-electric Project stage-III has been issued by the Ministry of Environment and Forests vide No.J-12011/26/2006.IA.I dt.4th Aug. 2006. A copy of the same is enclosed herewith for your kind information.

In this respect, we would also like to bring to your information that the EIA & EMP Reports prepared by us in consultation with our consultants, prior to the public hearing have been suitably revised / modified by us after attending to the various observations made by various respectable individuals during the public hearing as well as by concerned State Government agencies. We reiterate that the project / company have very high regards for the local people, the local culture, customs and traditions and also huge concern for the environment and ecology and hereby reaffirm that our commitments / assurances would be honoured in letter and spirit.

It is our genuine endeavor to develop the project in a highly beneficial manner to the local people with utmost care to the local sentiments and apprehensions. In this regard we request for your valuable guidance and suggestions to augment our efforts and we shall remain obliged for the same.

Thanking you,

Yours faithfully,

General Manager

TEESTA URJA LIMITED
Site Office : Near Power Colony, Mangan (P.O.), North Sikkim, 737 116, Sikkim
Tel. +91-3592-234022 Telefax : +91-3592-234275
Gangtok Office : Bashista Niwas, Shyari, P.O. Deorali Bazar, Gangtok 737 102, Sikkim
Tel : +91-3592-281717 Telefax : +91-3592-280081
Gurgaon Office : A-297, Sushant Lok Phase-I, Gurgaon-122002, Haryana
Tel : +91-124-4356720 Fax : +91-124-4356757