

PETITION NO...../GT/2026

**PETITION FOR DETERMINATION OF
TARIFF OF SUBANSIRI LOWER HYDRO
ELECTRIC PROJECT (2000 MW) FOR THE
PERIOD 23.12.2025 TO 31.03.2029.**

एन एच पी सी लिमिटेड
(भारत सरकार का एक नवरत्न उद्यम)
NHPC Limited
(A Government of India Navratna Enterprise)



Commercial Division

**NHPC Office Complex,
Sector33, Faridabad (Haryana)-121 003**

Volume-VI

ANNEXURE-III

OFFICE MEMORANDUM

Sub: Transfer of (i) Lower Subansiri Dam Project (ii) Lower Dihang Dam Project and (iii) Four Upper Sites in Arunachal Pradesh from Brahmaputra Board to NHPC.

Ministry of Water Resources has decided that Brahmaputra Board will hand over Lower Subansiri Dam Project as well as Lower Dihang Dam Project to NHPC at this stage so that balance work of preparation of DPR can be taken up by NHPC immediately. As proposed all the documents relating to both the projects along with infrastructure facilities developed at the sites will be transferred to NHPC. It would be worth mentioning here that NHPC has already taken up survey and investigation at 4 sites (2 uppermost sites each on Dihang and Subansiri River), but are yet to take over formally these four sites. It is desired that NHPC may take over all the six sites lock, stock and barrel. For this purpose, it is proposed that a Joint Committee consisting of technical, administrative and finance personnel from Brahmaputra Board and NHPC may be formed immediately to frame the modalities for effecting the transfer. The Joint Committee will also inter alia work out the expenditure incurred in creating the physical assets in connection with the investigation of projects at all the six sites which will be reimbursed by NHPC to the Brahmaputra Board. Chairman NHPC is requested to meet Chairman, Brahmaputra Board immediately to chalk out future course of action in the matter.

K.R. Joshi
(K.R. Joshi)

Sr. Joint Commissioner (R)
22-3-2000

1. Secretary (Power), Ministry of Power, Shram Shakti Bhawan, New Delhi
2. Chairman, Central Water Commission, Sewa Bhawan, R.K. Puram, New Delhi
3. Chairman, Brahmaputra Board and Addl. Secretary (WR), Min. of Water Resources, Shram Shakti Bhawan, New Delhi
4. Shri J. Vasudevan, Addl. Secretary (Power), Min. of Power, Shram Shakti Bhawan, New Delhi.
5. Member (D&R), CWC, Sewa Bhawan, R.K. Puram, New Delhi.
6. Chairman, NHPC, Office Complex, Sector 33, Faridabad, Haryana.
7. Shri Jarnail Singh, Joint Secretary to Prime Minister, PMO, New Delhi - w.r.t. int. UO letter No.18/17/99-NESC dated 11-3-2000
8. General Manager, Brahmaputra Board, Basistha, Guwahati.
9. Chief Engineer (E&NE), CWC Room No.901 (N), Sewa Bhawan, R.K. Puram, New Delhi.
10. Shri Sailesh, Dy. Secretary (Power), Ministry of Power, 4th Floor, Shram Shakti Bhawan, New Delhi-110001.

Copy for information to:

PS to Secy.(WR)/PS to AS(WR), M/o Water Resources, Shram Shakti Bhawan, New Delhi.

No. 16/23/99-DO(NHPC)
Government of India
Ministry of Power

Shram Shakti Bhawan, Rafi Marg, ...
New Delhi, the 1st May, 2000.

The Chairman & Managing Director,
National Hydro-electric Power Corporation,
Sector - 33, Faridabad.

Sub: Order of the Government Under Section 18-A of the Electricity
(Supply) Act 1948.

Sir,

I am directed to inform you that in pursuance of Section 18-A of the Electricity
(Supply) Act, 1948, the Government of India require National Hydroelectric Power
Corporation (NHPC) to establish, Operate and maintain the following schemes:

Investigation and implementation of Dehang (13,400 MW) and Subansiri
(7,300 MW) Hydro-electric Projects in Arunachal Pradesh.

Yours faithfully,


(Ajay Shankar)
Joint Secretary to the Govt. of India.
Tele: 3715378

No.16/23/99-DO(NHPC)
Government of India
Ministry of Power

New Delhi, the 10th October, 2002.

To

The Chairman & Managing Director,
National Hydro-electric Power Corporation,
Sector-33, Faridabad-121003.

Subject:- Revised Notification under Section 18(A) of Electricity (Supply) Act, 1948.

Sir,

I am directed to refer this Ministry's letter of even number dated 1.5.2000 regarding issuance of notification under Section 18 (A) of the Electricity (Supply) Act, 1948, in respect of Dehang (13,400 MW) and Subansiri (7300 MW).

In pursuance to partial modification of the notification referred above, I am directed to convey the approval of the Government of India in respect of the Subansiri HE Project as under :

The Government of India require National Hydroelectric Power Corporation (NHPC) to establish, operate and maintain the Subansiri Lower HE Project (2000 MW) in Arunachal Pradesh and Assam.

Yours faithfully,



(Anil Razdan)

Joint Secretary to the Govt. of India

☎ 3714009



अरुणाचल प्रदेश ARUNACHAL PRADESH

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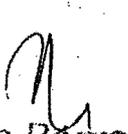
Memorandum of Agreement between
Government of Arunachal Pradesh
And
NHPC Ltd.

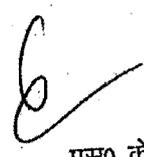
For execution of Subansiri Lower Hydro Electric Project (2000 MW)
on Subansiri River in Arunachal Pradesh.

This agreement is made on this ...~~2~~7th day of January, 2010 between the Governor of Arunachal Pradesh, represented by the Secretary (Power), Government of Arunachal Pradesh (hereinafter referred to as GoAP) which expression shall, unless repugnant to the context or meaning thereof, include its successors and assign(s), on **ONE PART**.

AND

The NHPC Ltd. a Corporation incorporated under the Companies Act, 1956, and also a generating Corporation within the meaning of the Electricity Act 2003,


Tunka Bagra
Secretary (Power)
Govt. of Arunachal Pradesh
Manager - 791117


एस० के० गर्ग / S. K. GARG
अध्यक्ष व
Chairman & Managing Director
एन एच पी सी लिमिटेड
NHPC Limited

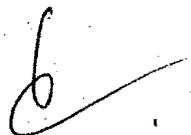
having its registered office at NHPC Office Complex, Sector-33, Faridabad – 121 003 (Haryana) through its Chairman & Managing Director, NHPC Ltd. (hereinafter referred to as Corporation) which expression shall, unless repugnant to the context or meaning thereof, include its successor(s), administrator(s) and permitted assign(s), on the **SECOND PART**.

"GoAP" and " NHPC Ltd." shall be individually referred to as "Party" and collectively as "Parties".

WHEREAS

1. GoAP has earmarked certain Projects for allocation to private developers, Central Sector developers, State Sector developers for the development of Hydro Power Projects in the State, which will generate economic activity in the State leading to its growth and will also serve as an engine to achieve the objective of promoting all round development in the State and the Country ; and
2. The Subansiri Lower Hydroelectric Project (2000 MW) on Subansiri river in Lower Subansiri District of the State of Arunachal Pradesh with an installed capacity of 2000 MW has been taken up for implementation by NHPC Ltd.
3. The Govt. of Arunachal Pradesh has agreed for execution of the Subansiri Lower Hydroelectric Project (2000 MW) in the state by the Corporation.

NOW, THEREFORE, AND IN CONSIDERATION OF PREMISES AND MUTUAL CONVENANTS AS SET FORTH HEREIN, THE PARTIES HEREBY IRREVOCABLY AGREE AS FOLLOWS:



एसो को गर्ग / S. K. GARG
अध्यक्ष व प्रबंध निदेशक
Chairman & Managing Director
एन. एच. पी. सी. लि.
New Delhi



Tumke Bagra
Secretary (Power)
Govt. of Arunachal Pradesh
Itanagar - 791111

Article 1

INTERPRETATIONS AND DEFINITIONS.

1. INTERPRETATIONS

- 1.1.1 The nomenclature of this Agreement, headings and paragraph numbers are only for the convenience of reference and shall be ignored in construing or interpreting this Agreement.
- 1.1.2 Reference to persons and words denoting natural persons shall include bodies, corporate, partnerships, joint ventures, statutory and other authorities and entities ("Persons").
- 1.1.3 Reference to any enactment, ordinance or regulation or any provision thereof shall include any amendment thereof or any replacement in whole or in part.
- 1.1.4 Reference to Recitals, Articles, Clauses, or Sub-clauses shall unless the context otherwise requires, be deemed to include the Recitals, Articles, clauses, or Sub-clauses of this Agreement.
- 1.1.5 The words importing singulars shall include plurals and vice-versa, as the case may be.
- 1.1.6 Terms beginning with capital letters and defined as per Clause 1.2 of this Agreement shall have the same meaning ascribed thereto, and any terms not defined in the Agreement would have the same definitions as available in the Electricity Act, 2003 ("The Act").
- 1.1.7 Any reference at any time to any agreement, deed, instrument license or document of any description shall be construed as reference to that agreement, deed, instrument, license or other document as amended, varied, supplemented, modified or suspended at the time of such reference provided that this Clause



Tumke Bagra
Secretary (Power)
Govt. of Arunachal Pradesh
Itanagar - 791111



एस० के० गर्ग / S. K. GARG
अध्यक्ष व प्रबन्ध निदेशक
Chairman & Managing Director
एन एच पी सी लिमिटेड of 22
NHPC Limited

shall not operate to increase liability or obligations of any Party hereunder or pursuant hereto in any manner whatsoever.

1.1.8 Any agreement, consent, approval, authorization, notice, communication, information or report required under or pursuant to this Agreement from or by any Party shall be valid and effectual only if it is in writing and under the hands of duly authorized representatives of such Party in this behalf and not otherwise.

1.1.9 Any reference to any period commencing 'from' a specified day or date and "till" or "until" a specified day or date shall include both such days or dates.

1.2. DEFINITIONS.

In this Agreement the following words and expressions and unless repugnant to the context or meaning thereof, shall have the meanings hereinafter respectively assigned to them:

1.2.1 **"Agent"** means the authorized representative or such other Authority as may be appointed by the State Government for the purpose of this Agreement.

1.2.2 **"Agreement"** means this agreement together with any amendments made thereto in accordance with the provisions herein contained;

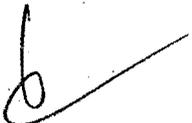
1.2.3 **"Agreement period"** shall have the meaning as specified in Article 3;

1.2.4 **"Central Govt."** means the Government of India;

1.2.5 **"CEA"** means the Central Electricity Authority constituted under Section 3 of the Electricity (Supply) Act, 1948 and which has been defined to be Central Electricity Authority under section 70 (2) of Electricity Act, 2003 or its successors, administrators or assignees ;

1.2.6 **"Commercial Operation"** means the state of Unit/Project when Unit/Project is capable of delivering Active power and Reactive Power on a regular basis after


Tumke Bagra
Secretary (Power)
Govt. of Jharkhand Pradesh
Patna - 800011


एसो केो गर्ग / S. K. GARG
अध्यक्ष व प्रबन्ध निदेशक
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having successfully completed the commissioning tests as per Prudent Utility Practices.

1.2.7. **"Commercial Operation Date (COD)"** means the date on which the commercial operation of Unit (s)/Project as the case may be, is achieved by the Corporation.

1.2.8 **"Corporation"** will mean NHPC Ltd. and having its Corporate office at Faridabad.

1.2.9 **"Detailed Project Report (DPR)"** means the Detailed Project Report pertaining to the project.

1.2.10 **"Dispute"** shall have the meaning as specified in Article 11;

1.2.11 **"Evacuation System"** means the network of power transmission lines and substations for transmitting the electrical output from the Interconnection Point upto main load centre(s);

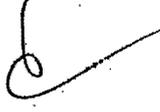
1.2.12 **"Financial closure"** means the date on which the Financing Agreements have been duly executed and the Corporation has access to such funding under the Financing Agreements;

1.2.13 **"Financing Agreement"** means the loan agreements, notes, indentures, security agreements, letters of credit, equity arrangements and other documents relating to the financing(including refinancing) of the project and the capital cost or any part thereof, as amended, supplemented or modified from time to time and approved by the competent authority;

1.2.14 **"Force Majeure"** shall have the meaning as ascribed thereto in Article 10;

1.2.15 **"GOI"** means the Government of India;


Tumke Bagra
Secretary (Power)
Govt. of Arunachal Pradesh
Itanagar - 791111


एस० के० गर्ग / S. K. GARG
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Chairman & Managing Director
एन.एच.पी.
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- 1.2.16 **"Interconnection Facilities"** means all the facilities which shall include without limitation, switching equipment, communication, protection, control and metering devices etc. at the Interconnection Point(s) in the switchyard of the generating stations to be installed and maintained at the cost of the Corporation to enable evacuation of Power output from the Project in accordance with this Agreement;
- 1.2.17 **"Law"** means any act, rule, regulation, notification, order or instruction having the force of Law enacted or issued by any competent legislature, Government or statutory authority in India and pronouncement of judicial /quasi judicial authorities;
- 1.2.18 **"Month"** means the English Calendar month;
- 1.2.19 **"Parties"** mean the State Government and the Corporation collectively;
- 1.2.20 **"Party"** means the State Government and / or the Corporation individually;
- 1.2.21 **"Power Purchase Agreement (PPA)"** means a contractual agreement to be signed by the Corporation with an electricity consumer, trader or any other parties permitted under the statute to purchase the power generated from the project;
- 1.2.22 **"PFR"** means the pre feasibility report pertaining to the project under this Agreement;
- 1.2.23 **"Project"** means the Subansiri Lower Hydro Electric Project (2000 MW) being established on Subansiri river in the Lower Subansiri District of Arunachal Pradesh with MWL at EL 208.25 M & TWL at EL 109.50 M including complete hydroelectric power generating facility covering all components such as dam, intake works, water conductor system, power station, generating units, project roads, bridges, offices, residential facilities, store, guest houses, security office and other connected facilities including the Interconnection Facilities;

1.2.24 "**Prudent Utility Practices**" means those practices, methods, techniques and standards that are generally accepted internationally from time to time by electric utilities for the purpose of ensuring safe, efficient and economic design, engineering, construction, commissioning, testing, operation and maintenance of various component of the project of the type specified in this Agreement and which practices, methods and standards shall be adjusted as necessary to take account of

- I. Installation, operation and maintenance guidelines recommended by the manufacturers of the plant and equipments to be incorporated in the project.
- II. The requirement of Indian Law.
- III. Physical conditions at the site.
- IV. Practices, methods, techniques and standards as changed from time to time that are generally accepted internationally for use in electric utility and for power generation in India.

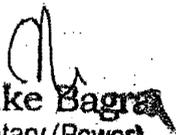
1.2.25 "**Site**" means the site of the project appurtenances, generating plant including land, waterways, roads and rights acquired or to be acquired by the Corporation for the purposes of the project.

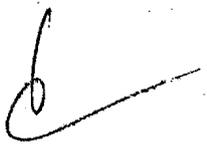
1.2.26 "**State**" means the State of Arunachal Pradesh.

1.2.27 "**State Government**" means the Govt. of Arunachal Pradesh;

1.2.28 "**Unit**" means one /more hydro generator (s) including ancillary equipment and facilities thereto forming the part of the project;

1.2.29 "**Year**" means the English Calendar year comprising of 365 days in a non-leap year and 366 days in a leap year.


Tumke Bagra
Secretary (Power)
of Arunachal Pradesh
791111


एस.के. गार्ग / S. K. GARG
अध्यक्ष व प्रबन्ध निदेशक
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पी.सी. लिमिटेड
NHPC Limited

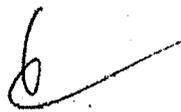
Article 2

GENERAL TERMS AND CONDITIONS OF THE AGREEMENT.

- 2.1 The GoAP hereby grants permission to the Corporation for development, commissioning, implementation, operation and maintenance of **Subansiri Lower HEP (2000 MW)** in Lower Subansiri Distt., Arunachal Pradesh.
- 2.2 The project shall be implemented by the Corporation on ownership basis.
- 2.3 The entire cost of investigation, DPR preparation, project implementation and subsequent operation and maintenance of the project will be borne by the Corporation.
- 2.4 The project shall be developed as a run-off the river / Storage Scheme in tune with the GoAP policy to develop the project in the most environment, eco, and people friendly manner.
- 2.5 The Corporation shall submit the DPR to the GoAP.
- 2.6 All clearances required from the Central Govt. in connection with the project implementation shall be arranged by the Corporation itself. The GoAP shall accord necessary clearances under its purview within a reasonable period. The GoAP shall extend all need based assistance in obtaining such clearances including licenses, approvals, sanctions, permits etc. as may be required for the project.
- 2.7 The Corporation shall be responsible for upkeep of the ecology of the project area and its surroundings by preventing deforestation, water pollution and defacement of natural landscape. The Corporation shall take all reasonable measures to prevent any destruction of flora and fauna, scarring or defacement of the natural surroundings within and in the vicinity of the project sites. The Corporation shall abide by the conditions laid down in the forest, wildlife and environmental clearances accorded by the competent authority.
- 2.8 The Corporation shall make available information regarding water discharge regularly to the GoAP



Tumke Bagra
Secretary (Power)
Govt. of Arunachal Pradesh
Phone: 791111



एसो के गर्ग / S. K. GARG
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एन एच पी लिमिटेड
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- 2.9 The GoAP or its agents or a person authorized by the GoAP in that behalf shall be free to investigate, survey and implement other projects of any nature either upstream or downstream, as the case may be, of the project provided that it shall not have any adverse impact on implementation, operation and maintenance of the Project.
- 2.10 The Corporation shall allow the officers/staffs or authorized agents of GoAP to use the roads and facility such as Post Office, School and Dispensary etc., that may be provided by the Corporation as a part of the project. The GoAP and its authorized agent shall be allowed to inspect the project and its site(s) upon advance notice.
- 2.11 The Corporation shall not incur any kind of financial liabilities in the name of the GoAP, in the execution and subsequent operation and maintenance of the project.
- 2.12 The Corporation will not be allowed to sell and transfer the power plant to any other party/parties without the prior permission of the GoAP. However, the Corporation shall be allowed to mortgage / hypothecate the power plant to the Lenders for availing financial assistance to meet the cost of the project with intimation to the GoAP. Further, the Corporation shall not be permitted to transfer the project under this agreement to any third party without the consent of the GoAP.
- 2.13 The Corporation shall make available to the GoAP for its use free of cost, 2(two) additional bays of 132KV rating.
- 2.14 The Corporation shall ensure that the execution, operation and maintenance of the project is in conformity with Prudent Utility Practices and the manufacturer's specifications.
- 2.15 The Corporation shall ensure proper quality control and safety measures during implementation of the project including any geological study, construction and testing at sites. The GoAP shall have the right to institute an appropriate mechanism to ensure the compliance by the Corporation in this regard.

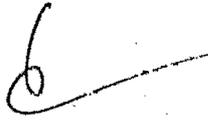

Tumke Bagra
Secretary (Power)
Dept. of Arunachal Pradesh
Itanagar - 791111


एस.के. गार्ग / S. K. GARG
अध्यक्ष व प्रबन्ध निदेशक
Chairman & Managing Director
एन.एच.पी.सी. लिमिटेड
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- 2.16 The Corporation shall make suitable financial provision in the project cost, if required, for the Catchment Area Treatment Plan in consultation with the State Forest & Environment and Wildlife Management Department as approved by the Ministry of Environment & Forests, Govt. of India. The cost involved on this account shall be paid by the Corporation to the concerned authorities of the Govt.
- 2.17 The Corporation has carried out Environmental Impact Assessment (EIA) in association with the State Environment & Forest Department and Wildlife Department as required under the Environment (Protection) Act, 1986 through consultant(s) drawn from a reputed organization and has obtained the consent of State Pollution Control Board.
- 2.18 The Corporation shall ensure such minimum flow of water immediately downstream of the dam/barrage for downstream requirements as shall be specified in the environmental clearance. The Corporation shall take appropriate steps as may be required for the protection of fish culture as per environmental requirement.
- 2.19 The Corporation shall ensure that the water requirement for the construction of the project including potable drinking water shall be generally arranged and harnessed by them from the river source. The local sources of water supply may be utilized by the Corporation only to the extent it does not adversely affect the local people.
- 2.20 The Corporation shall ensure that the materials excavated from the site shall be dumped in the area duly approved by the State Pollution Control Board.
- 2.21 The Corporation shall ensure that the taxes as per law are deducted at source from the payments made to the contractors and deposit the same to GoAP / other statutory authorities.
- 2.22 The Corporation shall be totally responsible for all related issues including safety aspect for implementation of the project.


Tunko Bagra
Secretary (Power)
Govt. of Arunachal Pradesh
Itanagar - 791111


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एन.एच.पी.सी. लिमिटेड
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- 2.23 The ownership of the Project shall vest with Corporation. However, it would be the prerogative of the Corporation to execute the Project Independently or through Joint Venture participation with any parties.
- 2.24 The Corporation shall be liable and responsible for complying with all the environmental obligations and conditions.
- 2.25 Any and all correspondence/ demands made or notice to be sent or required to be made under this Agreement shall be in writing in English language, signed by the Party giving such notice (Claim or demand) and shall be delivered personally or by any feasible mode or transmission coupled with sending original or registered post or E-mail to other parties at their addresses set forth herein below or at such other addresses as either party may subsequently notify.
- 2.26 The Power generated in the Plant after allowing free power to home state as aforesaid shall be allocated to the other States in the region etc. as per the existing policies of Central Govt. in this regard.
- 2.27 The Corporation shall be responsible for liaising with Power Grid Corporations of India Ltd. (PGCIL) or any other Central Transmission Utility and State Transmission Utility (STU) that may come up subsequently for developing evacuation system for the Project and for timely evacuation of the power from the generating point.
- 2.28 The inspection and approval of the works and electric accidents will be as per the provisions of the Electricity Act, 2003 read with the latest amendments and rules framed there under.
- 2.29 The locally produced / manufactured materials including steel (except the bulk requirement etc.) available in the State, fulfilling all technical specifications as may be required by the construction agency, should be given preference in case the price of such material is competitive.
- 2.30 The Office of Executive Director of Subansiri Lower HE Project (2000 MW) shall be located inside Arunachal Pradesh and all the business activities of the Project at the Project level shall be transacted from Headquarters in


Sumke Bagra
Secretary (Power)
Government of Arunachal Pradesh
Itanagar - 791111


एन एच पी सी लिमिटेड / S. K. GARG
अध्यक्ष व प्रबंध निदेशक
Chairman & Managing Director
एन एच पी सी लिमिटेड
NHPC Limited

Arunachal Pradesh except those activities which are dealt with by Corporate Office.

Article 3

LAND ACQUISITION AND PERIOD OF AGREEMENT / LEASE

- 3.1 The Site required for the construction, operation and maintenance of the project and for the associated works as will be assessed by the Corporation shall be transferred by the GoAP to the Corporation on lease basis for a lease period of 99 (Ninety Nine) years against payment of land revenue as per approved rate of GoAP. The GoAP shall acquire for the Corporation under the Land Acquisition Act, 1894 as in force and as per Bengal Eastern Frontier Regulation, 1873 (5 of 1873) at the expense of the Corporation such private lands within the State of Arunachal Pradesh, as may be required from time to time by the Corporation for the construction, operation and maintenance of the project.
- 3.2 The Corporation shall ensure that the land is used only for the project and activities ancillary to the project.

Article 4

ADHERENCE TO REGULATIONS OF THE CENTRAL & GoAP

- 4.1 The Corporation shall strictly comply with the following statutory regulations of the Central Govt. and the GoAP while implementing the project.
- 4.1.1 The Corporation shall strictly comply with the provision of the Forest (Conservation) Act, 1980. The Corporation shall also pay the cost of raising the Compensatory Afforestation including payment of the Net Present Value (NPV) of the forest land being diverted for non-forest purpose under the Forest (Conservation) Act, 1980. The Corporation shall also pay the royalty on the forest produces such as timber, ballies, and all river bed materials etc. as applicable to Central / State Govt. Departments as per prescribed rates of the GoAP in force from time to time. If any precious and semi-precious minerals/stone etc. is found from the river beds and/or from the land acquired


Turnke Bagra
Secretary (Power)
Govt. of Arunachal Pradesh
Itanagar - 791111


एस.के.गर्ग / S. K. GARG
समया व प्रवच निदेशक
Chairman & Managing Director
एन एच पी सी लिमिटेड
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for and transferred to or leased out to the Corporation for the purpose of construction and maintenance of the project or in case any object of archaeological importance is found by the Corporation or any of its employees / contractors/sub-contractors during the course of construction/operation of the project, the Corporation shall hand over the same to the Govt. of Arunachal Pradesh.

- 4.1.2 The provision relating to labour welfare existing as in force under the labour Laws/Acts shall be strictly adhered to by the Corporation during the implementation/operation and maintenance of the project.
- 4.1.3 The provisions of the Electricity Act, 2003 will be diligently adhered to during implementation and subsequent operation and maintenance of Hydro-electric station.
- 4.2 The fishing, recreational and navigational rights, tourism prospects in the river, water channel, reservoir, lake etc. shall remain vested in the Govt. of Arunachal Pradesh subject only to such restrictions as may be necessary for the operational requirements and safety and security of the project and the general guidelines of the Govt. of Arunachal Pradesh.
- 4.3 The Corporation shall comply with the Hydro Electric Power Policy of the Central / State Govt. as would be in force at the relevant point of time, during the course of implementation and subsequent operation and maintenance of the hydel station.

Article 5

FREE POWER TO THE STATE, EVACUATION & TRADING OF POWER

- 5.1 From the Commercial Operation Date (COD), the GoAP shall be given 12 % free power in lieu of the distress caused. The free power shall be calculated at the bus bar located in switchyard of the project.
- 5.2 The GoAP shall not be responsible for developing evacuation system for the project and the Corporation shall liaise with the appropriate authorities for the evacuation of the power from the generating point. However, in the event of

te Bagra
ary (Power)
nachal Pradesh
ar - 791111

एस.के. गार्ग / S. K. GARG
अध्यक्ष व प्रबन्ध निदेशक
Chairman & Managing Director
एन एच पी सी लिमिटेड
NHPC Limited

utilizing the infrastructure of the GoAP, necessary charges as mutually agreed shall be paid to the GoAP. The entire cost of grid interfacing, if so required, including cost of maintenance of the evacuation system will be the responsibility of the Corporation. However, in case the power generated from the project is purchased by the GoAP, the GoAP shall be responsible for evacuation of power from the bus bar onwards at its own cost.

- 5.3 The Corporation shall allow the GoAP to use its evacuation system and other infrastructures to the extent feasible, after accounting for the Corporation's requirements for evacuation of power generated from the project(s), if required by the GoAP on payment of necessary charges by the GoAP. Such charges shall be mutually decided subsequently and a separate agreement entered into.
- 5.4 It shall be the responsibility of the Corporation for the trading and sale of the power generated from the project. The GoAP will not be in any manner responsible for the sale and trading of the power on behalf of the Corporation.

Article 6

RECRUITMENT OF PROJECT PERSONNEL / AWARD OF WORK

- 6.1 Recruitment against the project in Group "C" & "D" posts and also skilled / semi skilled posts shall be made 100% from the State by the Corporation. In the event of non availability of suitable candidates meeting the prescribed qualification and registered with the local employment exchange, the posts shall be filled up from other suitable candidates during construction in consultation with the GoAP. Recruitment process in those categories of the posts shall be conducted within the State of Arunachal Pradesh. Placement and posting of all new recruits will be done against the project in the State.
- 6.2 In regards to the recruitment in the categories of Group "A" & "B" newly sanctioned posts, the same shall be made generally as per the Govt. of India guidelines issued from time to time. The reservation policy of the appropriate



Sumke Bagra
Secretary (Power)
of Arunachal Pradesh
Itanagar - 791111

एसके गोर्ग / S. K. GARG
अध्यक्ष व प्रबन्ध निदेशक
Chairman & Managing Director
एन एच पी सी लिमिटेड
NHPC Limited

Govt. in regard to recruitment rules for such "A" and "B" posts shall also be followed by the Corporation. Further, the posting of all new recruits against the project will be subject to the existing norms of the Corporation. The Corporation shall intimate creation of all the new posts against the project to the GoAP.

- 6.3 The Corporation shall reserve 25% of the executive (technical & non technical) posts, at all levels so as to utilise the services of suitable qualified engineers / officers having requisite experience, length of service and qualification from the GoAP on deputation basis. If suitable candidates from the State are not available, then the Corporation shall be free to fill posts from other candidates in consultation with the GoAP. The services of the officers on deputation shall be exclusively utilised against the activities of Lower Subansiri HEP. The deputation terms applicable shall be as per the Govt. of India rules in force and as amended from time to time. The deputation of the officers shall be within the sanctioned posts against the project. The analogous posts of the GoAP vis-à-vis Corporation shall be as follows:

(a) Chief Engineer	-	General Manager
(b) Superintending Engineer	-	Senior Manager
(c) Executive Engineer	-	Manager
(d) Assistant Engineer	-	Assistant/Deputy Manager

- 6.4 The Corporation shall give preference to the local contractors fulfilling the eligibility criteria in the award of the work except for the specialized jobs.
- 6.5 The project affected eligible candidates shall be given preference over others against the above mentioned reservation in various categories of posts/jobs.

Article 7

REHABILITATION & RESETTLEMENT OF PROJECT AFFECTED FAMILIES

- 7.1 The Corporation shall earmark a reasonable amount for the social works in accordance with Corporation's Policy on C.S.R.(Corporate Social Responsibility)


Imke Bagra
Secretary (Power)
of Arunachal Pradesh
Dispur - 791111


एस.के. गार्ग / S. K. GARG
अध्यक्ष व प्रबन्ध निदेशक
Chairman & Managing Director
एन.एच.पी. लिमिटेड
NHPCL Limited

and the National Policy on Rehabilitation & Resettlement in force. The Corporation shall also adhere/conform to the local laws of the State.

- 7.2 Rehabilitation & Resettlement plan if any, of the oustees from the project/project affected families shall be executed by the State Government as per the approved Rehabilitation and Resettlement Plan at the cost of the Corporation, keeping in view the latest guidelines issued by Govt. of India on the subject. The R&R Plan shall in any case be not inferior to the National Policy on Rehabilitation & Resettlement of the Central Govt. in force.
- 7.3 It will also be mandatory for the Corporation to follow the provisions of the Rehabilitation and Resettlement Policy, of Government of Arunachal Pradesh scrupulously.
- 7.4 In case of any contradiction in National Policy on Rehabilitation & Resettlement of the Central Govt. and from Policy on Rehabilitation and Resettlement of Govt. of Arunachal Pradesh the Policy on Rehabilitation and Resettlement of Govt. of Arunachal Pradesh shall prevail.

Article 8

LAW & ORDER

- 8.1 The State Government would make arrangement to maintain general law and order in and around project area for security and safety of properties of the project, protection of life of the workers and experts/ Engineers/Officers during execution, commissioning and subsequent operation and maintenance. However, if any special security arrangement is required by the Corporation within the project premises, such arrangements shall be made by the GoAP at the cost of the Corporation.

Article 9

INDEMNITY

- 9.1 The Corporation shall be fully responsible for any damage or loss arising out

of the construction, operation or maintenance of the project to any property or person and the Corporation also undertakes to indemnify the Govt. of Arunachal Pradesh on such account.

- 9.2 The widening, strengthening and construction of the National Highways, State Highways and Bridges and other roads, if required by the Corporation, shall be executed by the appropriate GoAP or Central Govt. agency on payment of reasonable cost and departmental charges in advance by the Corporation as per the estimate to be prepared by the executing State / Central Govt. agency. However, if the Corporation so desires to do the above activities at its own cost and if permissible under rule, the Corporation shall be permitted to do so. If any damage to the road and other Govt. and/or public property is done for which only the Corporation is responsible, it shall be got repaired by the Corporation at its own cost.
- 9.3 The Corporation shall be liable and responsible for all its acts, neglects, omissions and commissions and for the neglects, omissions and commissions of its contractors and employees.

Article 10

FORCE MAJEURE

- 10.1 The Force Majeure situation such as earthquake, flood, fire, explosion, epidemic, cyclone, external invasion, civil commotion, riots, landslide etc., which are beyond the reasonable control of the Corporation shall excuse the Corporation from performance of its obligations to the extent prevented, delayed or interfered with for the period of Force Majeure conditions persist. The Corporation shall make its best efforts to remove such causes of Force Majeure as expeditiously as possible and shall continue performance hereunder with due diligence whenever such causes are removed.

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Article 11

RESOLUTION OF DISPUTES & ARBITRATION THEREOF

11.1 In the event of any difference / dispute arising between the Parties, the same shall be resolved in accordance with the provisions of the Arbitration and Conciliation Act, 1996 unless the same has been resolved amicably by mutual consultations within 90(Ninety) days of the reference of dispute by either Party. The venue of the arbitration shall be Itanagar. The language of arbitration shall be English. The cost of arbitration shall be shared equally. In case of any litigation, the Gauhati High Court, Itanagar Permanent Bench shall have the sole jurisdiction.

Article 12

CONFIDENTIALITY

12.1 Each party hereto agrees that it shall not divulge any trade, commercial or technical secrets or confidential matters of one another to any third party, save and except for the purpose of implementation, operation and maintenance of the Project.

Article 13

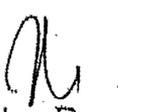
UPFRONT PAYMENT AND OTHER BENEFITS

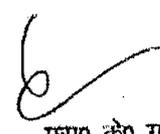
13.1 Subansiri Lower HE Project being under execution since 2003, GoAP agrees to the following conditions in lieu of payment of Upfront premium by the Corporation for the project:-

13.1(a) The Corporation shall contribute a sum of Rs. 17 (seventeen) crores before 31st March, 2010 to GoAP for construction of a Law College at Itanagar.

13.1(b) The Corporation shall contribute a sum of Rs. 10 (ten) crores before 31st March, 2010 to GoAP for construction of a Convention Centre at Itanagar.

13.1(c) The Corporation shall recruit 40 (forty) Indigenous youths in Group 'C' & 'D' posts before 31st May, 2010 as one time relaxation to the recruitment


Anil Bagra
Secretary (Power)
Arunachal Pradesh
Itanagar - 791111


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अध्यक्ष व प्रबन्ध निदेशक
Chairman & Managing Director
एन एच पी सी लिमिटेड
NHPC Limited

policy of the Corporation.

- 13.2 The Corporation shall provide 100 units of electricity per month to each Project Affected Family (PAF) for a period of 10(ten) years through concerned distribution agency from the date of commissioning of the project. In case the Project Affected Family (PAF) consumes less than 100 units/month, the cost of balance unused electricity, if any would be made available to PAF in cash or kind or a combination of both at the rate to be determined by the State Electricity Regulatory Commission.
- 13.3 The Corporation shall bear the State Government's share of 10(ten) % of the project cost of RGGVY (Rajiv Gandhi Grameen Vidyutikaran Yojana) within a radius/surface distance from the Power House/Dam site of 10 km.

Article 14

PROJECT MONITORING COMMITTEE

- 14.1 The GoAP shall constitute a Project Monitoring Committee with the Secretary (Power), GoAP or any other appropriate GoAP authority as the Chairperson for the purpose of overseeing the progress of the project and sort out the difficulties and issues that could arise with respect to implementation of the project. The Corporation shall be represented by a General Manager (Head of Project) of the Corporation. The Corporation shall submit a copy of monthly progress report to the GoAP for their information.

Article 15

OBLIGATIONS OF THE GoAP

The GoAP hereto recognizes that:

- 15.1 Subansiri Lower HEP (2000 MW) being a run-off the river / storage project shall utilize the flowing water of the river to generate electricity. Such right to utilize water available upstream of the project are granted by the GoAP for non consumptive use

Tumke Bagra
Secretary (Power)
Govt. of Arunachal Pradesh
Itanagar - 791111

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NHPC Limited

only without charging any royalty, duty, cess or levy of any kind of such use of water.

15.2 The tariff/or the energy generated at the project during pre-commissioning stage shall be fixed as per the specific guidelines of Govt. of India for such energy for hydro-electric projects.

15.3 The GoAP shall provide assistance, wherever required, to the Corporation to obtain, in accordance with the prevailing Law and regulations, necessary permits to install and use suitable radio communication systems including satellite communication equipment and walkie-talkies. Any system connecting with the national telecommunication system or any international telecommunication system will be subject to approval / license from the relevant authorities for the issuance of which the GoAP shall assist.

15.4 The GoAP shall provide assistance, wherever required, to the Corporation under the law and regulations, to obtain permission to procure, store and use such explosives which are required for the project, provided that the responsibility of obtaining such a clearance and making the necessary arrangements shall rest with the Corporation.

15.5 The GoAP shall provide assistance, wherever required, to the Corporation in obtaining all necessary import licenses for the project from the relevant Central Govt. authorities to the extent permissible by Law. The Corporation shall submit a list of such equipments required to be imported for the project to the GoAP. The GoAP shall provide necessary need based assistance in obtaining the concessions and incentives given by the Central Govt. for setting up of projects in North Eastern States.


Tumke Bagre
Secretary (Power)
Govt. of Arunachal Pradesh
Itanagar - 791111


एसो को गर्ग / S. K. GARG
अध्यक्ष व प्रबन्ध निदेशक
Chairman & Managing Director
एन एच पी सी लिमिटेड
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Article 16

OTHER CONDITIONS

- 16.1 The GoAP can impose an environment cess, according to the Law, which shall not be more than one paisa per unit of electricity sold and shall be collected at the source by the Corporation and deposited with the GoAP. No other taxes/duties/cess will be levied on the sale of electricity by the GoAP.
- 16.2 The GoAP agrees to exempt the Corporation from payment of 0.1% of the Project Cost as Project Monitoring, Evaluation and Coordination (both technical and financial) fee by the Corporation for this Project only.
- 16.3. Save and except as provided aforesaid none of the parties hereto shall assign their respective rights and obligations hereunder without prior consent in writing of the other party hereto.
- 16.4. The Corporation shall be governed and bound by the guidelines as may be notified by the Govt. of India or the GoAP under the relevant Acts from time to time.
- 16.5. The Corporation hereby covenants that on demand from the GoAP, it shall pay the amounts, if any payable hereunder by it to the GoAP failing which the GoAP may recover the same from the Corporation in any legal manner as arrears of land revenue.
- 16.6. The Corporation shall bear the stamp duty on the execution of this agreement.


Tumke Bagta
Secretary (Power)
Govt. of Arunachal Pradesh
Itanagar - 791111


एस० के० गर्ग / S. K. GARG
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NHPC Limited

(iii) The list of projects of less than 25 MW with cumulative installed capacity of 8.7 MW which are recommended is placed at Annexure III.

(iv) Environment flow cannot be computed for Tamen and Tago-I as data are not available. These projects are not allotted to any developer. In view of this, it is recommended that data should be collected during detailed survey and investigation for preparation of DPR and EIA/EEMP stage for both projects. Nevertheless, as per the prevailing norms, it is recommended that Environmental Flow of 20% in lean season, 25% in other 4 months and 30% in monsoon season should be maintained for both the projects.

(v) Oju I and II (700 MW & 1000 MW respectively) have been recommended to be merged as Oju (1878 MW). This will ensure in maintaining 1 Km of river stretch and will also avoid loss of 4.05 sq. km forest.

(vi) Tamnu HEP(55MW) has not been recommended as it doesn't meet the requirement of minimum environment flow. The recommendation to drop Tamnu HEP(55 MW) in Sui tributary of Subansiri basin will keep it free flowing and provide lateral connectivity for aquatic fauna and conserve migratory fish species. Tamnu is recommended to be dropped. The Tamnu HEP shall not be re-allocated by altering their design features, location, names, etc.

(vii) One unit of turbine of Subansiri Lower HEP should continuously run to ensure at least 204 cumec release in Subansiri River downstream for sustenance of aquatic eco system.

(viii) The executive summary of the Basin Study report as well as the addendum received from Consultant in this regard is attached as Annexure IV.

(ix) On the other free stretches of tributaries, no further HEPs should be planned/ allotted in the entire Subansiri basin even if they are of smaller capacity (less than 25 MW) and do not fall under the purview of EIA Notification, 2006.

Yours faithfully,

Bhant / 27/04/16
(Gyanesh Bharti)
Joint Secretary

Copy to:

1. DG(Forest), 4th Floor, Jal Block, Indira Paryavaran Bhawan, New Delhi for information and necessary action with regard to issue of FC in respect of HEPs pending for Subansiri basin Study report.
- 2.
3. Inspector General (FC), 5th Floor, Jal Block, Indira Paryavaran Bhawan, New Delhi for information and necessary action with regard to issue of FC in respect of HEPs pending for Subansiri basin Study report.

Annexure:1

The list of the projects considered in the Basin are as follows:-

Projects above 25 MW			
Sr. No.	Name	Installed Capacity (MW)	Altitude (m)
1.	Oju-I HEP	700*	2275
2.	Oju-II HEP	1000*	1889
3.	Niare HEP	800	1560
4.	Naba HEP	1000	1180
5.	Mili HEP	75	4395
6.	Sape HEP	38	1365
7.	Chom HEP	80	1135
8.	Chela HEP	75	1004
9.	Kurang I & II HEP	330	840
10.	Tanen HEP	175	320
11.	Tago - I HEP	55	1028
12.	Subansiri Lower HEP	2000	241
13.	Subansiri Middle (Kamala HEP)	1728	317
14.	Subansiri Upper HEP	2000	537
15.	Nalo HEP	360	925
16.	Dengser HEP	552	675
17.	Tammu HEP	55	300
18.	Keypin HEP	32	2092
19.	Ilva HEP	41	1514
Project less than 25 MW			
20.	Pango MHP @Hake Turi	2	586
21.	Taksing MHS	0.1	2126
22.	Jette Koro MHS @ Bora Rupok	0.05	933
23.	Japdin Nallah MHS	1	910
24.	Kashi MHS @ Sangram	2	899
25.	Payu MHS @ Koloriang	0.5	1755
26.	Kidding MHS	0.5	673
27.	Payu MHS @ Palin	2	1230
28.	Ture MHP @ Damla	0.05	774
29.	Payu MHS @ Panchi	0.5	1540

Annexure-II

Projects above 25 MW						
Sr. No.	Name	Installed Capacity (MW)	Altitude (m)	Lean Environmental Flow Release(EFR)	Pre-monsoon and Post-monsoon (EFR)	Monsoon (EFR)
1.	Oju-I HEP*	700	2275	20%	20%	20%
2.	Oju-II HEP*	1000	1889	20%	20%	20%
3.	Niare HEP	800	1760	20%	20%	20%
4.	Naba HEP	1000	1180	20%	20%	20%
5.	Mili HEP	75	1395	20%	20%	20%
6.	Sape HEP	38	1365	20%	20%	20%
7.	Chomi HEP	80	1135	20%	20%	20%
8.	Chela HEP	75	1004	20%	20%	20%
9.	Kurang I & II HEP	330	810	20%	20%	20%
10.	Taman HEP***	175	320	20%	25%	30%
11.	Tago-I HEP***	50	1028	20%	25%	30%
12.	Subansiri Lower HEP**	2000	241			
13.	Subansiri Middle (Kamala HEP)	1728	317	20%	20%	20%
14.	Subansiri Upper HEP	2000	537	20%	20%	20%
15.	Nalo HEP	360	625	20%	20%	20%
16.	Dengser HEP	552	695	20%	20%	20%
17.	Tamma HEP****	55	800	30%	55%	60%
18.	Neypin HEP	32	2092	20%	30%	35%
19.	Biya HEP	41	1044	20%	30%	30%

- * Oju-I & II has been merged as Oju HEP with IC of 1878 MW
- ** One unit of turbine should continuously run to ensure at least 200 cumec release in Subansiri River downstream of Subansiri Lower HEP for sustenance of riparian ecosystem
- *** Environmental flow cannot be computed for Taman and Tago-I as data are not available. These projects are not allotted to any developer. In view of this, it is recommended that data should be collected during detailed survey and investigation for preparation of DPR and EIA/EMP stage for both projects. Nevertheless, as per the prevailing norms, it is recommended that Environmental flow of 20% is to be released, 25% in stage 1 month and 30% in monsoon season should be maintained for both the projects.
- **** Tamma HEP is recommended to be dropped

Annexure-III

Project less than 25 MW			
1.	Pange MHP @Hake Tari	2	586
2.	Taksing MHS	0.1	2426
3.	Jette Koro MHS @ Bora Rupok	0.05	933
4.	Jugdin Nallah MHS	1	910
5.	Kush MHS @ Sangram	2	899
6.	Payu MHS @ Koloriang	0.5	1755
7.	Kidding MHS	0.5	673
8.	Pagu MHS @ Pafin	2	1230
9.	Fure MHP @ Damin	0.05	774
10.	Payu MHS @ Panchi	0.5	1540

Annexure-IV

Cumulative Impact and Carrying Capacity Study of Subansiri basin including Downstream Impacts

Executive Summary

River Subansiri (Singit) rises from the Kangig glacier range in Tibet at an elevation of 7090 m (23260 ft) above mean sea level. Total length of River Subansiri upto confluence with Brahmaputra (25 kms downstream of Jornat), Assam is 325 km. The total catchment area up to the confluence with the Brahmaputra is about 37,000 sq. km. out of which 14,000 sq. km. is in Tibet (40%) and the rest (60%) lies in India (21,800 sq. km. in Arunachal Pradesh and 1,200 sq. km. in Assam). Major tributaries of Subansiri are River Kamla and Kutang.

As per Central Electricity Authority (CEA) estimates, the Subansiri basin has 6092 MW hydropower generation potential (60% load factor) with a probable installed capacity of 13767 MW. This potential is planned to be harnessed by setting up about 18 hydropower projects- more than 25 MW- with installed capacity of 11,274 MW. 16 small HEPs (with installed capacity of less than 25 MW each) totaling 35.85 MW are already commissioned in Subansiri Basin. 10 small HEPs (with installed capacity of less than 25 MW each) totaling 8.7 MW are ongoing/new proposals in Subansiri Basin. The total IC of proposed 28 HEPs in Subansiri basin (including more than 25 MW and less than 25 MW HEPs) is 11282.7 MW.

The study titled "Cumulative Impact and Carrying Capacity Study of Subansiri basin including Downstream Impacts" was initiated by Central Water Commission, Ministry of Water Resources and Ganga Rejuvenation with an objective of assessment of the cumulative impacts of hydropower development and to provide optimum support for various natural processes and allowing sustainable activities. The study was assigned to a consortium of Consultants namely IRG Systems South Asia Private Ltd. and EQMS India Private Ltd., New Delhi. The objectives of study are:

- Inventorisation and analysis of the existing resource base
- Determination of regional ecological fragility / sensitivity
- Review of hydropower development plans
- Evaluation of cumulative impacts on various facets of environment due to hydropower development
- Broad framework of environmental action plan to mitigate the adverse impacts on environment in the form of preclusion of an activity, modification in the planned activity and implementation of set of measures for amelioration of adverse impacts.

In Subansiri Basin, as on 2004, out of total assessed potential of 6092 MW at 60% load factor, hydroelectric schemes with potential of 114.6 MW at 60% L.F. (1.86% of the assessed potential) have already been developed. 16 small HEPs (with installed capacity of less than 25 MW each) totaling 35.85 MW are commissioned in Subansiri Basin. 10 small HEPs (with installed capacity of less than 25 MW) totaling 8.7 MW are under consideration in Subansiri Basin. These projects are diversion by trench weir (broad crested) run-off river schemes. No pondage is allowed. Open channel and forebay tank arrangement is proposed. Table 1.1 (a, b & c) describes the current status of the projects in the basin.

1.1. Table 1.1 (a): Name and Number of Hydel Projects and Status of Works and Allotment (more than 25 MW)

Sr. No	Name of the project	Area (Sq.km)	Present IC (MW)	Altitude (metres)	FRL m	Ht. of the dam (m)	Tail Water Level (m)	Present Status	Status of Allotment of Projects
1	Oju-I*	9827	700	227 5	195 0	110	1670	Merged as single Project with IC: of 1878 MW Under S&I ToR approved by MoEF in Feb 2014. EIA/EMP pending	M/s Navyuga Engineering Company Ltd Delhi
2	Oju-II*	9979	1000	188 9	165 0	90	1300		
3	Niara	1118 1	800	166 0	128 0	100	1055	Under S&I ToR applied	M/s Coastal Infrastructure Pvt Ltd, Hyderabad
4	Naba	1127 2	1000	118 0	103 5	110	780	Under S&I ToR issued in July, 2013. EIA/EMP pending	Abir Infrastructure Private Ltd. Delhi
5	Miti		75	439 5	140 0		1200	Information as Per CEA Re-assessment Study. S&I yet to be taken up.	Not Yet allotted
6	Sape		38	136 5	115 5		1080	Information as Per CEA Re-assessment Study. S&I yet to be taken up.	Not Yet allotted

Sr. No	Name of the project	Area (Sq.km)	Present IC (MW)	Altitude (metres)	FRL (m)	Ht. of the dam (m)	Tail Water Level (m)	Present Status	Status of Allotment of Projects
7	Choml	1194	80	1135	1067	-	905	Under S&I	Adveta Power Pvt Ltd.
8	Chela	1430	75	1004	895	-	750	Under S&I	Adveta Power Pvt Ltd
9	Kurang I & II	2302	330	840	745	140	620	PFR Prepared.	North Eastern Electric Power Corporation Limited NEEPCO
10.	Tamen	7595	175	320	320	-	250	Information as Per CEA Re-assessment Study. S&I yet to be taken up.	
11.	Tago - I	-	55	1025	1080	-	790	Information as Per CEA Re-assessment Study S&I yet to be taken up	
12.	Subansi Lower	34900	2000	241	205	116	-	Under Construction	NHPC
13.	Subansi Middle (Kamala HEP)	7213	1728	317	455	275	285.50	DPR under examination in CEA. ToR obtained in Dec 2010. Extension of ToR granted for 4 th year in Feb 2014. Draft EIA.	Jindal Power Limited, Gurgaon

Sr. No	Name of the project	Area (Sq. km)	Present IC (MW)	Altitude (metres)	FRL m	Ht. of the dam (m)	Tail Water Level (m)	Present Status	Status of Allotment of Projects
								EMP under preparation	
14	Subansiri Upper	14605	2000	537	460	236.5 Above DFL	276	Under S&I ToR approved by MoEF in Apr 2011 Validity extended upto 27.04.2015 EIA/EMP pending.	KSK Energy Ventures Pvt. Ltd., Hyderabad.
15	Nalo	-	380	925	765	-	835	Under S&I ToR Obtained on 21/3/12 Applied for revised ToR EIA/EMP pending	M/s Coastal Infrastructure Pvt. Ltd. Hyderabad
16	Dengser	17505	652	675	630	100	490	Under S&I ToR applied	M/s Coastal Infrastructure Pvt. Ltd. Hyderabad
17	Tammu	-	63	300	310	-	220	Information as Per CEA Re-assessment Study S&I yet to be taken up.	Not Yet allotted
18	Nyepin	-	32	209	106	0	920	Information as Per CEA Re-assessment Study	M/s Ngulfa Developments Pvt. Ltd
19	Hiya	-	41	104	880	4	745	Information as Per CEA	M/s Sowbhag

Sr. No	Name of the project	Area (Sq.km)	Present IC (MW)	Altitude (metres) FRL m	Ht. of the dam (m)	Tail Water Level (m)	Present Status	Status of Allocation of Projects
							Re-assessment Study	ya Energy Pvt Ltd

* Oju 1 and Oju 2 have been merged as single scheme "Oju" with total IC of 1678 MW. Hence, a total of 18 HEPs (with IC of more than 25 MW) are located in Subansiri Basin with a total IC of 11274 MW.

1.2. Table 1.1 (b): Small Hydel projects (less than 25 MW) commissioned in Subansiri Basin

Sr. No.	Year of Commissioning	Name of small hydel Projects in Subansiri Basin	Catchment Area (Sq.m)	Present / Proposed IC (MW)	Name of Tributary / Main
1	2004-05	Patte MHS @ Tali	18	0.03	Patte
2	2009-10	Koye MHS	32	0.05	Koye
3	2009-10	Chambang MHS	3	0.03	Chambang
4	2011-12	Paya MHS @ Hiya	18	0.1	Paya
5	1977-78	Ma Ph - I MHS	124	25	Ma Ph
6	1992-93	Ma Ph - II MHS	124	1	Ma Ph
7	1992-93	Tago MHS	189	4.5	Tago
8	1981	Dulom (Dabonjo)	0.6	0.4	Dulom
9	2002-03	Maro MHS	15	0.03	Maro
10	2006-09	Sippi SHP	82	4	Sippi
11	2011-12	Pinto Koro MHS	32	0.03	Pinto
12	2011-12	Sikin Koro MHS	32	0.2	Sikin
13	2011-12	Sinyum Koro MHS	6	0.1	Sinyum
14	2011-12	Kopin Nalah MHS	46	0.1	Kopin
15	2005-06	Ayingmun MHS	22	0.25	Patte
16	2012-13	Limeking MHS	20	0.03	Kotter

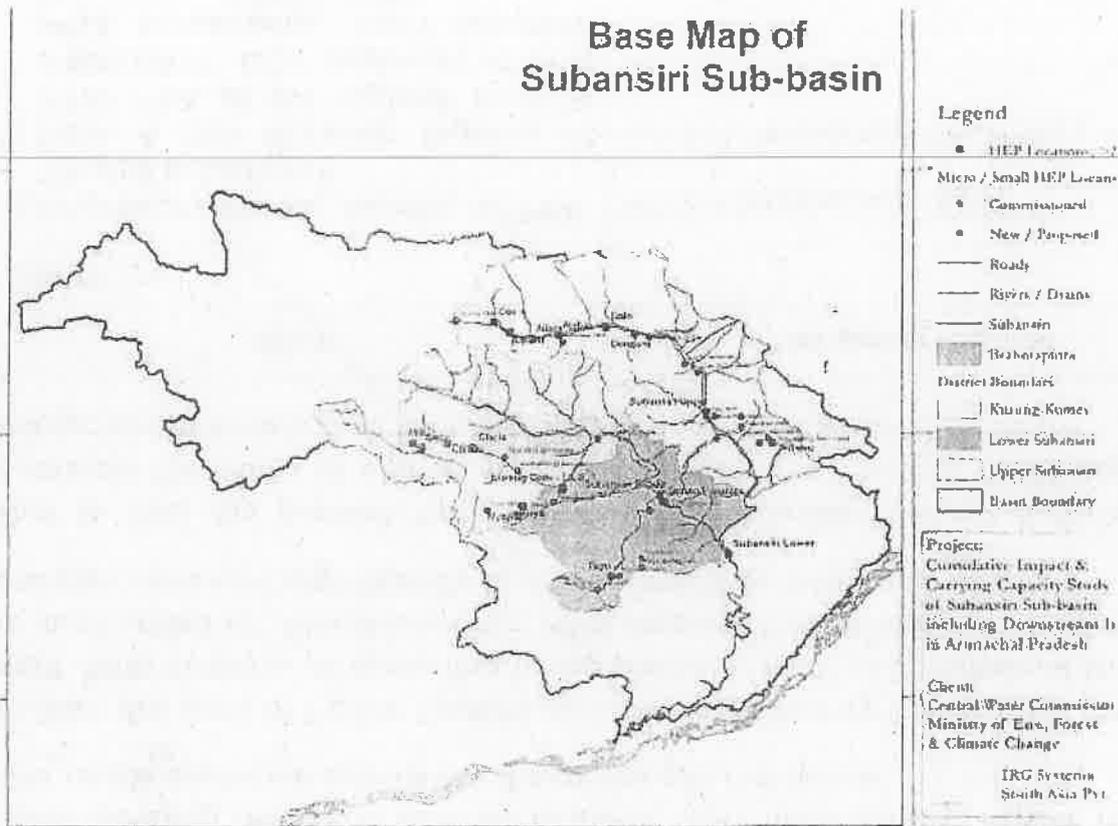
Total IC: 35.84 MW

1.3. Table 1.1 (c): New and ongoing Small Hydel projects (less than 25 MW) in Subansiri Basin

Sr. No.	New/Ongoing	Name of hydel Projects in Subansiri Basin	Catchment Area (Sq.m)	Present / Proposed IC (MW)	Altitude (metres)	Name Tribut / Ma
1	New Proposals	Pango MHP @ Hake Tari	35	2	586	Pan
2	On-Going	Taksing MHS	35	0.1	2426	Esri
3	New Proposals	Jetta Koro MHS @ Bora Rupok	15	0.05	933	Jett
4	New Proposals	Jugdin Nallan MHS	28	1	910	Jugd
5	On-Going	Kush MHS @ Sangram	32	2	899	Kus
6	On-Going	Payu MHS @ Kotonang	18	0.5	1755	Pay
7	On-Going	Kritling MHS	28	0.5	673	Kiddi
8	On-Going	Pagu MHS @ Pahn	32	2	1230	Pag
9	On-Going	Furo MHP @ Damin	18	0.05	774	Fur
10	On-Going	Payu MHS @ Panchi	18	0.5	1540	Pay

Total IC: 8.7 MW

Proposed and existing HEPs (including HEPs less than 25 MW) is given in Figure 1:



1.3.1 Figure 1: Hydroelectric Projects in Subansiri Basin:

As per the objectives, scope of work and Terms of reference, the study described basin characteristics, proposed hydropower development in Subansiri basin, hydrometeorology, terrestrial ecology, aquatic ecology etc. Based on the results of the model the study computed environment flows, assessed downstream impacts due to hydropower development and cumulative impact Assessment. The study recommended following

1. For recommending design and dropping the proposed HEPs, criteria of minimum environment flow, free flowing stretch of 1 km, slope and terrain, avoidance of forest loss and aquatic ecology were adopted.
2. Environmental flow has been estimated by HEC-RAS model to assess flow scenarios and recommend environmental flow for proposed HEPs. The flow scenario of 90% dependable year series of the each hydro electric project has been used and the average discharge of least four months monsoon four months and non lean non monsoon four months have been computed. The flow parameters i.e. water depth, velocity of flow and top flow width has been assessed for 10%, 15%, 20%, 30%, 40%, 50% and 100% release of respective average of the three season's flows of each

hydroelectric project to estimate the environmental flow release during the lean, monsoon and non lean or monsoon periods

- 3 Norm of free flowing stretch of 1 km between FRL and TWL of proposed and slope aspects of proposed. HEPs locations have been considered
- 4 Biodiversity and ecological aspects including aquatic fauna have been considered. Avoidance of forest loss has been considered especially in Upper Subansiri district which shows decline of forest cover as per State of Forest Report 2013. Migratory and threatened fauna including lion and dolphin have been considered for recommending E-flows for their sustenance. Based on the aforesaid methodology and criteria, the consultant recommended following

Redesigned Projects

- 2 projects Oju I and II have been recommended to be merged as Oju (1878 MW). The merger will keep the left bank of main stem of River Subansiri (location of earlier proposed Oju II) forest intact and also avoid loss of 4.05 sq km forest due to earlier proposed development of Oju II HEP.

Dropped Project

- The E flow in Lean Environmental Flow Release (EFR) of Tamnu HEP (55 MW) located at Situ a tributary of Subansiri River is 30%, Pre-monsoon and Post-monsoon EFR 55% and Monsoon EFR is 60%. Tamnu HEP has not been recommended as it doesn't meet the requirement of minimum environment flow.

1 HEP (Tamnu) out of 23 HEPs have been recommended to be dropped and 2 HEPs (Oju I and Oju II) have been recommended to be redesigned as one Oju HEP.

Recommended E-Flow of HEPs in Subansiri Basin:

Lean, Pre-monsoon and Post-monsoon and monsoon Environmental Flow Release is given in Table 2.A and B.

1.4.2 A Environmental flow release and recommendations
Projects in main stem of River Subansiri

SR No.	Name	Lean Environmental Flow Release (EFR)		Pre-monsoon and Post-monsoon Environmental Flow Release (EFR)		Monsoon Environmental Flow Release (EFR)	
		EFR in %	EFR in Cumec	EFR in %	EFR in Cumec	EFR in %	EFR in Cumec
1	Oju-I	20%	10.68	20%	37.51	20%	93.34
2	Oju-II	20%	10.77	20%	38.29	20%	95.27
3	Niare	20%	12.29	20%	43.73	20%	108.80
4	Nalo	20%	13.71	20%	48.75	20%	121.30
5	Dengser	20%	14.34	20%	50.99	20%	126.88
6	Subansiri Upper	20%	17.39	20%	61.85	20%	153.89

For Naba HE Project which lies between Niare and Nalo Environmental flow release should be (20% in lean), (20% in Pre and post monsoon) and (20% in monsoon)
Subansiri lower consist of dam toe power house hence one unit of turbine should continuously run to ensure at least about 240 cumec release in Subansiri River downstream of Subansiri lower HE Project for sustenance of aquatic ecosystem.

	→ Minimum e-Flow
	→ Maximum e-Flow

1.5. 2 B: Environmental flow release and recommendations
Project in tributaries of River Subansiri

Sr. No.	Name	Lean Environmental Flow Release (EFR)		Pre-monsoon and Post-monsoon Environmental Flow Release (EFR)		Monsoon Environmental Flow Release (EFR)	
		EFR in %	EFR in Cumec	EFR in %	EFR in Cumec	EFR in %	EFR in Cumec
1	Subansiri Middle	20%	47.65	20%	110.81	20%	201.98
2	Kurung-I II	20%	19.39	20%	45.09	20%	82.18
3	Mili	20%	4.78	20%	11.11	20%	20.25
4	Sape	20%	6.54	20%	15.21	20%	27.72
5	Chomi	20%	7.89	20%	18.34	20%	33.43
6	Chela	20%	9.55	20%	22.21	20%	40.49
7	Hiya	20%	4.01	30%	13.99	30%	25.50
8	Nyepri	20%	2.10	30%	7.33	35%	15.06
9	Tammu	30%	9.43	55%	40.22	60%	79.97

Note: Environment flow cannot be computed for Tamen and Tago-I as data are not available. These projects are not allotted to any developer. In view of this, it is recommended that data should be collected during detailed survey and investigation for preparation of DPR and EIA/EMP stages for both projects. Nevertheless, as per the prevailing norms, it is recommended that Environmental Flow of 20% in lean season, 25% in other 4 months and 30% in monsoon season should be maintained for both the projects.

→ Minimum e-Flow
→ Maximum e-Flow

Downstream impact:

Due to peaking releases from the HEPs in Subansiri basin, only the net release from the lower most project of the basin i.e. Subansiri Lower HEP will matter. It can be seen in general that peaking release have impact on discharge and water level pattern of Subansiri river up to about 1st 40 km downstream of the Subansiri HEP. After 1st 40 km and up to the Subansiri Brahmaputra confluence, the discharge and water level pattern tends to stabilize and fluctuation

in water level diminishes. In Brahmaputra the impact of peaking release is almost NIL as fluctuation in discharge is only few cumec. The consequent daily fluctuation in water level is at different locations along Brahmaputra is in the range of 0.08 m to 0.78 m.

No. 2/18(A)/2014-EIA
Government of India
Ministry of Environment, Forest & Climate Change
(IA.I Division)

Indira Paryavaran Bhawan
Jor Bagh Road, Aliganj
New Delhi-110003
Date: 27.06.2016

CORRIGENDUM

Sub: Cumulative Impact Assessment & Carrying Capacity Study (CIA &CCS) of Subansiri River Basin in Arunachal Pradesh - Regarding.

This is with reference to letter No. 2/18(A)/2014-EIA dated 27/04/2016 on the subject mentioned above. The corrigendum in this regard is follows:

S.No (vii) One unit of turbine of Subansiri Lower HEP should continuously run to ensure at least 240 cumec release in Subansiri River downstream for sustenance of aquatic ecosystem.

Instead of

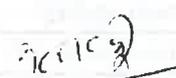
S.No (vii) One unit of turbine of Subansiri Lower HEP should continuously run to ensure at least 204 cumec release in Subansiri River downstream for sustenance of aquatic ecosystem.

Annexure-II ** One unit of turbine should continuously run to ensure at least 240 cumec release in Subansiri River downstream of Subansiri Lower HEP for sustenance of aquatic ecosystem.

Instead of

Annexure-II ** One unit of turbine should continuously run to ensure at least 204 cumec release in Subansiri River downstream of Subansiri Lower HEP for sustenance of aquatic ecosystem.

2.0 This has approval of the Competent Authority.


(Dr. S Kerketta)
Director

Copy to:

- i) The Chief Secretary, Government of Arunachal Pradesh, Itanagar, Arunachal Pradesh-791111.
- ii) The Secretary, Ministry of Power, Government of India
- iii) The Secretary, Ministry of Water Resources, River Development & Ganga Rejuvenation, Government of India.
- iv) DG (Forest), 4th Floor, Jal Block, Indira Paryavaran Bhawan, New Delhi for information please.
- v) IG (Forest), 5th Floor, Jal Block, Indira Paryavaran Bhawan, New Delhi for information please.

No. 11/1/2002-NHPC(Vol-V)

भारत सरकार
Government of India
विद्युत मंत्रालय
Ministry of Power
Hydro Division

Shram Shakti Bhawan, Rafi Marg,
New Delhi, dated the 3rd February, 2026

To

The Chairman and Managing Director
NHPC Limited
Corporate Office, Sector-33
Faridabad

**Subject: Allocation of surrendered share of state of Punjab from Subansiri
Lower HEP of NHPC Ltd – reg.**

Sir,

I am directed to refer to NHPC's letter dated 14.01.2026 and to convey authorization to NHPC Limited to deal with the 64 MW of capacity surrendered by Punjab State Power Corporation Limited (PSPCL).

This issues with the approval of the competent authority.

Yours faithfully,



(Himanshu Lal)

Deputy Director (NHPC)

Tel.: 23324357

Email: nhpc-mop@gov.in

Copy to:

1. Chairperson, Central Electricity Authority, Sewa Bhawan, New Delhi.
2. Member Secretary, North Eastern Regional Power Committee, Shillong.
3. Member Secretary, Northern Regional Power Committee, New Delhi.

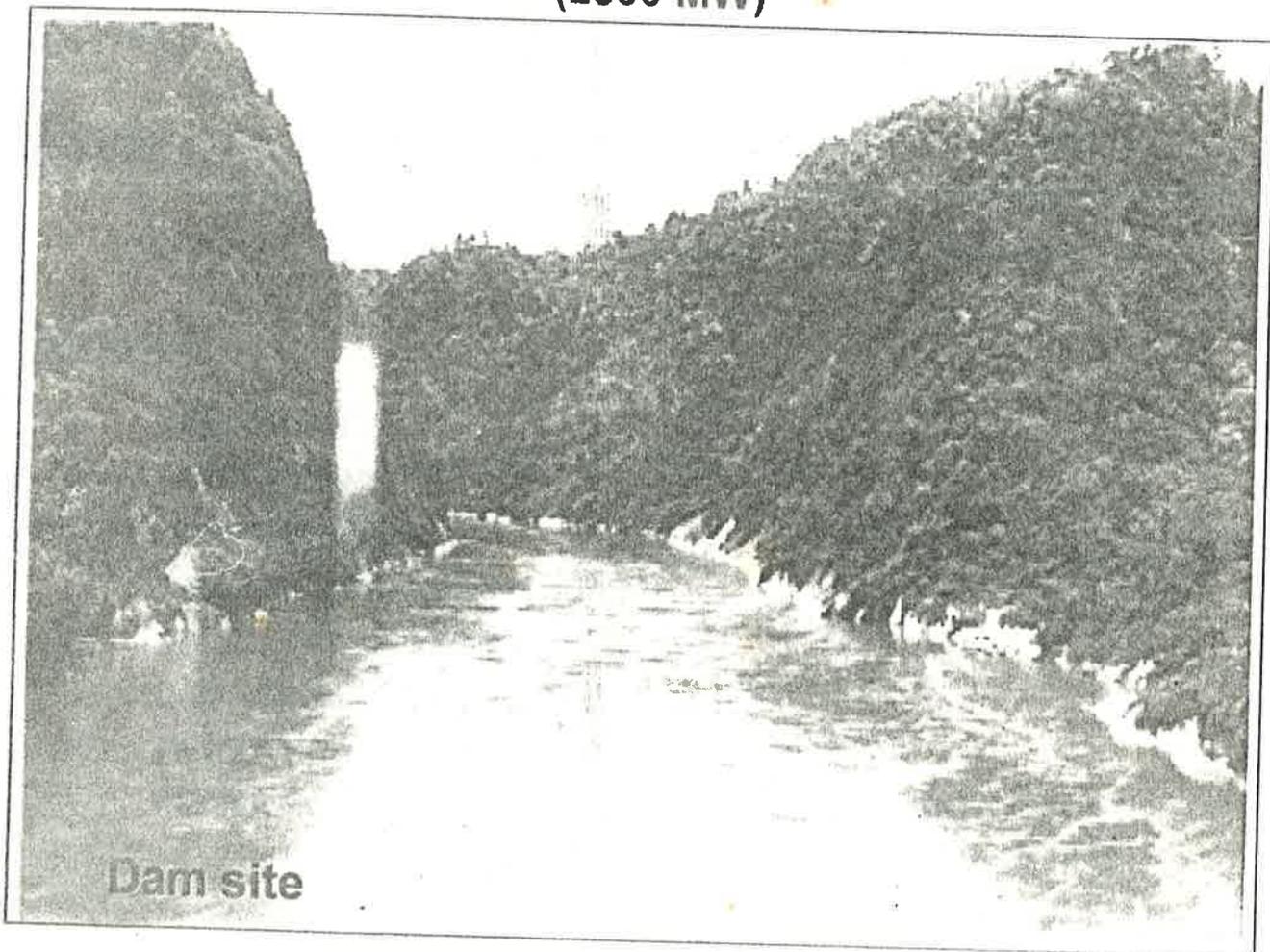
ANNEXURE-IV



NH/SLP/PMG/B31

NATIONAL HYDROELECTRIC POWER CORPORATION LTD.
(A Government of India Enterprise)

SUBANSIRI LOWER HYDROELECTRIC PROJECT
Arunachal Pradesh and Assam
(2000 MW)



EXECUTIVE SUMMARY

North Lakhimpur, Assam

August, 2001

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3. CONCRETE L I M
GENERAL ARRANGEMENT PLAN
4. DAM CROSS SECTION
5. DAM- LONGITUDINAL SECTION
6. POWER HOUSE COMPLEX PLAN AT EL- 96-00
7. POWER HOUSE COMPLEX PLAN CROSS SECTION

CHAPTER 1

PROJECT SUMMARY

1.1 BACKGROUND

The four main tributaries, Siang, Debang, Lohit and Subansiri contribute as much as 60% of the total flow of the entire Brahmaputra river at Guwahati. Of these, the contribution of Subansiri is about 11% and the contribution of Siang is about 33%. With a view to exploit hydro potential and to derive benefits of flood moderation, two large projects were conceived, one in each river basin by Brahmaputra Board. Brahmaputra Board had prepared Detailed Project Reports (DPR) after conducting detailed survey and investigation works of two projects namely Subansiri Dam Project (4800 MW) and Dihang (Siang) Dam Project (20000 MW) in April 1983 and May 1983 respectively. These projects could not be taken up for execution because of objections from Arunachal Pradesh Government on account of large submergence of its land including main towns namely Daporizo in Subansiri basin, Along in Siang basin and consequent displacement of inhabitants.

To avoid the submergence of township, Brahmaputra Board in the 23rd Special adjourned meeting held on 27.7.95 at Guwahati decided to take up investigation of new dam sites (Alternative proposals) in the Subansiri Basin, which are listed below :

A 272 m (revised 213 m) high dam in the u/s of Tamen on river Kamla (a tributary of river Subansiri) with installed capacity of 2000 MW.

A 272 m (revised 265 m) high dam in u/s of Daporizo on river Subansiri with installed capacity of 2500 MW.

A 111 m (revised 116 m) high dam (already investigated for 259 m high dam) in u/s of Gerukamukh on river Subansiri with installed capacity of 2800 MW.

In the above meeting, it was decided to carryout the joint inspection of the new dam sites of Subansiri basin by officers of CWC, GSI, Govt. of Arunachal Pradesh and Brahmaputra Board so as to conduct feasibility investigations of the alternative proposal. The joint inspection was conducted from 20.12.95 to 22.12.95. The joint inspection team found the proposal prima facie feasible and recommended detail investigations for the upstream dams.

Similarly for Siang basin also three dams in place of one high dam in cascade development as per following details were planned:

A 257 m high dam at Pugging on river Siang with installed capacity of 11,000 MW.

A 154 m high dam on river Siyom (a tributary of river Siang) at Mega village with installed capacity of 700 MW.

iii. A 65 m low dam at 29th mile (already investigated for 259 m high dam) on river Siang with installed capacity of 1,700 MW.

Preparation of Detailed Project Report (DPR) on the Subansiri Lower Dam had been taken up by Brahmaputra Board in the year 1998-99. Various agencies viz. Central Water Commission (CWC), Central Soil and Material Research Station (CSMRS), Indian Meteorological Department (IMD), Water and Power Consultancy Services (WAPCOS) & National Productivity Council (NPC) were involved in this job with target date for submission of DPR as March, 2000. Nevertheless DPR could not be submitted and the Ministry of Water Resources transferred Subansiri Lower HE Project alongwith other five projects in Subansiri & Siang Basin

to NHPC vide their letter dated 22.3.2000 and subsequent order of Ministry of Power No. 16/23/99/DO (NHPC) dated 01.05.2000.

PROJECT

1.2.1 General

Subansiri Lower Project is located in both the states of Arunachal Pradesh and Assam. The left bank of dam will be in the state of Assam and the right bank of dam and power house will be in the state of Arunachal Pradesh. The project township at Gerukamukh will be the headquarter of the project and is located on the left bank of river Subansiri in Dhemaji district of Assam. The project is about 471 km from Guwahati, the capital city of Assam and the largest city of northeastern states. The nearest broad gauge railhead is Nagaon while the nearest meter gauge railhead is Gogamukh in District Dhemaji in Assam state. Location of the project is shown in Drg. No. NHSB-1AA2-41-GA-001.

1.2.2 Hydrology

Catchment area of river Subansiri at dam axis is about 34,900 sq. km. The submergence area at FRL is 33.5 Sq. Km. The average annual rainfall at Gerukamukh station is 2356 mm while maximum and minimum temperature is 34.15° and 7.85° respectively. The rainy season in the area is from May to October.

At present there are 23 rain-gauge stations in and around the catchment. The present network density comes out to one rain-gauge for every 1050 Sq Km for the upper catchment and one rain-gauge for every 462.5 Sq Km for the lower catchment

1.2.3 Geology and Seismicity

The project area is occupied by sandstone of Middle Siwalik formation. The sand stone are medium to fine grained having typical salt and pepper texture and are soft in nature. The sand stone is massive and current bedded at places. The sand stone are steeply dipping at 70 to 80 degree in southerly or south easterly direction. Four sets of joints are dissecting the rock mass. Bedding shears are common in the area.

North-Eastern region of India falls in zone V of the seismic zoning map of India and is considered one of the most seismically active region. DEQ, University of Roorkee in its preliminary report on ' Site Specific Earthquake Parameters for Subansiri Lower HE Project ' submitted in March 2001 has recommended adoption of values of 0.38g and 0.19g for MCE and DBE conditions respectively.

1.2.4 Dam

The project envisages utilisation of 90 m of gross head by construction of a 116 m high concrete gravity dam. The length of the dam at top i.e. El 210.0 m is 271.0 m. Out of this 175.5 m length is the spillway and balance 95.5 m is non-overflow section. Spillway for concrete dam is proposed to be designed for a probable maximum flood (PMF) of 37,500 Cumecs. Keeping in view large quantum of silt being carried by river Subansiri, low level orifice type spillway has been proposed. To pass PMF flood 8 bays of spillway opening each of size 11.5 m X 14.7 m with crest at El 150 m has been proposed. Further, one extra bay of spillway of 11.5 m crest has been provided to take care of any irregularity.

1.2.5 WATER CONDUCTOR SYSTEM

The water is lead to head race tunnel through 8 nos. intake structures with invert at El. 160 m. The invert has been kept 10 m above the spillway crest to keep the intake above probable silted bed. An inclined type trash rack structure is proposed at the entrance of the intake structure.

8 numbers 9.5 m diameter horse shoe shaped concrete lined head race tunnels have been proposed. The length of the tunnels varies from 225 m to 390 m.

D/s of the each head race tunnel 8 m diameter steel lined pressure shaft with 68.25 m vertical drop and 29 m horizontal portion at top and 19 m at bottom of the vertical portion has been proposed. The center line elevation of lower horizontal portion has been kept as El 96.0 m i.e. center line of turbine.

The water from turbine shall be discharged back to river through draft tube and tail race tunnel. The overall size of draft tube at exit shall be 12.0 m (W) X 10.0 m(H). For draft tube gate one 2.0 m wide intermediate pier has been provided. As such each unit shall consist of two draft tube opening each of 5.00 m X 10.0 m. The gates have been provided on the upstream face of the surge chamber cum draft tube gate cavern. From downstream face of this cavern horse shoe shaped concrete lined tail race tunnel of 9.5 m diameter takes off. The length of TRT varies from 450 m to 780 m. Suitable outlet arrangement has been proposed at the end of each tail race tunnel.

1.2.6 Power House Complex

One underground power house cavern on right bank has been proposed to house eight units of 250 MW each. Power house cavern shall be 337 m(L) X 24 m(B) X 62.4 m(H) in size. Eight bus shafts, one for each unit, of 6 m X 6 m have been provided connecting the power house cavern to transformer cavern provided on upstream of power house cavern. Further a 8 m X 8 m D-shaped gallery has been provided between power house cavern and transformer cavern to facilitate toeing of transformers between service bay and transformer cavern. In view of large width of power house cavern, MIV has been proposed to be kept in a separate cavern. MIV cavern has been clubbed with transformer cavern provided u/s of power house cavern making it a Transformer cum MIV cavern.

As per the transient studies surge shaft is required for each TRT. Keeping in view the requirement of large size of individual surge shaft a single surge chamber has been proposed to be excavated. However the chamber has been proposed to be divided in eight surge tanks, one for each TRT, by providing reinforced concrete column, beam and wall arrangement. Draft tube gates have been provided on upstream face of the surge chamber.

For arresting seepage water, two drainage galleries have been provided u/s of Transformer cum MIV cavern. The gallery shall be of size 2.5 m X 3 m with invert at El 113.0 m and El 136.0 m.

8 m D-shaped cable cum ventilation tunnel has been proposed to connect the transformer cavern to switchyard. Switchyard has been provided at about 350 m downstream of power house at \pm El 190.0 m.

1.2.7 Power Generation

The power generation and optimisation of the Subansiri Lower project has been made based on the 20 year synthetic flow series on 10 daily basis at Gerukamukh site with the objective of maximising the average yearly energy production and the firm power during the lean season, within the economical limits.

To ensure guaranteed output during any lean period, a live storage of 645 Mcum has been provided. This will also ensure to maintain minimum required storage capacity for peaking in the coming years, even with a certain reduction of live storage due to sedimentation that occurs in the Himalayan rivers even after providing flushing arrangement by means of low level spillway gates.

The average net operating head for the turbine is 86 m and the design discharge is 322.4 cumecs. Computer studies for power output and energy generation on 10 daily basis for the 90% dependable year for installed capacities of 1,200 to 2,500 MW have been carried out.

From these studies it is seen that a minimum continuous generation of 351.17 MW is available during the lean month of March for 90% dependable year. It is also seen that with an installed capacity of 2,000MW, it will always be possible to meet system peak requirement for about 4 to 5 hours in a day in the lean period. In view of above it is proposed to install 2,000 MW at Subansiri Lower HE project.

The total energy generation with an installed capacity of 2,000 MW at the power house bus bar is 7,909.41 GWH and 9,482.46 GWH for the 90% dependable year and the 50% dependable year respectively. However, due to reservoir regulation constraints for flood moderation annual energy

generation would only be 7,551.1 and 358.31 GWH energy would be sacrificed on account of flood moderation requirement of the region.

1.2.8 Cost Estimate and Financial Forecast

The Project is estimated to cost Rs. 7468.91 Crores at March 2001 Price level excluding transmission portion. This includes Rs. 6262.16 Crores as Hard cost comprising of Rs. 4037.32 Crores for Civil Works and Rs. 2224.84 Crores for Electrical and Mechanical works and Soft cost as Rs. 1206.75 Crores as IDC.

The energy output of the Project with an installed capacity of 2000 MW has been estimated at 7551.10 GWh at the 90% dependable year.

The produced energy will be added to the North-Eastern grid and integrated operation studies indicate that the full energy from Subansiri Lower Hydro-electric project will be absorbed from the year 2008-2009 and onwards. It will be available to the beneficiary states to meet out their power deficiencies.

Cost of generation and sale rate of energy at Power house bus bar works out to 1.82 Paise per kWh and 2.61 Paise per kWh respectively for a 90% dependable year at March 2001 Price level.

1.2.9 Construction Schedule

It is expected that after submission of DPR Govt. of India will sanction the project by December 2001. Project has already submitted the proposal for diversion of forest land for the project. The private and Govt. land required for the project are already available with the project. It is expected that all forest land required for construction of the project will be available by

March 2002. His Excellency Governor of Assam allotted 131.30 ha of forestland for this project in the month of May 1979. Brahmaputra Board developed township area, store area; roads etc. in the above allotted forestland. NHPC has taken over old and damaged infrastructure from Brahmaputra Board along with 131.30 ha of forestland in the month of June 2000.

The infrastructure work in the project have been planned to be completed within 30 months from the date of sanction of the project. The work on diversion tunnel has been planned to be started from 13th month and to be completed by the end of 24th month. The first diversion has been planned at the end of 34th month. The work for excavation of abutment of concrete gravity dam has been planned from 22nd month and to be completed by end of 37th month. The excavation in riverbed has been planned to be started from the 37th month in the first season diversion. Three diversions of the river have been planned in three seasons to bring the level of concrete dam above flood level. This will be possible at the end of 64th month. The work in plunge pool will also be started along with the work of main concrete dam. The concreting in dam has been planned to be completed by the end of 82nd month alongwith the plunge pool works. Erection of gates and other hydromechanical works have been planned to be started from 70th month and to be completed by the end of 84th month. HRT work has been planned to be awarded by the end of 24th month. The excavation of adit to HRT has been planned to be started from 25th month and to be completed by the end of 31st month. The tunnel portion length will be concrete lined and grouted by the end of 49th month. The intake excavation has been planned to be started from 46th month and to be completed by the end of 60th month. The concreting will be started from 58th month and will be completed by the end of 72nd month. The erection and commissioning of the gates have been planned to be completed by 84th month. Adit to pressure shaft has been planned to be started from

25th month and to be completed by 30th month. Pressure shaft excavation has been planned to be started from 31st month and to be completed by 57th month. The liner erection work has been planned to be started from 58th month and to be completed by the end of 80th month. Adit to power house has been planned to be started from the 22nd month and to be completed by 30th month. The excavation in power house cavern has been planned to be started from 31st month and to be completed by the end of 64th month. Mean while the concreting in substructure will be started from 40th month and in super structure from 53rd month. The EOT crane level in service bay and first unit has been planned to be achieved by 63rd month. The finishing work in power house has been planned to be started from 70th month and to be completed by 84th month. Most of the concrete work has been planned to be completed by 76th month.

The adit to Transformer Cavern has been planned to be started from 22nd month and to be completed by the end of 33rd month. From 34th month the excavation for transformer cavern and MIV gallery will be started and will be completed by the end of 63rd month. Concreting will be started from 55th month and to be completed by 67th month. The erection and commissioning of transformer and MIV will start from 68th month and to be completed by 84th month.

The excavation of cable gallery will start from 55th month and will be completed by 62nd month. The concreting will start from 63rd month and will be completed by 68th month. The work of cable tray placing will start from 69th month and will be completed by 72nd month. The cable laying will start from 73rd month and will be completed by 84th month.

Approach road to Switchyard has been planned to be started from 25th month and to be completed by 36th month. From 37th month the excavation of switchyard will be started, which will be completed by 51st

month. From 49th month concreting will be started, which will be completed by 67th month. The erection of structure and equipment has been planned to be started from 58th month and to be completed by 75th month.

The excavation work for TRTs has been planned to be started from 25th month and to be completed by 54th month. From 54th month concreting will be started, and to be completed by 67th month. The grouting will be completed by 72nd month. Surge chamber adit excavation has been planned to be started from the 22nd month and to be completed by 30th month. The surge chamber excavation has been planned to be started from 31st month and to be completed by the end of 60th month. After that concreting has been planned to be completed by the end of 71st month then grouting by end of the 76th month. The erection of gates will start from 65th month and shall be completed by 79th month.

The award for design, manufacturing and supply of generating units has been planned to be completed by 12th month. The supply has been planned to start from 31st month. The erection of first two units has been planned to be started from 49th month and to be commissioned by 77th month. All remaining six units has been planned to be commissioned in set of two units by 81st, 82nd and 84th month respectively.

SALIENT FEATURES

1 LOCATION

- STATE : ARUNACHAL PRADESH/ASSAM
- DISTRICT : LOWER SUBANSIRI/DHEMAJI
- RIVER : SUBANSIRI
- DAM SITE : 2.3 KM U/S OF GERUKAMUKH VILLAGE ON ASSAM ARUNACHIAL PRADESH BORDER
LATITUDE 27° 33' 15" N
LONGITUDE 94° 15' 30" E
- NEAREST BG RAIL HEAD : NAGAON
- NEAREST AIRPORT : GUWAHATI

2 HYDROLOGY

- CATCHMENT AREA : 34,900 SQ KM
- LOCATION OF CATCHMENT : LATITUDE 27° N AND 29° N
LONGITUDE 91° 45' AND 94° 45' E
- AVERAGE ANNUAL RAINFALL : 2356 MM
- AVERAGE MAXIMUM TEMPERATAURE : 34.15 C
- AVERAGE MINIMUM TEMPERATURE : 7.85 C

- MONTHLY MEAN TEMPERATURE
 - MAXIMUM : 30.23 C
 - MINIMUM : 16.73 C
- MAXIMUM OBSERVED DISCHARGE AT DAM SITE : 12024 CUMEC
- MINIMUM OBSERVED DISCHARGE : 188 CUMEC

3 RESERVOIR

- MAXIMUM WATER LEVEL (MWL) : EL 208.25 M
- FULL RESERVOIR LEVEL (FRL) : EL 205.0 M
- MINIMUM RESERVOIR LEVEL (MRL) : EL 190.0 M
- MINIMUM DRAW DOWN LEVEL (MDDL) : EL 181 M
- GROSS STORAGE AT EL 205.0, 190.0 & 181.0 M : 1365 / 923 / 720 M CUM
- AREA UNDER SUBMERGENCE AT FRL : 33.50 SQ KM

4 DAM

- TYPE : CONCRETE GRAVITY DAM
- TOP ELEVATION OF DAM : EL 210.0 M
- HEIGHT OF DAM : 116 M

ABOVE RIVER BED
LEVEL

- HEIGHT OF DAM : 133 M
- ABOVE DEEPEST
FOUNDATION LEVEL

5 SPILLWAY

- DESIGN FLOOD : 37500 CUMEC
- TYPE : ORIFICE TYPE
- CREST ELEVATION : EL 150 M
- NUMBER & SIZE OF : 9 NOS; 11.5 M X 14.7 M
- SPILLWAY OPENING
- ENERGY DISSIPATION : SKI-JUMP WITH PLUNGE
POOL

6 DIVERSION TUNNEL

- NUMBER : 5
- SIZE : 9.5 M DIAMETER
- SHAPE : HORSE SHOE
- LENGTH : From 485 to 640 M
- DIVERSION CAPACITY : 4,550 M³/s
- HEIGHT OF U/S : 31 M
- COFFER DAM
- HEIGHT OF D/S : 19 M
- COFFER DAM

7 INTAKE

- INVERT LEVEL : EL 160
- NUMBER & SIZE OF : 8 NOS; 7.3 M X 9.5 M
- GATE OPENING

- TRASH RACK
 - INCLINED TYPE
 - 2 bays of 7.5 M X 23.75 M
 - with central pier of 2.5 M

- 8 HEAD RACE TUNNEL
 - NUMBER : 8
 - SIZE & SHAPE : 9.5M DIA, HORSE SHOE
 - LENGTH : From 225 to 390 M
 - DESIGN DISCHARGE : 322.4 CUMEC

- 9 PRESSURE SHAFT
 - NUMBER : 8 NUMBERS
 - SHAPE : CIRCULAR, STEEL LINED
 - DIAMETER : 8 M
 - LENGTH : Horz. at top & bottom -- 58 M
(Excluding bends at top & bottom)
Vertical - 68.25 M

- 10 POWER HOUSE
 - TYPE : UNDERGROUND
 - INSTALLED CAPACITY : 2,000 MW
 - NUMBER OF UNITS : 8 Nos.
 - POWER HOUSE : 24 M X 62.5 M X 337 M
 - CAVERN
 - TRANSFORMER CUM : 15 M X 42.0 M X 327 M
 - MIV CAVERN
 - SERVICE BAY LEVEL : EL 111.5 M
 - TYPE OF TURBINE : FRANCIS
 - GROSS HEAD : 90 M

- BUS DUCT GALLERY : 6 M X 6 M X 30 M
 - Diameter Of MIV : 7 M

- 11 SURGE CHAMBER CUM
DRAFT TUBE GATE CAVERN
 - SIZE : 15 M X 61.0 M X 249 M
(COMPARTMENTED INTO 8
NUMBERS)
 - DRAFT TUBE OPENING : 12 M x 10 M including a
intermediate piers of 2.0 M
width

- 12 TAILRACE TUNNEL
 - SHAPE : HORSE SHOE SHAPED
 - LENGTH : From 450 M to 780 M
 - DIAMETER : 9.5 M

- 13 SWITCHYARD
 - SIZE & LOCATION : 100 M X 300 M AT EL 180 M

- 14 ACCESS TUNNEL
 - SIZE : 8 M D - SHAPED
 - LENGTH : 3065 M

15 POWER GENERATED

INSTALLED CAPACITY : 2,000 MW
ANNUAL ENERGY GENERATION IN 90% DEPENDABLE YEAR : 7,551.1 MU

16 PROJECT COST

□ TOTAL COST : Rs. 7468.61 crores
(At March, 2001 Price Level including IDC)
□ COST OF GENERATION AT BUS BAR PER UNIT INCLUDING 12% STATE SHARE AND RETURN ON EQUITY) : Rs 2.61 paise per kwh

CHAPTER – 2

PROJECT COST

2.1 BASIS FOR ESTIMATE

GENERAL

The estimate has been prepared to arrive at the capital cost of Subansiri Project at March 2001 P.L. and is of feasibility study level of accuracy.

I-WORKS

Under this heading, provision has been made for various components of the Project as detailed hereunder.

A-PRELIMINARY – 31.65 Crores

This covers the provision for surveys and investigations to be conducted to arrive at the optimum of the project components, including pre-feasibility stage investigations already done.

B-LAND -- 3.28 Crores

This covers the provision for acquisition of land for construction of the project colonies, offices and stores and compensation for trees and standing crops. Provision for rehabilitation of displaced persons has been included on the basis of prevailing norms.

C-WORKS – 1525.84 Crores

This covers the cost of diversion tunnel and concrete dam along with associated hydro-mechanical equipment. The unit rates for various items are based upon Central Water Commission's norms. All rates have been worked out on current market rates. The

analysis of rates for principal items of work and hourly use rate of machinery are given in Chapter-8.

The quantities indicated in the estimates are calculated from the preliminary engineering drawings and as per experience of other on-going or commissioned projects. A provision of 5% has been made for contingencies and the Department's first line supervision charges.

J-POWER PLANT CIVIL WORKS – 1568.89 Crores

This covers the cost of project components viz. Intake structure, Headrace Tunnel, Power House civil works, Pressure shaft, Tail Race Channel and other appurtenant works. The unit rates for various items are based on Central water Commission norms and worked out at current market rates. The details of items and the supporting analysis are given in chapter-8.

K-BUILDINGS – 88.76 Crores

The cost of the buildings required (both residential and non-residential) for the execution of the project has been included under this head. The costs are worked out on plinth area basis for the type of construction involved.

O-MISCELLANEOUS – 76.46 Crores

This head covers the provision for cost of the following Miscellaneous works.

- a) Capital cost of electrification, water supply, sewage disposal, fire fighting equipments etc.
- b) Repair and maintenance of electrification, water supply, sewage disposal, medical assistance, recreation, post office, telephone and

telegraph office, security arrangements, fire fighting, inspection vehicles, schools, transport of labour etc.

- c) Other services such as power supply, model studies, laboratory testing, Railway siding, R&M of Guest House and transit camps, training of Engineers, police station, community center, retrenchment compensation, photographic instruments as well as establishment and R&M charges etc.

**P-MAINTENANCE DURING CONSTRUCTION – 32.32 Crores
AND Y-LOSSES ON STOCK – 8.08 Crores**

A provision of 1% and 0.25% of C-Civil works, J-Power Plants, K-Buildings and R-Communications has been made for maintenance of works during construction period and losses on stock respectively.

Q-SPECIAL TOOLS AND PLANT – 203.28 Crores

The provision has been made to cover the residual value of the special equipment i.e. capital cost of the equipment less the credit due to resale or transfer of equipment and life of machinery used in works. It is assumed that 75% of the life of machinery will be used in the works.

R-COMMUNICATION – 48.47 Crores

The cost of new roads, improvement of roads and strengthening of bridges has been booked under this head.

X-ENVIRONMENT AND ECOLOGY – 102.78 Crores

The provision has been made for implementation of environmental management plan under this head.

ELECTRICAL WORKS-GENERATION – 2224.84 Crores

The head covers the cost of generating plant and equipment, auxiliary equipment and services and switchyard equipments. Appropriate provision for taxes, duties and transport to site and erection and commissioning have been estimated.

II-ESTABLISHMENT – 368.65 Crores

Provision for establishment has been made at 10% and 6% of I-works for civil and Generation works respectively.

III-TOOLS AND PLANTS – 36.90 Crores

This provision is distinct from that under Q-Special T&P and is meant to cover cost of survey instruments, camp equipment and other small tools and plants. The outlay is provided at 1% of cost of I-works.

IV-SUSPENSE – 0.00

No provision has been made under this head as all the outstanding suspense are expected to be cleared by adjustment to appropriate heads at completion of the project.

V-RECEIPTS AND RECOVERIES – (-) 149.75 Crores

Under this provision, estimated recoveries by way of resale or transfer of special T&P are provided for.

2.2 CASH FLOW STATEMENT

The proposed cash flow excluding interest during construction and escalation will be as follows:

Year	Estimated cost at March 2001 P.L. (Rs. In Crores)
1st	181.86
2nd	765.80
3rd	984.98
4th	1146.42
5th	1455.81
6th	1146.10
7th	581.19
Net Cost	6262.16

CHAPTER – 3

ENVIRONMENTAL & ECOLOGICAL ASPECTS

3.1 INTRODUCTION

The National Hydroelectric Power Corporation (NHPC), proposes to construct a 116m high dam at Gerukamukh, near North Lakhimpur, on river Subansiri in the Lower Subansiri district of Arunachal Pradesh. The submergence area of the dam is 3350 ha, spreading over two villages, Siberite and Gengi, under the Gensi circle of Lower Subansiri district. The project comprises the construction of 8 Head Race Tunnels of 9.5 m diameter each and an underground power house with a capacity of 2000 MW (8 x 250 MW).

3.2 ENVIRONMENTAL BASELINE STATUS AT GERUKAMUKH

3.2.1 Meteorology

The Subansiri basin comes under the tropical and temperate climatic zones. As a result it exhibits a great diversity in the rainfall pattern. The annual rainfall varies from 630 mm at Raga to 4740 mm at Gerukamukh. Although rainfall occurs throughout the year, majority of it is received during June to mid-September under the influence of southwest monsoon. The relative humidity in the region is high throughout the year, the winter months being less humid.

3.2.2 Geology

The geology of the area is represented by formations ranging from Proterozoic to Quaternary age. The State of Arunachal Pradesh can be

divided into four distinct physiographic segments namely the Himalayan Ranges, the Mishmi Hills, the Naga-Patkoi Ranges and the Brahmaputra Plain.

The Himalayan Ranges rise abruptly from the Brahmaputra plain and merge with the Tibetan plateau in the north, the age of the rock formations ranges from Proterozoic to Quarternary and had attained the present height during different phases of orogenic movements.

The Mishmi Hills are the northern continuation of Myanmar Hills and contain rocks of Cretaceous to Neogene age.

The Naga Patkoi ranges consists of Paleogene-Neogene sediments overlying unconformably over the Pre Cambrian rocks.

The Brahmaputra plains are formed by the valley fill Quarternary deposits brought down by the Brahmaputra and its tributaries.

The generalised geological succession of the area is given in table 10.1

Table 3.1: Generalised succession of the area

Age	Group/Formation	Lithology
Recent Unconsolidated to Sub Recent	Brahmaputra Plains	Alluvium deposits, beds of boulders, pebbles, sand and silt
-----Unconformity-----		
Tertiary	Kimen Formation	Sandstone & gravelly boulder bed
	Subansiri Formation	Massive SSt. with Salt & Pepper texture
	Daffla Formation	Alternating Sequence of SSt. & Shales
	Kimi Formation	Sandstone & Red Shales

-----Unconformity-----		
Lower Permian	Lower Gondwana Group	Shales, Diamictite, Conglomeratic SSt.
-----Unconformity-----		
Proterozoic	Bomdilla Group	Dolomite, Limestone, Interbedded Quarzites & Phyllites.
Archean	Se La Group	Greenschist, Marble, Gneiss and Schist, Amphibolite with intrusive of Hornblende Granite and Tourmaline granite.

3.2.3 Seismicity

The project area lies in the Eastern Himalayas which are seismologically active as per the seismic zoning map of India (IS: 1893 – 1984). The region is considered as one of the most seismically active regions of the world. The entire area falls under Zone V.

3.2.4 Landslides

Landslides are commonly observed in the project area. A statistical study of the incidence of landslides indicates that these are fairly common in the Upper Tertiary formations. Most of the landslides have taken place or are initiated along one or the other of the joint sets during the earthquakes. In the Upper Tertiary formations, the steep southerly dipping bedding joints are the dominant initiating factor.

3.2.5 River System

Subansiri is a major right bank tributary of river Brahmaputra. The river originates beyond the Great Himalayan Range at an altitude of 5340m. In the higher reaches, where it is known as *Tsari chu*, the Subansiri is flowing in an approximately westerly direction. It follows a southeasterly course along the Lesser Himalayan zone with an average height of 3048 m and takes the name 'Subansiri'. The Subansiri river basin is one of the largest sub basins in the Brahmaputra valley. Throughout its journey from the Central Himalayas to the Arunachal foothills, the river Subansiri receives the discharge from numerous big and small mountainous streams. The number of its tributaries are more in the Siwalik foothills than in other zones. The main tributary of the river is Kamla, which confluences with Subansiri about 26 km east of town Raga. The Subansiri river system has a total catchment area of about 37000 sq. km. The altitude within the catchment ranges from 5591m (above the MSL) in the Central Himalayas to about 152m near the foothills. The catchment area intercepted upto the proposed dam site is about 34,900 Sq.km. out of which about 14000 sq. km lies in Tibet and the remaining in India. The snow line varies widely with varying local factors. The catchment is crescent shaped with its concavity towards the western side.

3.2.6 Water Quality

The Subansiri basin has low population density and irrigation intensity. Thus there are no major sources of organic loading in the river. As a part of the field studies, water samples were collected from river Subansiri and analysed. The results obtained are given in table 10.2. and it has been observed that the water quality of river Subansiri is good and all the parameters are within the permissible limits. The low BOD (1.9mg/l – 2.1 mg/l) & COD (2.7mg/l – 3.0 mg/l) values and correspondingly high DO

values (8.6mg/l – 9.0 mg/l) indicate the absence of pollution sources. The low values of heavy metals indicate absence of pollution from industrial sources.

Table 3.2: Water quality analysis of river Subansiri

Parameter	Geru W1	Geru W2	Geru W3	Geru W4	Geru W5
PH	6.7	6.9	7.1	6.8	7.1
TDS, mg/l	187	170	207	174	205
Sulphates, mg/l	10	18	17	9	16
Chlorides, mg/l	67	84	107	64	94
Nitrates, mg/l	3	6	8	3	6
Phosphates, mg/l	2	4	6	2	7
Sodium, mg/l	123	8	69	118	71
Potassium, mg/l	35	1	1	33	29
Calcium, mg/l	19	18	21	18	16
Copper, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Iron, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc, mg/l	0.03	0.04	0.04	0.03	0.03
Cadmium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Magnesium, mg/l	11	10	11	10	9
Lead, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Manganese, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Cyanides	<0.01	<0.01	<0.01	<0.01	<0.01
Electrical conductivity, micro mhos/m	251	230	284	235	279
Fluorides, mg/l	1.2	1.21	3	1.2	1.1
Hardness, mg/l	71	68	74	69	62
DO, mg/l	8.7	8.6	8.7	8.8	9.0
BOD, mg/l	1.9	2.1	1.9	2.1	2.1
COD, mg/l	2.7	2.9	3.0	2.9	2.9

3.2.7 Landuse Pattern

Land use/ land cover is the most important parameter for evaluation and conservation of biodiversity. Therefore, qualitative and quantitative status of the vegetation are basic requirements for strategy formulation and future monitoring. For this purpose vegetation mapping has been carried out using IRS-ID data. Different types of classification schemes have been followed during the study viz. density classification, forest type classification etc. Ground truth studies were conducted in the area to validate various signatures in the Satellite Images and correlate them with different land use domains. The landuse details of the project area are depicted in table 10.3.

Table 3.3: The land use pattern of the project area

Landuse cover	Area in percentage
Dense mixed Forest	55.78
Open mixed Forest	4.12
Grasses	2.47
Jhum land	9.7
Dense scrubs	16.02
Settlement /Exposed rocks	3.58
River/water bodies	8.33

The total forest area required for the project is 3931.30 ha out of which 3350 ha is coming under submergence. In Arunachal Pradesh the land is classified as Reserved Forest or Proposed Reserved Forest and Unclassified Forest. There is no private land or non-forest land. The land is neither surveyed nor taken into Revenue records. The entire unclassified State Forest is traditionally controlled by the villagers. The

landuse pattern of the submergence area has been studied through digital satellite imagery data. The major land cover is coming under forest.

3.2.8 Flora

The vegetation of the submergence area is mostly semi-evergreen interspersed locally with deciduous components. Some areas near Damporijo have riverine vegetation. Except for the area under riverine vegetation, most of the study area has secondary vegetation. Bamboo trees are observed in few areas. As per the District Gazette, the project area has five major types of forest mentioned below:

Type	Elevation (m)
* Tropical Evergreen Forests	<900
* Sub-tropical forests	900-1800
* Sub-tropical grasslands	100-1500
* Temperate forests	1800-3500
* Sub-alpine and alpine vegetation	>3500

Since the FRL is 205 m, the major forest type is Tropical Evergreen Forest.

The area is very rich in biodiversity and about 177 plant species have been encountered at the project site out of which 92 are of trees, 26 of shrubs, 42 of herbs and 17 of lianas. *Duabanga grandiflora* is the most dominant species in Damporijo and Gerukamukh. The three rare/endangered species observed were *Bambusa mastersii*, *Cyathia spinulosa* and *Heritiera amminate*. During the course of survey 35 economically important species, namely *Dillenia indica*, *Calamus flagellum*, *Thunbergia coccinea*, *Pandanus sp.*, *Piper sp.*, *Wallichia sp.*,

etc. have also been observed. Table 3.4 gives names of some of the plants found in the area.

Table 3.4: Plant species encountered in the Project area

<u>Botanical name</u>	<u>Local Name</u>
Trees	
<i>Amoora wallichii</i>	Amari
<i>Toona febrifuga</i>	Poma
<i>Mengleitia insignis</i>	Phulsopa
<i>Duabanga grandiflora</i>	Khokan
<i>Canarium strictum</i>	Dhuna
<i>Altingia excelsa</i>	Jutuli
<i>Stereospermum chelonoides</i>	Paroli
<i>Sapium baccatum</i>	Seleng
Shrubs	
<i>Morinda angustifolia</i>	
<i>Ixora acuminata</i>	
<i>Maesa chisia</i>	
<i>Mellastoma malabathricum</i>	
<i>Capparis multiflora</i>	
Herbs	
<i>Solanum torvum</i>	
<i>Ageratum conyzoides</i>	
<i>Urena lobata</i>	
<i>Eupatorium odoratum</i>	
Cane / Palm	
<i>Plectocomia assamica</i>	Hathibeth
<i>Calamus flagellum</i>	Raidang
Bamboo	

Pseudostachyum polymorphum Bojal

Dendrocalamus hamiltonii Kako

Bambusa pallida Bijli

Climber

Piper sp.

Mikania micrantha

Acacia penata

Fern

Phagopteris auriculata

3.2.9 Fauna

The project area has a fairly good forest cover and serves as a habitat for many species. The area is still quite rich in wildlife. The submergence area runs very close to the Talee Wildlife Sanctuary. The major mammal species observed in the area are Large Indian Civet, Barking deer, Wild boar, Serow, Sloth bear, Clawless otter, Toddy cat, Jungle cat and Elephant. During the survey it was gathered that elephants do move in the area. Normally they move from Dolangmukh to Likabali and travel upto Garu and Gansi forest areas. They cross river Subansiri near Dolangmukh and move upto Garu and Gansi forest areas. The upper stretch of the river including the area coming under submergence flows in a deep gorge with high velocity. So it is not likely to affect the elephant corridor. The reptilian family is represented by Himalayan Keelback, Checkered Keelback, Indo-Chinese rat snake, Striped Keelback, etc. The commonly observed bird species in the area include Cormorant, White Stork, etc. Table 3.5 gives the names of some faunal species observed in the Project area

Table 3.5: List of faunal species

A. Mammals

- Leopard- *Panthera pardus* (E)
- Barking deer- *Muntiacus muntjak* (E)
- Wild boar- *Sus scrofa* (E)
- Serow - *Capricornis sumatralensis* (E)
- Sloth bear- *Melursus ursinus*
- Clawless otter- *Aonyx cinerea* (R)
- Large Indian Civet- *Viverra zibetha*
- Toddy cat- *Paradoxurus hermaphroditus*
- Jungle cat- *Felis chaus* (E)
- Elephant- *Elephas maximus*(E)

B Snakes:

- Diard's blind snake- *Typhlops diardi*
- Python- *Python molurus* (E)
- Copper head- *Elaphes radiata*
- Indo- Chinese rat snake- *Ptyas korras*
- White banded kukri- *Oligodon albocinctus*
- Himalayan keelback- *Rhabdophis himalayanus*
- Striped keelback- *Amphiesma stolata*
- Checkered keelback- *Zenochrophis piscator*
- Banded krait - *Bungrus fasciatus*
- Common cobra- *Naja naja*

3.2.10 Fisheries

Unlike other states of the country, there are no regular and defined fish landing centres in Arunachal Pradesh. Likewise, there is no fish-landing center in the project area and therefore fish potential of river Subansiri is difficult to estimate. It was also observed during the field visit, that no large-scale fishing is being practiced in the area. The fish life can be

classified under the following three categories namely temperate species, warm sub-tropical species and warm tropical species. About 55 species have been recorded. The major species reported in the river include *Tor tor*, *Tor putitora*, *Schizothorax richardsonii*, *Danio dangila*, *Garra lamta*, *Labeo dero*, etc. Species of *Tor* (Mahaseer) and *Schizothorax* are migratory. Mahaseers are normally observed at 800 – 1200 m above MSL. They come to the lower reaches for spawning.

3.2.11 Socio-Economic Composition

The proposed dam is located in the Lower Subansiri district, which is spread over an area of about 10,135 Sq.km. Two villages, Siberite and Gengi are coming under submergence. 38 families (20 in Siberite and 18 in Gengi) comprising 325 persons would be affected by the project, losing their *jhum* lands and agricultural land (WRC/TRC land). The *Jhum* land is however owned by the Village Level Committee (VLC). These committees allot land to each family and the land under cultivation is a community property.

The Apatani, Nishi, Tagin, Bori, Bokar and Hill Miri tribal groups belonging to the Adi (Galo) tribe inhabit the area. About 65 % of them are Animists, following the tribal laws, while the rest follow Christianity. These people lead a sedentary life, in groups, locally known as *busthi*. Different exogamous clans inhabit each *busthi*. It was observed that on an average each *busthi* has about 15 homesteads. The houses are usually constructed of wood, bamboo and thatch, which are raised over a platform (made of logs) about 3-4 feet above the ground. Primarily, the inhabitants of the *busthi* are cultivators. It was learnt that *jhum* or shifting cultivation was once the only way of sustenance they knew. However, over the years these groups have been very receptive to innovations in agriculture, i.e. to Terrace Cultivation. Presently a vast majority of the inhabitants are

involved in terrace rice cultivation (TRC) and wet rice cultivation (WRC). However, most of them have still retained their *jhum* fields and continue to practice it in the already opened *jhum* lands. Besides cultivation, these folks also rear animals. The most commonly found animals are cows, goats, pigs, poultry and dogs. *Mithun*, a semi-domesticated animal, is also reared. This animal is considered as a status symbol and enhances the social standing of the individual who owns it. The overall socio-economic standard of these people is however very low. Only few families own modern material assets. Literacy rate is 50.7%. Most of them are engaged in cultivation and only 3.14% are involved in services and teaching.

3.3 ENVIRONMENTAL IMPACTS

The environmental impacts of proposed Subansiri Lower Hydroelectric Project are projected in the light of the construction activity of dam, submergence, tunneling, road construction, housing and dumping of excavated material etc.. Majority of the environmental impacts due to construction works are temporary in nature, lasting mainly during the construction phase. These issues will have to be properly addressed so that their impacts do not continue after the construction phase. The construction of the project is likely to take 7 years including one year for infrastructure development. The major anticipated impacts are as follows:

Impacts due to change in landuse.

Impacts on socio-economic status

Impacts on water environment

Impacts on biodiversity

Impacts on aesthetic environment

In order to minimise the adverse impacts of development activities in the region, various environment management plans are proposed.

3.4 ENVIRONMENTAL MANAGEMENT PLAN

3.4.1 Catchment Area Treatment Plan

The catchment area treatment is extremely crucial in the context of hydropower development as the life of the reservoir depends on the type of the catchment from which it collects the drainage. Therefore, a catchment area treatment plan has been formulated with the main objective of arresting soil erosion in the upstream catchment. This will also help in rejuvenation of various degraded ecosystems in the catchment. According to the topographic factors, soil type, climate and vegetation cover in the catchment area, various afforestation measures have been proposed to be undertaken with the aim to check soil erosion, prevent/check siltation of reservoir and to maintain its storage capacity in the long run. About 1472 ha of open degraded forest and 7360 ha of *jhum* land needs to be treated with biological and engineering treatment measures.

3.4.2 Resettlement and Rehabilitation:

Following benefits are proposed to be provided to the oustees under the R & R Plan:

Homestead land

Alternate agriculture land to agriculture based displaced families, subject to availability.

Those who do not accept land in lieu of land and wish to settle elsewhere under their own arrangement shall be paid compensation for their immovable property (land, building and trees etc.) as per the norms of the State Government.

Suitable amount for improvement / development of land for making it fit for cultivation.

Subsidy for seeds, fertilizers etc.

Transportation cost for household goods and cattle to the new place of settlement.

Solatium charges.

Infrastructure facilities, such as approach roads, electricity, water supply, education, health center etc. in the resettlement area.

The project management will assist and encourage the displaced families/ individuals to take up useful income-generating schemes such as poultry farming, animal husbandry, etc. However, the basic responsibility for initiating such schemes will be of the State Government.

A Resettlement and Rehabilitation Committee will be formed to monitor the Rehabilitation works.

3.4.3 Compensatory Afforestation Scheme

For construction of the project 4039.30 ha of forestland is required. The forest area coming under submergence is 3350 ha. Thus 8078.60 ha of degraded forest, which is double the area proposed to be acquired, needs to be afforested.

The basic objectives of the proposed scheme for Compensatory Afforestation are as under:

1. To make good the loss of trees/forests in the construction of Subansiri Lower H.E. Project.
2. To combat soil erosion in all its form within the forest area for the safety of roads, weir sites and powerhouse installation and to check silt discharge into the reservoir.
3. To provide instant temporary employment to Project Affected Persons.
4. To maintain environmental balance.

The compensatory afforestation shall be carried out in the already identified sites. The plantation area is proposed to be fenced with barbed wire.

3.4.4 Conservation of Flora & Fauna

The catchment of river Subansiri harbour a rich diversity of flora and fauna. The Tale Wildlife Sanctuary is located nearby. Conservation measures would be taken to protect the rich biodiversity of the area. The submergence area is generally remote and therefore no human interference on the wildlife is expected. In and around the main construction area i.e. the dam site, power houses, etc. where construction workers congregate, some disturbance in the wildlife population could be a possibility. However in view of the wildlife concentration in the area the impact due to various construction activities would be marginal. Hunting of animals is a common practice among the tribals. An inflow of population in the area, however, might lead to an increase in poaching to some extent. So necessary measures would be undertaken with the help of the Forest Department to mitigate such impacts.

3.4.5 Sustenance of Riverine Fisheries

a) Sustenance of fisheries

The development of reservoir for subsistence and commercial fisheries has to be carefully planned. Since, reservoir fisheries is principally based on Stock and Take system, introduction of stocking material has to be based on carrying capacity of the water body. Considering the subsistence fishery in the proposed reservoir and river stretches upstream and downstream of the dam site, it is a justifiable and

economical method to improve the availability of animal protein for local population. The development of proposed reservoir in Lower Subansiri Project will meet the requirement of fish to some extent in the State of Arunachal Pradesh. The stocking program in the proposed reservoir will help in increasing the potential impact in terms of improving upon the existing catches leading to commercial fishing.

The stocking Programme comprises of the following:

- Acclimatization stocking (a new fish species is introduced in a water course)
- Supplementary stocking (a species already living in a water body)
- Transfer stocking (transportation of mature fish from one water body to another)
- Repetitive stocking (species which do not propagate in natural conditions)

b) Maintenance of minimum flow:

During the survey fishing was carried out 1 m inside from the shoreline of river Subansiri. It was found that in a stretch of 1 km, fish catch was about 950 g. The average width of the river in the project area when considered as 100 m, it is plausible to assume that in one km river stretch, loss of about 100 kg might take place in case the river gets to a point of near desiccation. In order to avoid the fish loss, a minimum flow will be maintained in the downstream stretch during the lean season.

3.4.6 Control of Water-Borne Diseases/ Health Management

The construction of a reservoir replaces the riverine ecosystem by a lacustrine ecosystem. The vector of various diseases breed in shallow areas not very far from the reservoir margins. The magnitude of breeding sites for mosquitoes and other vectors in impounded water is in direct proportion to the length of the shoreline. The construction of the reservoir would increase the shoreline by many times as compared to the pre-project shoreline of various rivers and tributaries under submergence. Thus, the construction of the proposed reservoir would enhance the potential breeding sites for various disease vectors. In the proposed project area, malaria is the prominent vector-borne disease. There are chances that its incidence may increase due to the above-mentioned reasons. Thus anti-malarial operations will be undertaken with the help of Primary Health Centers and the State Health Department.

3.4.7 Restoration of Dumping Sites / Quarry Area

A huge quantity of material would be excavated from the HRT and adits during tunneling operations. In addition to this, the construction of Intake structure, pressure shaft, power house complex and the approach roads would also generate a large amount of material. Even though during construction some of the muck will be utilised for back filling and for wire crates, for providing protection of slopes along the banks, both upstream and downstream of dam, still maximum quantity of the excavated material will need to be relocated at selected muck disposal sites which would be restored through plantation etc.

3.4.8 Management of Impacts Due to Construction of Roads

The approach roads will have to be constructed as a part of the access to the construction sites. In a pristine and relatively undisturbed environment like Arunachal Pradesh, construction of roads will create some disturbance, which will have to be mitigated. In addition, in hilly terrain, landslides are often triggered due to road construction because of the loosening of rocks by the water trickling from various streams. Steeply sloping banks are liable to landslides, which can largely be controlled by providing suitable drainage. The basic principle is to intercept and divert as much water as possible. The erosion of the banks can be best controlled by plantation. Engineering solutions such as surface drainage, sub-surface drainage, toe protection etc. can be used wherever required. Landslides can be stabilized by engineering or bio-technical measures alone or a combination of these.

3.4.9 Green Belt

The construction of proposed dam near Gerukamukh would result in creation of reservoir, which would submerge an area of about 3350 ha. The reservoir periphery has areas with steep to very steep slopes. Presently there are a few slips and slides on the periphery of the proposed reservoir. However owing to steep slopes, filling up of reservoir and water level regulation may lead to minor slips and slides. Therefore, it is proposed to create a green belt around the reservoir area to safeguard against possible slips and slides and also to protect against the soil erosion (sediments) from the portion of catchment draining directly into the reservoir. The indigenous tree species will be planted for the creation of

green belt. In addition to these, other species that thrive well under high humidity and flood conditions will also be planted.

3.4.10 Solid Waste Management and Sanitary Facilities

A large labour population is likely to migrate into the project site, which is expected to cause a greater degree of urbanisation. The construction phase coincides with the mushrooming of a large variety of allied activities to meet the varying demands of the labour population in the project area. About 5000 labourers and technical staff will aggregate the area during this phase. The increase in population as a result of construction of the proposed project is likely to be about 10 to 15 thousand. The domestic water requirements for the immigrant population will be of the order of 1.1 mld of which 0.9 mld will be generated as sewage. The untreated sewage will have BOD level of 250-300 mg/l, which is much higher than the permissible limit of 30 mg/l for disposal of wastewater into surface water bodies. Hence, adequate treatment of sewage generated and disposal method for solid waste would be provided.

3.4.11 Air Pollution Management

In a water resources project, air pollution occurs mainly during project construction phase. The major sources of air pollution during construction phase are:

- * Pollution due to fuel combustion in various equipment:
The operation of various construction equipment requires combustion of fuel. Normally, diesel is used in such equipment. No major impact is anticipated on this account.

- * Emission from various crushers:

The operation of the crusher during the construction phase is likely to generate some suspended particulate matter in the ambient air. However, since there are no major settlements close to the dam site, no adverse impact on this account are anticipated.

* Fugitive emissions from various sources:

During construction phase, there will be increased vehicular movement in the area. A lot of construction material like sand, fine aggregates are stored at various sites, during the project construction phase. The impacts on this account are generally insignificant in nature.

However, measures will be adopted to mitigate the effects of air pollution.

3.4.12 Provision of LPG / Fuel wood Depots

It is estimated that during the construction of Subansiri Lower H.E. Project a peak labour force of 4000 shall be employed. The project is expected to be completed in about 5-6 years. As the majority of the labour force will be taken from outside the project area, it is proposed to keep a provision for the distribution of fuel wood as well as LPG to minimise the pressure on the adjoining forests due to illicit felling and removal of timber.

3.4.12 Disaster Management

As the catchment area is prone to cloud bursts and flash floods, necessary mitigative measures would be taken for installing flood forecasting and warning systems. One of the preventive measures in avoiding dam failure disaster is by issuing flood warning to the public downstream when 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. Therefore, dam break modeling has been conducted to assess the hypothetical situation of dam failure.

The dam failure study involves the following steps:

- Development/ identification of the inflow hydrograph of the reservoir at the time of failure.
- Routing that hydrograph through the reservoir.
- Calculating the outflow hydrograph at various desired d/s locations, and

Finding the movement of the flood wave downstream to determine travel time, maximum water level reached, inundated areas, etc.

An emergency action plan for evacuation and rescue would be formulated giving details of communication system, monitoring and surveillance mechanisms, etc.

3.4.14 Landscaping

The proposed Project would involve construction of powerhouse, residential and labour colonies, offices, roads, quarrying activities and crushing sites. These would result either in the modification or destruction of the existing landscape. So necessary measures would be taken for restoration of the aesthetic environment of the project area.

3.4.15 Environmental Studies

The environment management cell will coordinate in carrying out environmental monitoring and implementation of various environmental mitigatory measures.

CHAPTER 4

ECONOMIC EVALUATION

4.1 PROJECT BENEFITS

The Subansiri Lower Project will generate 7551.10 Gwh annually in a 90% dependable year. The project will also provide 2000 MW peaking capacity in the power system of the North-Eastern Region. This project will also partly operate as base load station during high discharge period of the year.

4.2 COST ESTIMATES AND PHASING OF EXPENDITURES

The cost of construction of the project excluding associated transmission system has been estimated at March 2001 price level with a completion period of 7 years of time including 1 year for development of infrastructure.

The estimated cost of the project is Rs. 6262.16 Crores.

4.3 PHASING OF EXPENDITURE & COMPLETION COST

The phasing of expenditure has been worked out on the basis of anticipated construction programme.

The completion cost of the project with annual escalation @ 6% on civil works and @ 4% on Electrical Works has also been worked out as Rs. 7873.09 Crores.

The phasing of expenditure for both the present cost and completion cost are shown as below:

Year	Estimated cost at March 2001 P.L. (Rs. In Crores)	Estimated completion cost (Rs. In Crores)
1st	181.86	196.06
2nd	765.80	871.37
3rd	984.98	1156.11
4th	1146.42	1381.15
5th	1455.81	1819.61
6th	1146.10	1540.99
7th	581.19	907.81
Net Cost	6262.16	7873.09

4.4 INTEREST DURING CONSTRUCTION (IDC)

Based upon above phasing of expenditure the interest during construction (IDC) have been calculated with 70:30 debt equity ratio and 14.5% interest on loan for both estimated present cost and estimated completion cost of the project.

The estimated IDC are as below:

- a) IDC with estimated present cost Rs. 1206.75 Crores
- b) IDC with completion cost Rs. 1403.63 Crores

4.5 COST OF ENERGY GENERATION

The cost of energy generation has been calculated for the annual energy generation in a 90% dependable year based upon following assumptions.

1.	Debt-equity ratio	70: 30
2.	Annual interest rate on loan	14.5%
3.	Return on equity	16%
4.	Annual interest rate on working capital	18.5%
5.	O&M Charges	1.5% of Project Cost
6.	Free power to Home State	12% of the energy available after losses
7.	Depreciation considered	1/12 th of loan amount during loan repayment period

The cost of generation at bus bar and sale rate with 12% free power to home state amounts to Rs. 1.82 per unit and Rs. 2.61 per unit respectively at March 2001 price level. This sale rate of power does not include water cess, income tax, incentive/penalty etc.

The cost of generation at bus bar and sale rate with free power to home state, at completion cost, amounts to Rs. 2.26 and Rs. 3.25 per unit respectively.

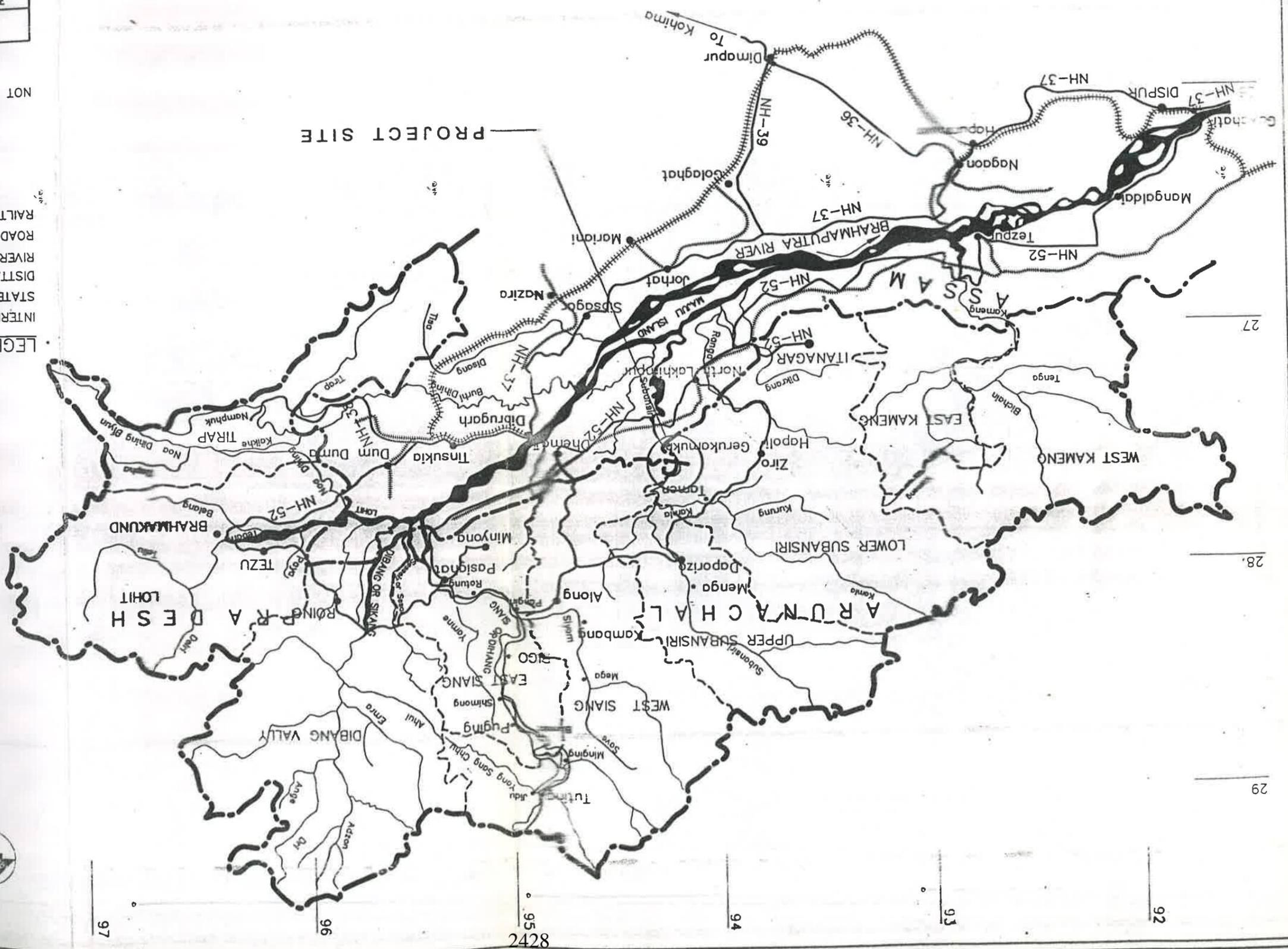
The levellised tariff of the Project at completion cost works out to be Rs. 2.63 Per Unit.

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SUBANSIRI LOWER HYDROELECTRIC PROJECT		
INDEX PLAN		
NATIONAL HYDROELECTRIC POWER CORPORATION LTD. भारतीय विद्युत् प्राधिकरण लि. SUBANSIRI LOWER HYDROELECTRIC PROJECT		

NOT TO SCALE

LEGEND

- INTERNATIONAL BOUNDARY
- STATE
- DIST.
- RIVER
- ROAD
- RAILTRACK
- MG



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DATE MAR 2001

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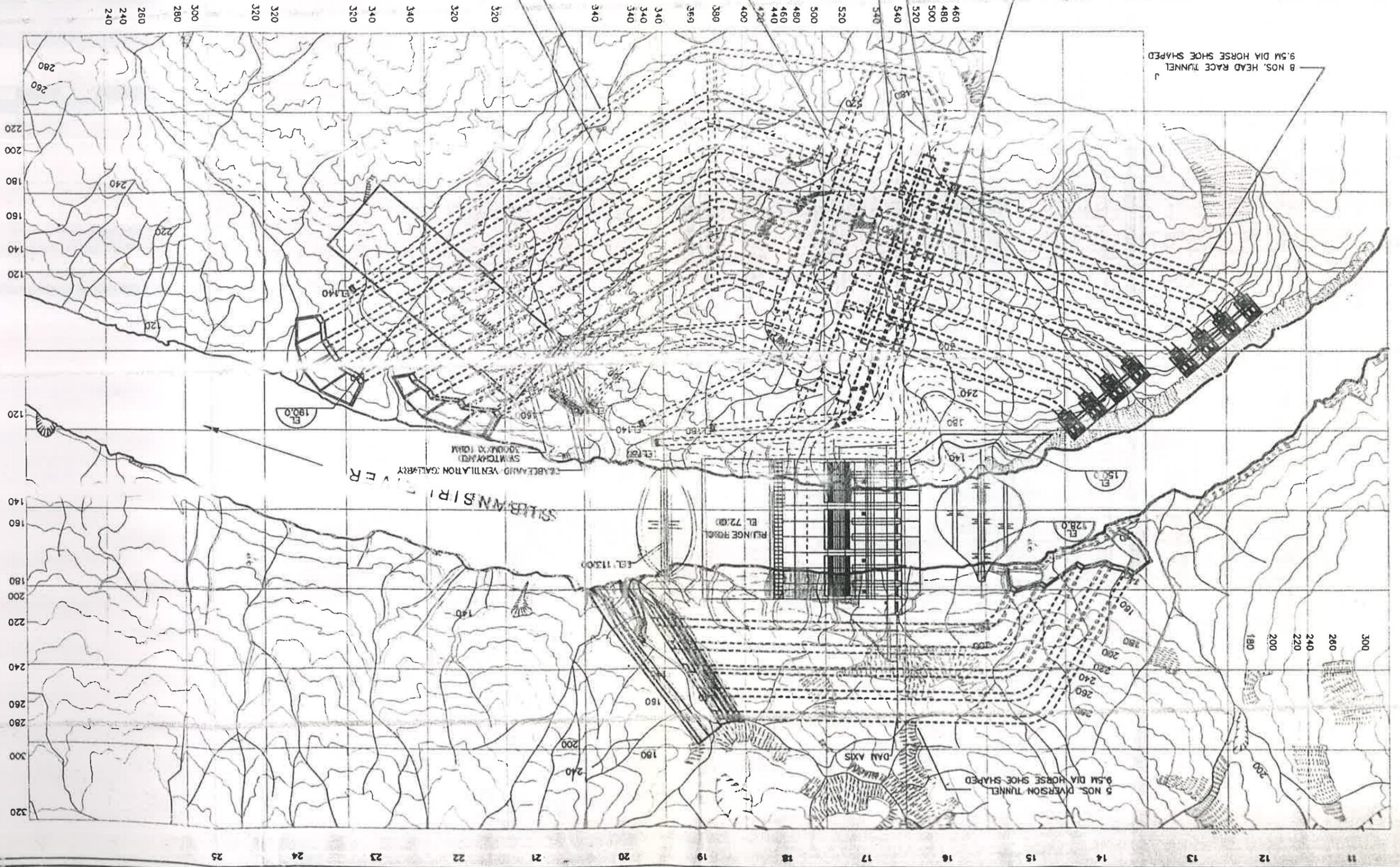
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LAYOUT PLAN

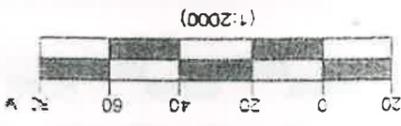
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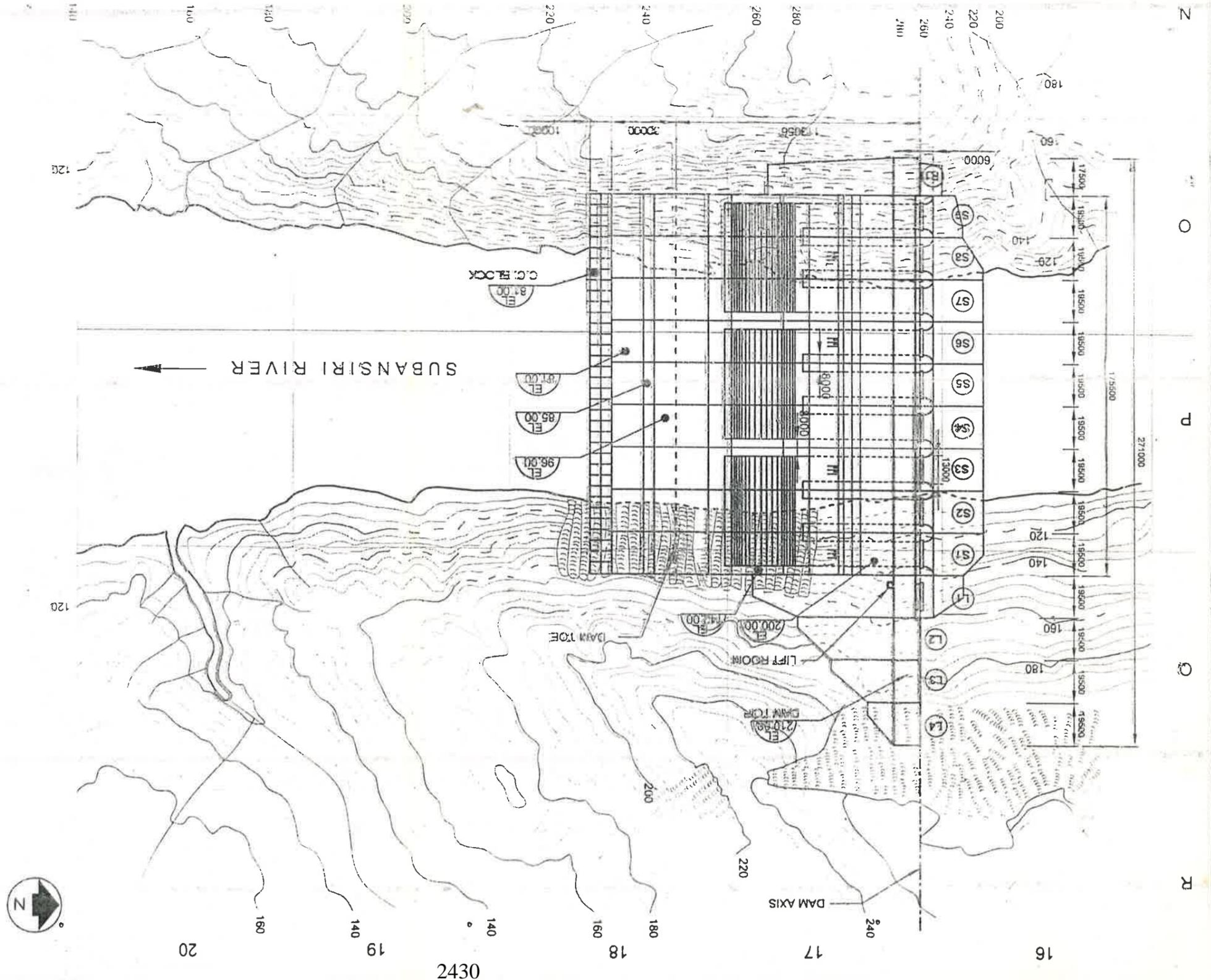
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- 2 THIS DRAWING IS FOR DPR PURPOSE ONLY.

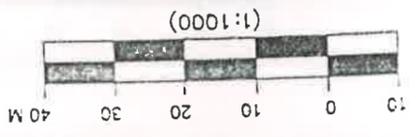
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CONCRETE DAM GENERAL ARRANGEMENT PLAN	
DRAWN BY: P. K. SHARMA CHECKED BY: P. K. SHARMA DATE: MAR 2004	DRG. NO: NH-SB-20A2-41-CA-007 F/DC/E/04/03/02



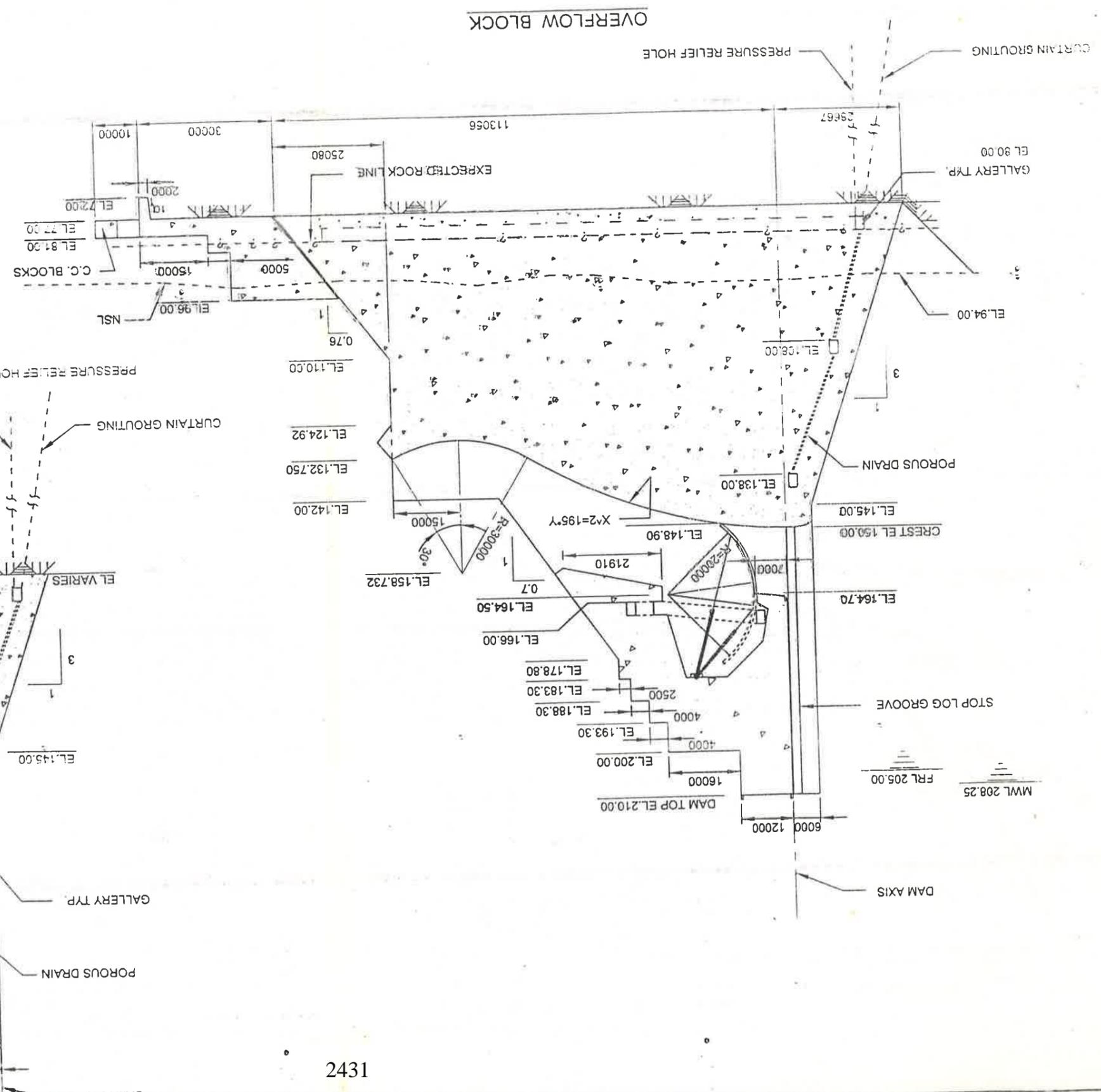
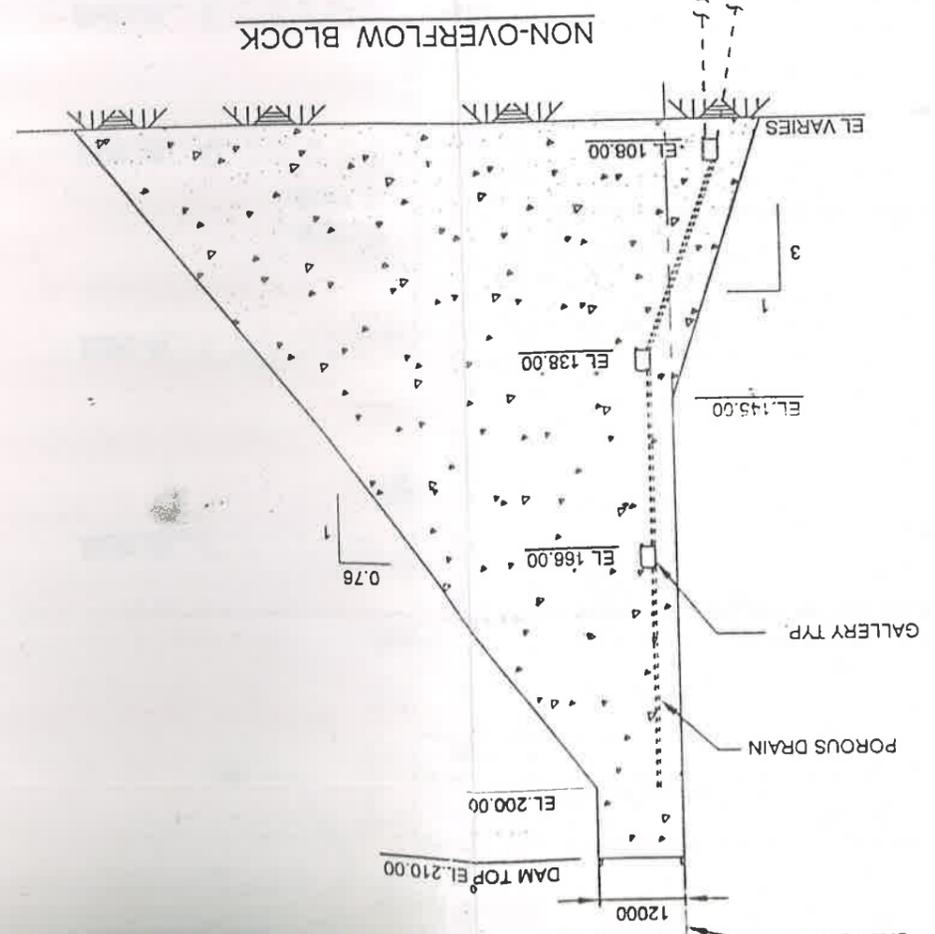
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 2. THIS DRAWING IS FOR DETAILED PROJECT REPORT ONLY.



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PROJECT	SUBANSIRI LOWER HYDROELECTRIC PROJECT
DAM	
CROSS SECTIONS	
NATIONAL HYDROELECTRIC POWER CORPORATION LTD.	



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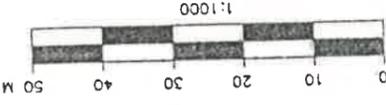


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CHECKED BY: RAJESH K. S. JOSHI		DRG. NO: NHSB-CA2-41-GA-016	
APPROVED BY: RAJESH K. S. JOSHI		PROJECT: POWER HOUSE COMPLEX	
SUBSANSARI LOWER HYDROELECTRIC PROJECT			
NATIONAL HYDROELECTRIC POWER CORPORATION LTD.			

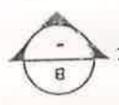
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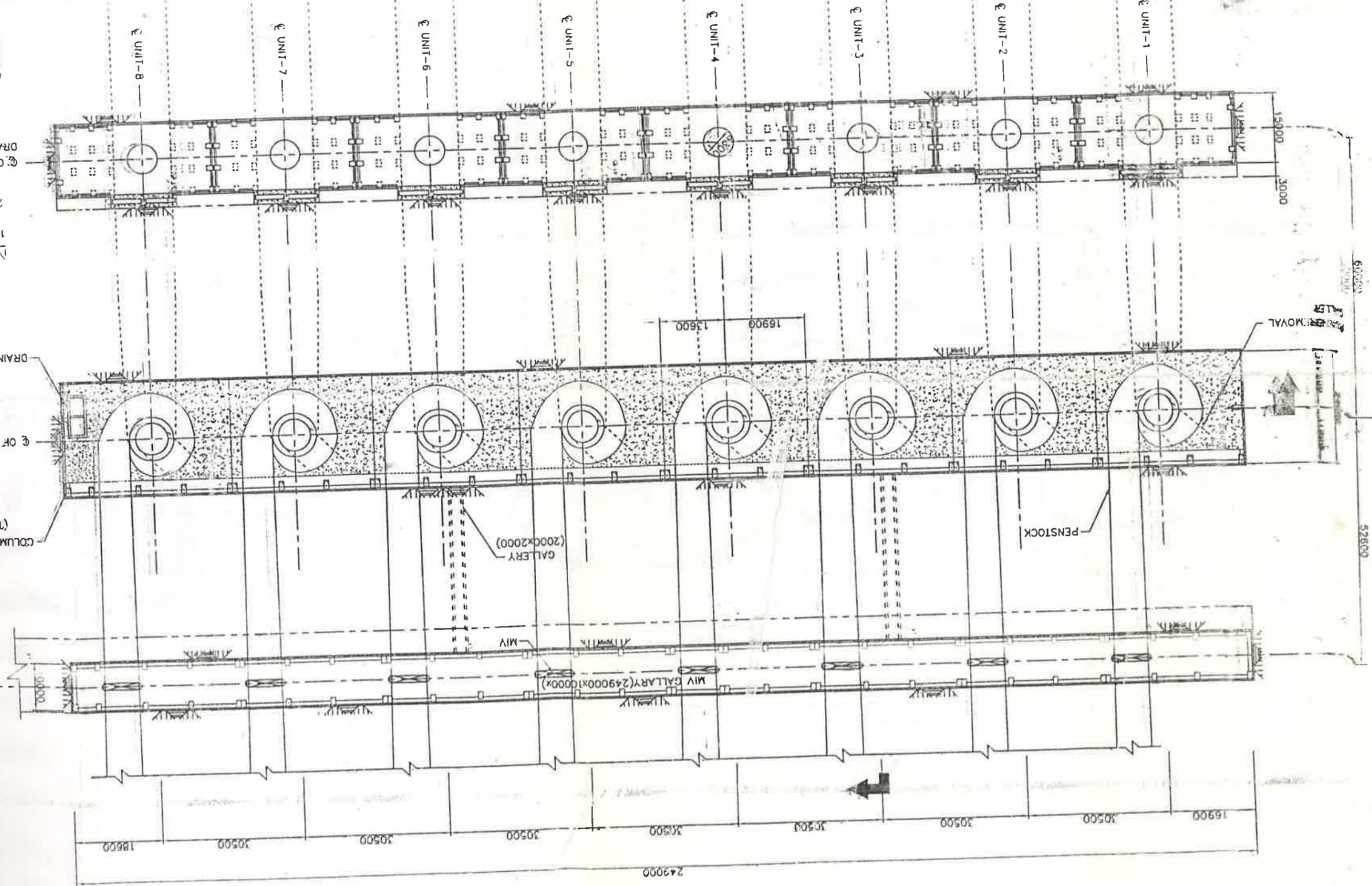
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DRAINAGE AND DEWATERING SUMP



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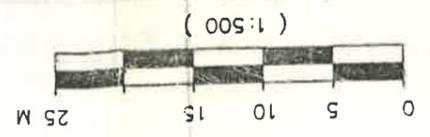
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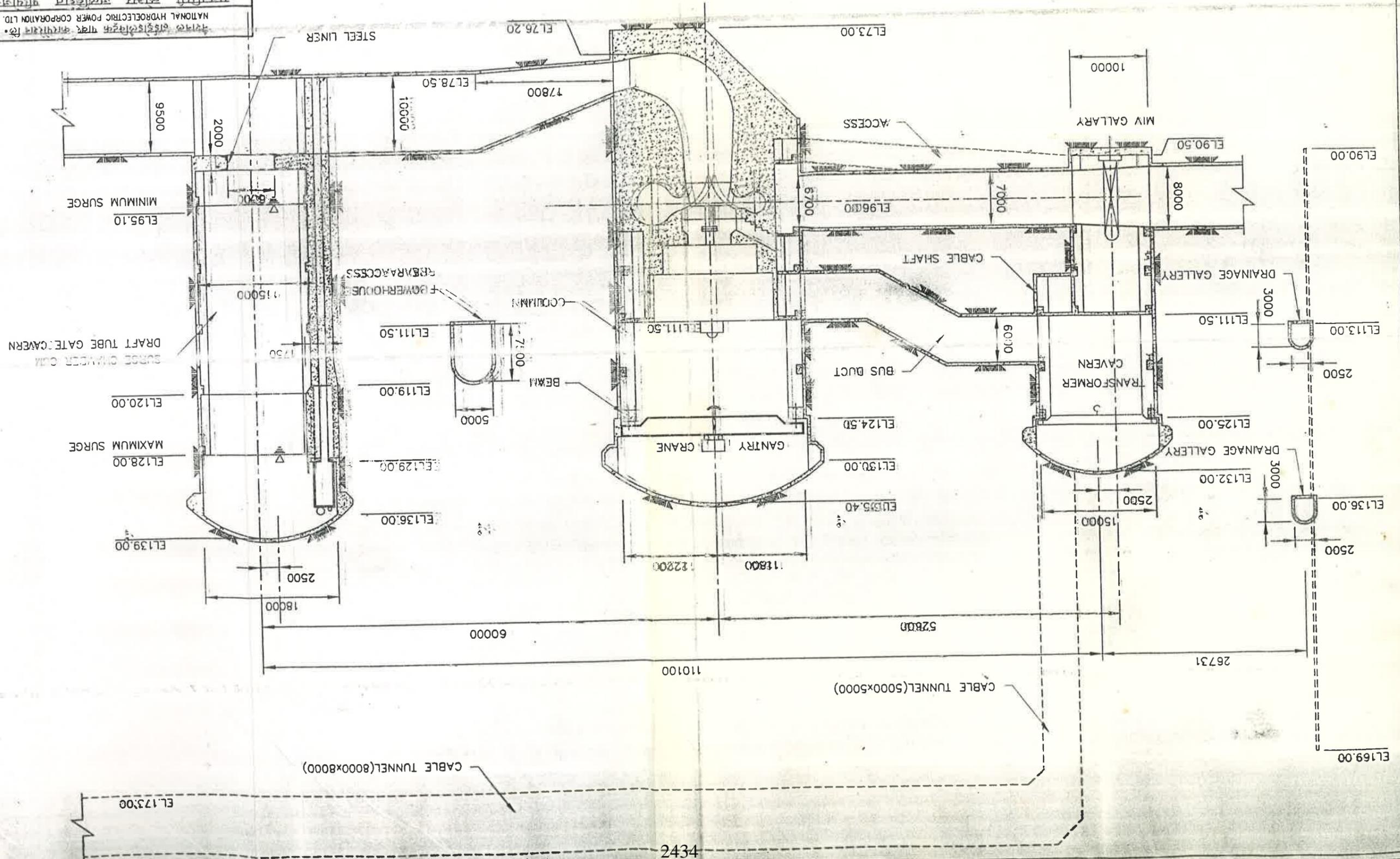
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APPROVED	SK
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COMPANY	NATIONAL HYDROELECTRIC POWER CORPORATION LTD.

CROSS SECTION
POWER HOUSE COMPLEX

NOTES
1 ALL DIMENSIONS ARE IN MILLIMETRE AND ELEVATIONS ARE IN METRE.
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CROSS SECTION



NHPC LIMITED
(A GOVT. OF INDIA ENTERPRISE)



**Subansiri Lower HEP Project (8X250 MW=2000 MW)
in Arunachal Pradesh/ Assam**



**ADDENDUM
TO
CONCURRED DETAILED PROJECT REPORT**

FARIDABAD

FEBRUARY 2018

**Subansiri Lower HE Project (2000 MW) in Arunachal Pradesh/ Assam
(ADDENDUM TO THE CONCURRED DPR)**

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Certificate



एनएचपीसी लिमिटेड
(भारत सरकार का उद्यम)

NHPC Limited
(A Government of India Enterprise)

संदर्भ सं./Ref. No. NH/DP/IP/SLP-MOC

फोन/Phone : _____

दिनांक/Date : 26/02/2018

CERTIFICATE

This is to certify that all the changes/ modifications carried out by M/s NHPC and as examined & approved by CEA/CWC/GSI/CSMRS during the appraisal process subsequent to approval of DPR in Dec. 2003, have been incorporated in "Addendum to the Concurred DPR" of Subansiri Lower HE Project (2000 MW) in Arunachal Pradesh/ Assam.

Balraj Joshi
Director (Technical)

बलराज जोशी / BALRAJ JOSHI
निदेशक (तकनीकी) / Director (Technical)
एन एच पी सी लिमिटेड / NHPC Limited
(भारत सरकार का उद्यम / A Govt. of India Enterprise)
सैक्टर-33, फरीदाबाद / Sector - 33, Faridabad

Approval of Memorandum of Changes



भारत सरकार

Government of India

विद्युत मंत्रालय

Ministry of Power

केन्द्रीय विद्युत प्राधिकरण

Central Electricity Authority

सचिव का कार्यालय

Office of Secretary

परियोजना मूल्याङ्कन समन्वय निदेशालय

Project Appraisal Co-ordination Directorate

पत्र सं. 2/NHPC/²⁶~~37~~/CEA/05-PAC/3174-76

दिनांक : 11.12.2017

**Chairman & Managing Director,
M/s NHPC Ltd.,
NHPC Office Complex, Sector-33,
Faridabad -121003 (Haryana)**

Sub : Subansiri Lower HEP (2000 MW) in Arunachal Pradesh - Memorandum of Changes reg.

Sir,

Reference is invited to NHPC letter no. NH/PD/IP/SLP/2890 dated 05.11.2013 & no. 1810 dated 14.10.2015 submitting therewith proposal of "Memorandum of Changes (MoC) carried out in features from the appraised DPR" of Subansiri Lower Hydro Electric Project (2000 MW) in Arunachal Pradesh for approval of CEA.

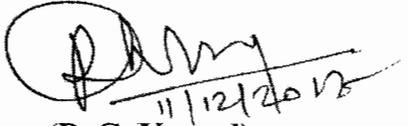
Based on the observations and clearances issued by CEA/CWC/GSI/CSMRS during the examination of MoC and also after the deliberations on various issues, the Authority have accepted the recommendations of appraising groups on Memorandum of Changes from approved DPR for Subansiri Lower Hydro Electric Project (2000 MW). The Salient features approved earlier while concurring the DPR (13.01.2003) and now approved in the form of Memorandum of Changes are given at Annexure.

कमरा सं. 322, सेवा भवन, आर.के.पुरम-1, नई दिल्ली-110066 टेलीफैक्स: 011-26108476 ईमेल: directorpac@nic.in वेबसाइट: www.cea.nic.in

Room No. 322, Sewa Bhawan, R.K Puram-I, New Delhi-110066 Telefax: 011-26109742 Email: directorpac@nic.in Website: www.cea.nic.in

In this regard, the final approval letter shall be issued after the fulfillment / receipt of six sets of the "Addendum to the Concurred DPR" incorporating all the changes / modifications carried out and as examined & approved by CEA/CWC/GSI/CSMRS during the appraisal process subsequent to approval of DPR in Jan., 2003 along with a Certificate by the Appropriate/Competent Authority, not below the rank of Director on the Board, of M/s NHPC Ltd. certifying the same, for the record of the Authority within one month of issuance of this letter.

Encl: As Above



(P. C. Kureel)

Secretary, CEA

Ph. 011-26108476

Email: prabhat.kureel@gov.in

Copy for Information to:

1. Chief Engineer (HPA-II), CEA
2. Chief Engineer (Planning), M/s NHPC Ltd., NHPC Office Complex,
Sector-33, Faridabad -121003 (Haryana)

Salient Features

Subansiri Lower HEP (8x250 MW=2000 MW) in Arunachal Pradesh by NHPC Ltd.

Memorandum of Changes from Concurred DPR

		As per Concurred DPR	As per Memorandum of Changes
1.	DIVERSION TUNNEL		
	Length	From 485m to 640m (Total 3.4 km)	From 493m to 693m (Total 4 Km)
2.	Dam		
	Height of dam above deepest foundation level	133m	125m
3.	SPILLWAY		
	CREST ELEVATION	EL 150m	EL 145m
	Number & size of Spillway Opening	9 NOs; 11.5m X 14.7m	9 NOs; 11.5m X14.0m
	Cut-off Wall	U/s cut-off wall beneath overflow & part NOF.	<ul style="list-style-type: none"> • U/S cut-off wall under overflow & all NOF blocks. • D/S cut-off wall in central spillway portion
4.	HEAD RACE TUNNEL		
	Length	From 225m to 390m (Total Length=2.2 km)	From 608m to 1164m. (Total Length = 7.2 Km)
5.	Surge Chamber		
(a)	U/S Surge Chamber		
	Number of Compartment & Size		<ul style="list-style-type: none"> • 8 nos. surge chambers of size 26 m x 16 m x 62 m.
	Surge tunnels	No provision due to underground power house.	<ul style="list-style-type: none"> • 8 Nos. Surge Tunnels • 9.5m Dia. • Horse Shoe Tunnel • Total length 3545m. • Length varying from 400m to 485m
(b)	D/S Surge Chamber Cum Draft Tube Gate Cavern		

	Size	15 m X 62.5m X 249m (Compartmented into 8 Numbers)	Not required now.
6.	Pressure Shaft		
	Diameter	8m	9.5/8/7m
	Length	Vertical 68.25m + 48m horizontal	192m to 215m (Vertical portion part 48m) (Steel lined portion of 155m).
7.	POWER HOUSE		
	Type	Underground	Surface
	Power House Cavern	337 mx24m X 62.4m	288mX 61m X 64m
	Transformer cum MIV Cavern	327mx15m X 42.0m	-
	Bus Duct Gallery	6m X 6m x 30m	-
8.	Draft tube opening	12m X 10m including intermediate piers of 2.0 m width	3 m X 5.75m x 7.5m for each unit
9.	TAILRACE TUNNEL/CHANNEL	Tunnel	Channel
	Shape	Horse Shoe shaped	-
	Length	From 450m to 780m	35m
	Diameter	9.5m	-
	Width	-	206m
10.	SWITCHYARD		
	SIZE & LOCATION	100m X 300m at EL 190m	Pothead yard between A to B line at EL.136.00m
11.	ACCESS TUNNELS		
	Size	8m D-Shaped	9m D-Shaped
	Total Length	2422m	2161m for HRT,PS top and bottom .
	Size	5mX 7.5m, D - shaped	9.0m, D-Shaped
	Total Length	343m	1568m for Surge Tunnel
	Size	9m X 10m, D - shaped	-
	Total Length	300m	-
12.	Spillway Radial Gates		
	Crest Elevation level	EL 150 m	EL 145 m
	Opening size	11.5m x 16m	11.5m x14.0m
13.	Spillway Bulkhead Gates		

	Crest Elevation level	EL 150 m	EL 145 m
	Opening size	11.5 x 14.7 m	11.5 m x 16.34 m
	Operating head	55 m	60 m
14.	Draft tube gates		
	No. of gates	2 Nos. / Unit	3 Nos. / Unit
	Opening size	5.0 m x 10.0m	5.77m x 7.5 m(Mid)/5.74mx7.5m(Ends)
	Hoists	1 No. Gantry Crane	24 Nos. Rope Drum Hoists
15.	Diversion Tunnel Gates		
	Gate Size	3.75m x 9.5 m	3.75 m x 10.253m
16.	Pressure Shaft		
	PS-1 to PS-8	9.5m dia to 8.0 m dia travel about 36 m horizontally; then	9.5 m dia to 8.0 m dia travels about 13.5 m horizontally; then
		Drops vertically from EL159.5 m to EL96.0m.	Drops vertically from EL139.75 m to EL114.0 m
		Bottom horizontal limb, having a length of 35 m connects to the reducer cone near MIV gallery.	Bottom horizontal limb, having a length of 35 m,, the diameter further reduces to 7.0 m. from transition after travelling horizontally about 49 m liner connects to MIV
17.	Tailrace stop log gates	One set of stop logs for opening size of 9.5m x 9.6m	-

Salient Features

9177
SUBANSIRI LOWER H.E PROJECT (8 X 250 MW= 2000MW)

Salient Features

	<u>PARTICULARS</u>	<u>AS PER CONCURRED DPR</u>	<u>AS PER APPROVAL TO MEMORANDUM OF CHANGES</u>
1	LOCATION		
	State	Arunachal Pradesh/ Assam	No Change
	District	Lower Subansiri /Dhemaji District	No Change
2	HYDROLOGY		
	Catchment Area (Sq.Km)	34900	No Change
3	RESERVOIR		
	Full Reservoir Level (M)	205	No Change
	Minimum Reservoir Level (M)	190	No Change
	Minimum Draw Down Level (M)	181	No Change
	Gross Storage (Mcum) at EL 205m, 190m, 181m	1365, 923, 720	No Change
4	DIVERSION TUNNEL		
	Number/Size (m)	5	No Change
	Size	9.5 (dia)	No Change
	Shape	Horse Shoe	No Change
	Length	From 485M to 640M (Total 3.4 km)	From 493M to 693M (Total 4 Km)
	Diversion Capacity (Cub.m/second)	4,550	No Change
5	DAM		
	Type	Concrete Gravity Dam	No Change
	Top Elevation of Dam (m)	210	No Change
	Height of Dam above River Bed Level (m)	116	No Change
	Height of Dam above Deepest Foundation Level (m)	133	125
6	SPILLWAY		
	Design Flood(Cumec)	37500	No Change
	Crest Elevation	EL 150M	EL 145M
	Number & Size of Spillway Opening	9 NOS; 11.5M X 14.7M	9 NOS; 11.5M X 14.0M
	Cut-off Wall	U/s cut-off Wall beneath overflow and part NOF.	<ul style="list-style-type: none"> • U/S cut-off wall under overflow & all NOF blocks. • D/S cut-off wall in central spillway portion .
7	INTAKE		
	Invert Level (m)	160	No Change
	Number & Size of Gate Opening	8 NOS; 7.3 M X 9.5 M	No Change
8	HEAD RACE TUNNEL		
	Number	8	No Change
	Size & Shape	9.5M Dia, Horse Shoe	No Change
	Length	From 225M to 390M (Total Length= 2.2 km)	From 608M to 1164M. (Total Length = 7.2 Km)
	Design Discharge	322.4 Cumecs	No Change

LTPC
SUBANSIRI LOWER H.E PROJECT (8 X 250 MW= 2000MW)

Salient Features

9 SURGE CHAMBER			
(a) U/S SURGE CHAMBER			
	Number of Compartment and Size		8 Nos. Surge chambers of size 26M X 16M X 62M
	Surge Tunnels	No provision due to underground power house.	8 Nos. Surge Tunnels • 9.5 M Dia. • Horse Shoe Tunnel • Total length 3545m. • Length varying from 400m to 485m
(b) D/S SURGE CHAMBER CUM DRAFT TUBE GATE CAVERN			
	Size	15 M x 62.5M X 249M (Compartmented into 8 nos.)	Not required now
10 PRESSURE SHAFT			
	Number	8	No Change
	Shape	Circular, Steel Lined	No Change
	Diameter	8M	9.5/ 8/ 7M
	Length	Vertical 68.25 M + 48 M horizontal	192 M to 215 M (Vertical portion part 48 M) (Steel lined portion of 155M).
11 POWER HOUSE			
	Type	Underground	Surface
	Installed Capacity	2,000 MW	No Change
	Number of Units	8	No Change
	Power House Cavern	337M X 24M X 62.4M	288M X 61M X 64M
	Transformer cum MIV Cavern	327M X 15M X 42.0M	-
	Gross Head / Design Head	91M / 86M	No Change
	Diameter of MIV	7M	No change
	Bus Duct Gallery	6M X 6M X 30M	-
	Draft Tube Opening	12M X 10M including intermediate piers of 2.0M width	3 X 5.75M X 7.5M for each unit
12 DESIGN ENERGY (Gwh)			
	Subansiri Lower (Alone)	7421.59	No Change
13 TAILRACE TUNNEL/CHANNEL			
		Tunnel	Channel
	Shape	Horse Shoe Shaped	-
	Length	From 450M to 780M	35M
	Dia	9.5M	-
	Width	-	206M
14 SWITCHYARD			
	Size & Location	100M X 300M AT EL 190M	Pothead yard between A to B line at EL 136.00M
15 ACCESS TUNNELS			
	Size	8M D-SHAPED	9.0M D-SHAPED
	Total Length	2422M	2161M for HRT,PS top and bottom
	Size	5M X 7.5M D – Shaped	9.0M , D-Shaped
	Total Length	343M	1568M for Surge Tunnel
	Size	9M X 10M D – Shaped	-
	Total Length	300M	-

SUBANSIRI LOWER H.E PROJECT (8 X 250 MW= 2000MW)			
Salient Features			
16	SPILLWAY RADIAL GATES		
	Crest Elevation Level	EL 150M	EL 145M
	Opening Size	11.5M X 16M	11.5M X 14M
17	SPILLWAY BULK HEAD GATES		
	Crest Elevation Level	EL 150M	EL 145M
	Opening Size	11.5M X 14.7M	11.5M X 16.34M
	Operating Head	55M	60M
18	DRAFT TUBE GATES		
	No. of Gates	2 Nos./Unit	3 Nos./Unit
	Opening Size	5.0M X 10.0M	5.77M X 7.5M (Mid)/ 5.74M X 7.5M (Ends)
	Hoists	1 No. Gantry Crane	24 Nos. Rope Drum Hoists
19	DIVERSION TUNNEL GATES		
	Gate Size	3.75M X 9.5M	3.75M X 10.253M
20	PRESSURE SHAFT		
	PS-1 to PS-8	9.5M dia to 8.0M dia travel about 36M horizontally; then	9.5M dia to 8.0M dia travels about 13.5M horizontally; then
		Drops vertically from EL 159.5M to EL 96.0M.	Drops vertically from 139.75M to 114.0M
		Bottom horizontal limb, having a length of 35 M connects to the reducer cone near MIV gallery.	Bottom horizontal limb, having a length of 35M, the diameter further reduces to 7.0M from transition after travelling horizontally about 49 M liner connects to MIV.
21	TAILRACE STOP LOG GATES	One set of stop logs for opening size of 9.5M X 9.6M	-

Background Note

Background Note on Memorandum of Design Changes from DPR (Civil)

1) Introduction

Subansiri Lower Hydroelectric project planned with an installed capacity of 8 x 250 MW is currently under execution by NHPC. The project is located 2.3 km upstream of Gerukamukh, bordering Assam and Arunachal Pradesh, with the left abutment of the dam located in Assam and the intake and power components in Arunachal Pradesh.

The project envisages utilisation of 91 m of gross head by construction of a 125 m high concrete gravity dam from deepest foundation level. Spillway for concrete dam is designed for a probable maximum flood (PMF) of 37,500 Cumecs. To pass spillway design flood, 9 bays of spillway opening each of size 11.5 m X 14.0 m with crest at El 145 m have been proposed. The water is lead to head race tunnels through 8 nos. intake structures with invert at El. 160 m. Eight (8) numbers, 9.5 m finished diameter horse shoe shaped concrete lined head race tunnels have been proposed. The length of the tunnels varies from 608 m to 1164 m. For u/s surge arrangement, 8 nos individual surge tunnels of 9.5m finished diameter inclined at 1V in 10H with 8 nos vertical shafts of 9.5m diameter of height varying from 9.25m to 11.9 m have been provided. The length of each of 8 nos. surge tunnels varies from 485m to 400m. In the d/s of each head race tunnel, steel lined pressure shaft of 8 m /7 m finished diameter of varying length 192 m to 215 m has been proposed. Surface power house of size 288m X 61m X 64m is proposed with installed capacity 2000MW(8 nos. X 250MW) utilizing 322.4 cumecs design discharge at gross head 91m.

2) Background

2.1) DPR

Detailed Project Report was prepared first by the Brahmaputra Board and it was later handed over to NHPC. DPR of Subansiri Lower H.E .Project of installed capacity of 2000 MW with 8 units each of 250 MW was prepared in Jan. 2001 with an underground power house, MIV cum transformer cavern and downstream surge chamber cum draft tube cavern.

DPR proposal was accepted and cleared by CEA during Techno-economic clearance (TEC) in Jan 2003. TEC has since been accorded vide letter No.2/NHPC/26/01-PAC/207-34 dated 13.01.2003 (copy enclosed).

3) Post DPR Changes in the project vis a vis approved DPR

After obtaining TEC, pre-construction stage investigations were taken up as per the advice of CWC(Refer CWC's letter No:3/387/2002-C&MDD (NW&S)Dte398/401 dated 7/11/2002 & 02/1/02/M(S)/NWS/586-87 dated 13.11.02. As suggested by CWC , studies were taken up for feasibility of type of power house and after studies, underground power house arrangement was changed to surface type with a provision of u/s surge arrangement and deletion of tailrace tunnels and d/s surge chamber. During construction also, some changes were required to be made in surge and pressure shaft arrangement as per site/geological/ construction conditions. Modifications in dam spillway arrangement were made as per recommendations of Dam design Review panel (DDRP). Thus the following changes in Subansiri Lower H.E. Project have been made:-

- 1) Changes in Power house area arrangement from underground to surface.**
- 2) Changes in surge arrangement.**
- 3) Changes in pressure shafts General arrangement.**
- 4) Changes in dam spillway sections as per DDRP.**

The details & chronology of the changes are described below:-

3.1) Changes in Power house area arrangement from underground to surface

DPR of Subansiri Lower H.E. Project was submitted to CEA in June 2001 for TEC. TEC has since been accorded vide letter No.2/NHPC/26/01-PAC/207-34 dated 13.01.2003.

In DPR, an underground power house along with two other caverns, namely transformer cum MIV cavern on upstream and Surge chamber cum draft tube gate cavern on downstream was envisaged. During DPR, an underground power house was preferred over surface power house mainly because of topographical constraints and long monsoon season in that area. However, the caverns did require an elaborate rock support arrangement because of low engineering/strength parameters of rock. In view of this, provisions of 120 T and 60 T cable anchors were also kept in DPR. A drift was proposed running for entire length of power house which was still to be taken up by the time of submission of DPR.

The adoption of underground power house for this project had long been deliberated in CWC and apprehensions on efficacy of rock support in rock having low engineering properties were

apprehended. During discussions, it was informed by NHPC that a detailed analysis based on mathematical modeling shall be undertaken. Moreover, CWC suggested additional investigations to ascertain the engineering properties as well, as efficacy of rock bolts before the detailed design of the caverns. DPR with underground power house was accepted and cleared for TEC with keeping additional provision on account of further investigations and consequential incorporation in the structural design. (Refer CWC's letter No: 2/1/02/M(S)/NWS/586-87 dated 13.11.02.)

Consequently, numerical analysis on Flac 3D was carried out in absence of in-situ stress of that area, it was assumed on the basis of experience. The result indicated that caverns could be made stable by increasing the distance between upstream two caverns from 30.8m to 50.0m. Since the distance between downstream two caverns cannot be increased as that has bearing on efficiency and effectiveness of surge control, the rock wall between them could be made stable by providing pre-stressed cable anchors extending from one cavern to other. The important parameter that surfaced in this study was that the caverns need to be located under maximum rock cover of 120.0m. Further construction of drift was taken up and by now, had advanced to 275m in power house cavern area. To establish the in-situ stress, instrumentations in a test section in the drift within the PH cavern area had also been undertaken.

In light of the above studies, it became clear that the underground power house caverns though can be stabilized but the same shall require re-alignment of caverns to reduce the rock cover over the caverns and more importantly shall require an experienced and highly skilled constructing agency to undertake the work with meticulous planning. Needless to say, such large caverns in sandstone having low engineering properties shall be first of its kind internationally. However, any lapse in planning and construction phase from the constructing agency may jeopardize the whole project. In India, experience of constructing agencies i.e. civil contractor in underground caverns has not been substantive & encouraging. Surface excavation though, more cumbersome in execution in area having intensive monsoon, has less geological uncertainties. Hence provision of a surface power house was explored even though prima-facie topographical constraints and effect of long monsoon season on construction work does not support its consideration in straightway.

In this alternative, the power house has been located between two nallahs about 600m downstream of Dam axis, near to the river bank leading to increase in length of water conductor

system. But it may be clarified that with elimination of TRT, the total length of water conductor system has reduced from the combined length of earlier proposed HRT and TRT. With longer HRT's, requirement of surge tank in the u/s water way had arisen. MIV has been proposed on u/s of machine hall. Transformers and GIS have been proposed to be located d/s of machine hall. Tail race channel has been provided now to lead water from power house back to river Subansiri. It is well understood that, because of available topography, surface power house involved huge excavation and huge excavation cut slopes which are as high as 150m.

Advantage for surface excavation for power house in the instant case are (a) reduced geological uncertainties during construction and (b) less problem due to more experience of construction agencies in India in surface excavation vis-a-vis underground excavation outweighs advantages of underground power house.

The said change was intimated to CEA by NHPC vide letter no.NH/PD/PC/SUB (L)/2060 dt.02.09.2013 along with a technical note comprising the reasons for change.

Also, consequent to the change in type of powerhouse, the dimensions of the powerhouse were modified from 337m x 62.4m x 24m in DPR to 288mx 61m x 64 m. In view of the above, the type of powerhouse was modified from underground to surface type. This change in type of Power house necessitated the change in water conductor system, addition of upstream surge chamber, deletion of tailrace Tunnels & d/s surge arrangements.

The revised layout drawings of water conductor system & Power house arrangement issued during implementation are enclosed.

Tenders were accordingly issued during 2003 for surface power house and associated water conductor system with u/s surge arrangement. The civil works were awarded in December 2003 and contract was formulated in Jan 2004. The construction work was taken up subsequently. The back hill slope excavation for power house & u/s surge chamber was going on till Jan 2008 when a major slide took place in the back hill slope.

3.1. a) PH backhill slope treatment

Surface Power house Geology

Consequent to the change of type of powerhouse, the Surface powerhouse is located on the right bank of Subansiri River. Taking cognizance to the topographical condition vis a vis tunnel alignment and other engineering structures, the surface powerhouse is aligned in N 18°E –

S 18°W direction. This area is occupied with medium grained, grayish colored sandstone upto EL 200m and beyond this; the surface is covered by Talus material having thickness varying between 5m and 8m.

In the tender stage, apart from bedding planes, 3 other sets of discontinuities were anticipated in the area. The surface powerhouse was to negotiate few shear zones having thickness up to of 50mm primarily along bedding planes. Based on the surface geological mapping a zone of closely jointed rock mass of approximately 10m thick was anticipated on back slope of power house. The RMR values derived on the basis of surface and subsurface data indicated Class-III & Class-IV rock. Further it was mentioned in the tender stage that some patches of very poor rock particularly in the vicinity of shear zones shall have to be negotiated and would require appropriate treatment. The Tender stage geological plan & section of powerhouse area have been enclosed.

3.1. b) Power house backhill slope failure & the consequent Changes thereon in Support system in power house back slope

The power house back hill cut slope was under execution when a major slide took place in January 2008. During the Tender Stage it was anticipated that the surface powerhouse would negotiate few shear zones primarily along bedding planes and based on the surface geological mapping a zone of closely jointed rock mass was anticipated on back slope of powerhouse. Prior to slide of powerhouse back slope in January, 2008 the power house back slope was supported with 150 mm thick shotcrete with wire mesh. 32 mm dia 8.0 m long rock anchors below 124.0 m and 25 mm dia 6.0 m long rock anchors above EL 124.0 m were provided @ 3.0 c/c along with 76 mm dia pressure relief holes spaced @ 6.0 m c/c. Apart from above support arrangement, a row of 120 T capacity rock anchors 35.0 m long was provided at EL 126.0 m bench along the entire length of power house.

A minor slide occurred in July 2007 and during the heavy rains of Jan 2008 the gully erosion along the existing shear zone caused a major hill slope failure. An external expert committee was constituted by NHPC on 04.03.2008 to examine the slope failure and suggest improvements in the slope treatment, consisting of the following members:

- 1) Mr. R. Jeyaseelan, Former chairman Central Water Commission.
- 2) Mr. B.M.Hukku, Former Sr. Dy. Director General Geological Survey of India.
- 3) Dr. K.Venkatachalam, Former Director Central Soil and Materials Research Station.
- 4) Mr. Ashok Kumar Chief Engineer (HPM), Central Electricity Authority.

5) Mr. D.Karkun G.M (D &E) NHPC, Co-ordinator.

The committee observed that the slope failure was inferred to be due to a shear zone (140/450) intersecting the power house foundation diagonally. In general, the bed rock comprises mostly of feldspathic sandstone of siwalik group. The rock has been tested to have low permeability of 1 to 3 lugeons. Feldspars are mostly weathered causing deterioration and kaolinisation of the bed rock material apparently above the shear zone. The failure is attributed mainly to this feature and other discontinuities in the form of four sets of joints.

Further the experts committee gave their recommendations vide report dated 22.04.2008 to the management. The committee suggested for additional Geological and Geotechnical investigations (In-situ and Lab tests), detailed stability analysis of back slope based on appropriate rock strength values obtained from laboratory / insitu tests, planned easing out of slope along with rock support by anchors / tendons & adequate instrumentations to monitor the rock behavior for its performance.

NHPC finalized the further line of action to implement the recommendations of external committee. In-situ and Lab tests were conducted through CMRI Dhanbad, CSMRS New Delhi, NIRIM Kolar and IIT Guwahati. The updated geological plan of the Powerhouse area & geological sections were obtained for overall understanding of the geological conditions of the affected zone, enclosed. As per the line of action decided by NHPC, the PH cut slope was analyzed based on available data. The proposal for stabilization of cut slope was finalized based on above analysis and updated geological plan and sections and modified excavation drawings were issued. Cable anchors of 70T capacity, 35m long have been provided all along the slope from unit 3 to unit 6 along with 200Thk. Concrete cladding over 100Thk. Shotcrete with wire mesh along with originally proposed rock supports. Also, 12m long 32mm dia. rock anchors have been provided all along the slope from unit 3 to unit 6. 800mm dia. RCC Dowels have been provided at bench EL.120.80 and EL.114.50 and 600mm dia. RCC dowels have been proposed at the bench of EL93.50 and EL86.00. Accordingly the revised drawings were issued and the same are Enclosed. Prior to failure the excavation was done by drilling and blasting method. After failure the entire slope was excavated by mechanical means. In unit 1, 2, 7 & 8 the rock support arrangement has not been modified. Further, additional instrumentation for monitoring the back hill slope behavior was proposed.

3.2) Changes in Surge Arrangement

3.2.a) Background

DPR stage design conceptualized underground power house in the right bank hill near to dam and hence upstream surge arrangement was not considered. However d/s surge arrangement was envisaged in view of longer tail race tunnels. The size of d/s surge chamber cum draft tube gate operating cavern was 249m(L) x15m(W)/18m(W) x 62.5(H) m. Copies of DPR stage drawings are enclosed. After adopting surface power house, U/s surge chamber was required in view of longer HRTs. 8 nos surge chambers of size 26m x 16m x 62m were required as per transient studies and the same was adopted during tendering and contract formulation as shown in modified General arrangement drawing. Copies of Tender drawings NHSRL-1AT2-41-GA-002 & NHSRL-3DT2-41-GA-009 are enclosed.

During firming up of construction methodology of u/s surge chamber, in view of the experience gained in surface excavation for other structures in the prevailing geological conditions at site till then, project expressed the difficulties and apprehension about the construction of rectangular surge chamber, apprehension about its stability and safety of men and machine, construction of rectangular sides with given support and inability to construct in scheduled time period. Therefore the issue was deliberated in detail with project, geology division, construction equipment planning division, Project scheduling group and construction management group to modify / change the surge chamber to suite the site & construction requirement.

The adopted change was rectangular surge chamber excavation from El.221.50m to El.205.00m with 30m/35m long cable anchors on 400 thick RCC cladding. For surge shafts below El.205m, keeping in view the low rock mass properties encountered in the project area and apprehensions expressed by project, the shape of surge shafts were modified from rectangular to elliptical shape (29.0m x 19.0m finished size) having total excavated size 240m(L)X 21.3M(W) X 62.5(H). The construction methodology for elliptical shaped shafts with excavation of alternate surge chambers was envisaged with rock breakers, normal rock support i.e. concrete and rock anchors /bolts and sequential concreting below El.205.00m. Copy of old construction drawings NH-SRL-3DC2-41DD-330 & 331 showing elliptical shaped surge shafts are enclosed).

3.2.b) Effect of back slope failure on surge arrangement

However after the power house back slope failure, the external expert committee gave following observations in respect of surge shafts (elliptical) in its report:-

- Due to vertical faces of the surge shaft for a length of 240m in such rock conditions, stress /stability analysis to be conducted.
- The rock mass in its present state in the saturated conditions is likely to be exerting pressure on the concrete lining of the surge shaft and hence long term stability is not ensured.
- Due to less cover on the downstream side due to failure of power house back slope, the concrete diaphragm needs to be checked and may require review.
- Additional rock mechanic tests (lab & in-situ) are to be conducted for site specific rock mass properties and potential wedges are to be identified for specific rock support in the surge shafts area

Additional geological investigation and rock mechanic tests as advised by expert committee were conducted which indicated unfavorable rock mass properties for large structures. These test results and geological conditions were found to be adverse than what were considered earlier in design of surge chambers during DPR / Tender stage.

3.2.c) Stress & Deformation studies of construction stage arrangement by IISC, Bengaluru.

As per advice of expert committee, it was decided to go for numerical stress & deformation analysis of surge shafts (elliptical) to understand the deformation characteristics & stability of rock mass and concrete lining during excavation and in the long run for large sized 8 nos. surge shafts in such geological conditions. Analysis by mathematical modeling of the excavation of the odd numbered surge shafts simulating the construction sequence of excavation, placement of shortcrete cladding and provision of either post-tensioned cables or grouted rock bolts before undertaking the next stage of excavation has indicated that excavation cannot be taken below EL 187 m for given set of rock mass parameters. Naturally, the even numbered surge shafts whose excavation was to follow after completion of the odd numbered surge shafts cannot be excavated. Hence the studies conducted at IISc, Bengaluru indicated instability of surge shafts in such geological conditions during construction of initial 4 surge shafts after midway level.

3.2.d) Present surge arrangement

In view of the Stress & Deformation studies carried out by IISC, Bengaluru & its findings, it was felt to totally change the design and layout of surge arrangement for long term stability & durability of the surge arrangement.

The adopted surge arrangement was proposed to have individual surge tunnels of 9.5m finished diameter inclined at 1V in 10H and with vertical shafts of 9.5m diameter & 9.25m to 11.9 m height. The lengths of each of 8 nos. surge tunnels varied from 485m to 400m. The layout was firmed up considering extreme down surge & upsurge levels as \pm El. 171/173m & 212/216m respectively as per Transient studies carried out by NHPC and confirmed by CWPRS, Pune based on mathematical model studies. M/S Alstom, designers of the E & M machines for this project also carried out transient analysis independently and the results were found to be in confirmation with the above transient studies results.

With this layout, 9.5m diameter was chosen as 8 no. HRT of same size were already under execution at project. This would have matched the machinery requirement and construction methodology of HRTs about which project had experience of satisfactory performance in existing rock conditions. With this design & layout, the diameter and height of vertical shafts have been drastically reduced and clear distance between vertical shafts is increased significantly. However, careful construction was required in a stretch of about 100m for each surge tunnels where HRTs below surge tunnels are close and intervening rock cover is comparatively less. Additional rock support measures were required to be included in the design for a stretch of around 100m of each HRTs. Drawing no 333, 334 & 335 showing general arrangement plan and sections of this technical feasible surge arrangement is enclosed. The drawings of modified surge arrangement were forwarded to CEA vide D&E div. letter no-NH/D&E/LS/2087 dated 03.11.2008 (Copy enclosed).

After conceptualization of surge arrangement with 8 nos inclined surge tunnels, detailed designs were taken up for construction drawings and quantity estimates were prepared. Separate contract agreement (LOT-SSL.5) was formulated and the work of surge arrangement was awarded in July 2009 by NHPC for Construction of surge tunnels, surge shafts and associated construction adits. The quantity estimate is given in Part-II document- Revised Cost Estimate.

3.2.d.1) Detailed Design studies of present surge arrangement

With this modified surge arrangement, diameter & height of vertical shafts were significantly reduced w.r.t. previous surge arrangement.

For excavation stability, a 3D numerical stress & deformation analysis was carried out using Software FLAC3D for the given topographical conditions & low cover zones along with the rock mass characteristics.

This study/analysis was carried out for excavation of underground openings without considering advantages of rock anchors, shotcrete, Steel ribs & RCC concrete lining in the analysis to make the model simple and workable. The excavation was found to be stable with the rock mass parameters considered in the analysis. Never the less, the following preliminary & final rock support measures were provided in addition to mechanized excavation in the design & drawings as per site and construction requirements.

- (i) Essential Steel Ribs support in low rock cover zones irrespective of class and steel ribs as per site & geological requirements
- (ii) Steel fibre reinforced shotcrete (SFRS)
- (iii) Rock anchors
- (iv) Contact & consolidation Grouting
- (v) Specialized means like chemical grouting, pipe roofing and advanced probing etc.

In addition to Surge tunnels, the underneath HRT's were additionally supported by essential rib support irrespective of class & RCC lining at low cover zones.

The details of rock support measures for surge tunnels/HRT are given in drawings no- 335, 336, 338 and 509 (copy enclosed).

Further, detailed structural analysis was carried out for design of concrete lining in operation and maintenance conditions for long term stability of surge tunnels arrangement using structural software STAAD-Pro 2006. Analysis for junction of surge tunnel, surge shaft & HRT has been carried out as a 3D problem and the balance portion as 2D problem. However the main focus of the study is design of RCC lining in tunnels and shafts near junction.

The thickness of concrete lining/ RCC lining in surge tunnels is minimum 600 mm in overt & 750mm in invert with enlarged thickness at kerb going up to 1000mm. In Surge shafts of 9.5 m finished dia, thickness of RCC lining is minimum 1000 mm. The details of concrete and reinforcement for lining are given in drawings no-519, 520, 531 and 532 which are enclosed.

3.3) Changes in pressure shafts General arrangement

In view of easing of power house back slope, excavation profiles for power house back slope and its rock support measures got revised which resulted in reduced rock cover over upper portion of some of the pressure shafts. Taking into account the requirement of lateral rock cover over upper portion of the pressure shaft no.2, 3, 4, 5 & 6 at El.161.30m and rock support envisaged on the modified excavation profiles of PH back slope, it was considered necessary to modify the layout of the pressure shafts also by shifting the pressure shafts inside the hill mass to increase the

lateral rock cover so that minimum hindrances are encountered at site during excavation of these penstocks/pressure shafts.

Therefore, it was proposed to shift the pressure shafts no.2, 3, 4, 5 & 6 into the hill mass by around 40m so that the lateral rock cover to power house back slope gets significantly increased and construction of back slope and upper penstocks become manageable. An additional adit of 9m diameter has been proposed to facilitate the HM & civil works of lower penstocks. The typical details of excavation drawings plan & section for pressure shaft-2 & 3 are given in drawings no-317, 320 & 321 which are enclosed. The quantity estimate for additional pressure shafts work along with Adit is given in Part-II document- Revised Cost Estimate.

Hence, with the changes described in above paras, the layout of Water conductor system and power house area arrangement has been revised. Tail race tunnel system adopted in DPR has been replaced by tail race channel of smaller length. HRT length has been increased after deletion of TRT. The D/s surge chamber cum draft tube gate operating cavern adopted in DPR has been replaced by u/s surge tunnels & surge shafts system as per technical requirement.

3.4) Changes in dam spillway section as per DDRP

After obtaining TEC, pre construction stage investigations were taken up as per the advice of CWC (Refer CWC's letter No: 3/387/2002-C&MDD (NW&S) Dte 398/401 dated 7/11/2002. As suggested by CWC, investigations, tests & studies were carried out, u/s slopes of overflow blocks were flattened and drawings were issued for tender as well as for construction of the dam works. The tender drawings showing sections of overflow and NOF blocks are enclosed. The construction work was taken up subsequently. The dam works was going on till December 2011 when the work was stopped due to local protest.

Initially, during 2007-08, protest against the project started gaining momentum from some sections of the civil society in Assam with AASU & KMSS taking the lead. The protest or concerns of locals gradually picked up. At the instance of Govt. of Assam (GoA), in the context of mounting agitation / protests against the project, NHPC constituted an Expert Group (EG) in May 2008 to evaluate the d/s impact of the project. The EG was constituted consisting of professors from IIT-Guwahati, Guwahati University and Dibrugarh University. The Expert Group presented its report in May 2011(part -I & part-II) after a site visit to SLP.

Further, as desired by GoA, NHPC also constituted a Joint Steering Committee (JSC) comprising representatives from BB, CWC, WRD, Government of Assam & Govt. of Arunachal Pradesh ,

IIT-Roorkee and NHPC to examine Part-II recommendations of Expert Group's report and identify feasible measures to take care of possible downstream impacts, flood management , erosion protection etc. and report on their physical/financial aspects. JSC submitted its report in Aug-2012.

At the instance of Prime Minister Office (PMO), the Planning Commission constituted a Technical Expert Committee (TEC) with Dr. C.D. Thatte & Dr. M.S. Reddy Ex. Chairman CWC & Ex. Secretary, Ministry of Water Resources (MoWR) to review the status of SLP and to recommend/report on how NHPC could move forward. TEC submitted the report in July-2012 to Planning Commission with recommendation to form an independent Dam Design Review Panel (DDRP) and/or CWC to review the design features of the dam keeping in view the suspected foundation competency, Energy Dissipation Arrangement (EDA) & adequacy of provision of Cut-off walls. DDRP was constituted by MOP and appointed Chairman, CWC as the chairman of DDRP during December 2012.

DDRP submitted its report to MOP, GOI on 4th June13. The DDRP report has been accepted by Ministry of Power, GOI vide letter dated26.06.2013 and has asked NHPC to take the Project forward on the lines suggested by DDRP. DDRP has recommended some design innovations in the dam spillway layout and profile.

As per the recommendations, the length of the conveyance structure of spillway shall be increased so as to place the plunge pool at a considerable distance that would not allow the scour to reach towards dam foundation on long term basis. The spillway bucket elevations for central bays (S4, S5, and S6 & S7), side bays S3, S8 and extreme bays S1, S2 and S9 shall be kept at different elevations as per the prevailing rock profiles at site to avoid cutting in the already stabilized rock cut slopes. Since the six central bays of spillway shall have the capacity of around 18,000-19,000 cumecs with reservoir water level at El.190M (reservoir elevation during most part of the monsoon as per approved rule curve) in the reservoir, the pre-formed plunge pool would be provided for six central bays only. However, DDRP has recommended to use deflectors for the side bays so that the water jet falls in the plunge pool in case of extreme flood conditions.

3.4.1) Concrete cut-off wall

The issue related to provision of concrete cut-off wall was discussed with CWC during Techno-economic clearance (TEC). Accordingly, 800mm thick and 50m deep u/s cut-off wall has been envisaged by NHPC beneath all spillway blocks and part NOF blocks near the heel through gallery in the dam. The cut-off wall shall be constructed by specialized agency.

The upstream concrete cut-off wall proves to be effective as, it not only provides a continuous and credible seepage cut-off but it is also more durable as it is constructed of concrete which is less prone to deterioration than grout curtains which have inherent drawback of deviation thereby leaving some gap un-grouted. The quantities of concrete cut-off wall are given in Part-II document- Revised Cost Estimate.

DDRP has also recommended to extend the U/s cutoff wall in non-overflow blocks in both abutment and provision of additional d/s cutoff wall in four central spillway blocks. A copy of the DDRP conclusion & the recommendations along with MOP letter dated 26th June13 is enclosed.

3.4.2) Hydraulic model Studies

The additional hydraulic model studies for modified spillway are being taken up at CWPRS, Pune for firming up of the location and size of preformed plunge pool in front of the 6 central Spillway bays i.e. S3 to S8, fine tuning of spillway profiles, study of spillway flow conditions for evolving the aeration arrangement; and to work out the dimensions of the deflector proposed in the bucket of end spillway bays i.e. S1, S2 & S9 for deflecting the jet towards plunge pool proposed to be formed in front of the central bays.

The details of extended spillway plan & section as recommended by DDRP are enclosed.

3.4.3) Stability analysis

DDRP in its report has recommended to carry out the static and dynamic analysis of modified spillway section. Accordingly, Pseudo-static stability analysis (Response –spectrum method) of deepest modified spillway block S4 having base width of 271 m has been carried out as per IS: 6512 and IS: 1893 codal provisions. Though, DDRP has mentioned in its report that the previous sections have been meeting all the requirements of stability all along and were found safe, the

proposed sections with extra large base width will give additional safety to dam foundation by preventing it from erosion and further add to the safety and stability of the dam in the long run.

Gravity dam section is designed on the most adverse load combinations A, B, C, D, E, F or G given below as prescribed in IS :6512-1984:

Load Combination A (Construction condition)

Load combination B (Normal operating condition)

Load combination C (Flood discharge condition)

Load Combination D: Combination A with earthquake

Load Combination E: Combination B with earthquake

Load Combination F: Combination C, but with extreme uplift

Load Combination G: Combination E, but with extreme uplift (drains operative)

The vertical stresses on dam foundation and FOS against sliding & overturning in all prescribed loading conditions given in IS: 6512 are given in below table:

Table. 1. Abstracts of Results of stability analysis

Description	Factor of safety		Normal vertical stresses (MPa)	
	Against overturning	Against sliding	Heel	Toe
Load combination A	-	-	1.34	0.62
Load combination B	2.73	1.94	1.15	0.44
Load combination C	2.35	2.01	1.13	0.24
Load combination D 	7.41	5.17	1.04	0.79
Load combination D1 	21.82	5.84	1.32	0.79
Load combination E 	2.15	1.35	0.90	0.62
Load combination E1 	2.24	1.55	0.86	0.95

Load combination F	1.62	2.95	0.67	0.33
Load combination G 	1.39	1.32	0.35	0.57
Load combination G1 	1.62	1.56	0.63	0.57

As per the above results, it can be seen that the maximum stress on the foundation works out to 1.32MPa against the ultimate bearing capacity of 6.3MPa as recommended by CMRI, Dhanbad based on Plate Load test results conducted on the exposed dam foundation.

The 3-D FEM analysis of modified spillway block S4 has also been carried out using SAP (version 15.0.0) software to work out the stresses and displacement on the dam base besides analyzing the overall behavior of the dam structure for response spectra and time history as per the site specific seismic studies conducted by IITR and approved by NCSDP. The results are comparable with the Pseudo-static stability analysis (Response Spectrum method) and deformations have been found to be minimal.

4) Conclusion

In view of the above, it can be concluded that:-

- Changes in Power house area arrangement from underground to surface was made due to prevailing rock mass characteristics & geotechnical considerations for large size underground excavation stability in spite of topographical constraints & intense monsoon seasons .
Power house back hill slope stabilization was carried out with suitable rock support measures.
- Changes in surge arrangement from d/s surge chamber cum draft tube gate operating cavern to a system of upstream surge tank/ underground tunnels & shafts was necessitated due to change in type of Power house which was due to prevailing Geological , geotechnical, construction, long term stability considerations
- Changes in pressure shafts General arrangement was made by shifting 5 nos pressure shafts (PS-2 to PS-6) inside hill due to low cover zones after power house back slope failure. This change was necessitated due to prevailing site/geological & geotechnical conditions.

- Changes in dam spillway section with extended ski jump bucket and increased base width, relocation of plunge pool far away from Dam toe, extension of u/s cutoff wall under NOF & provision of d/s cutoff wall in central blocks have been made as per DDRP recommendations. These modifications / design innovations in dam spillway are likely to further add to the safety and stability of the dam.

Hence the above changes in the project components and Power House back hill slope stabilization measures were adopted as per requirements of design & satisfactory construction and are considered necessary as per technical and geological requirements and submitted for concurrence by CWC & CEA. Changes in dam spillway sections have been made as per the DDRP recommendations for added safety & stability of the dam.

**BACKGROUND NOTE ON DESIGN CHANGES IN HM COMPONENTS
SUBANSIRI LOWER HE PROJECT**

Subansiri Lower H.E. Project planned with an installed capacity of 8 x 250 MW is currently under execution by NHPC Ltd. The project is situated 2.3 km upstream of Gerukamukh, bordering Assam and Arunachal Pradesh, with the left abutment of dam located in Assam, and the intake structure and power components in Arunachal Pradesh.

DPR was first prepared by Brahmaputra board and was later handed over to NHPC Ltd. DPR of Subansiri Lower HE Project with installed capacity of 2000MW with 8 units each of 250 MW was prepared in Jan-2001. DPR proposal was accepted and cleared by CEA during Techno-economic clearance in Jan-2003 vide letter no 2/NHPC/26/01-PAC/207-34 dated 13.01.2003.

The project envisages utilization of 91 m of gross head by way of construction of a 125 m high concrete gravity dam from deepest foundation level. Spillway for concrete dam is designed for a probable maximum flood (PMF) of 37500 Cumecs. To pass spillway design flood, 9 bays of spillway opening each of 11.5m x 14.0 m with crest at EL 145m have been proposed.

The present memorandum discusses design changes in HM components with respect to DPR stage.

CHANGE IN DESIGN POST DPR:

After obtaining TEC, pre-construction stage investigations were taken up as per the advice of CWC (Ref: 3/387/2002-C&MDD (NW&S)Dte398/401 dated 7.11.2002 abd 022/1/02/M(S)/NWS/586-87 dated 13.01.02.

As suggested by CWC, studies were taken up for feasibility of type of power house ,and after studies, underground type power house was changed to surface type with a provision of u/s surge arrangement, whereas the tailrace tunnels and d/s surge chamber have been deleted.

During construction stage, some changes were required to be made in surge shaft and pressure shaft arrangement as per prevalent geological and site conditions. Modifications in dam spillway arrangement were made as per recommendations of Dam Design Review panel (DDRP). Dam spillway crest level was revised from EL 150m (during DPR stage) to EL 145m (construction stage). The size of the spillway openings have been changed from 11.5m x 14.7m (DPR stage) to 11.5m x 14m (construction stage).

The design change memorandum for Civil works has already been submitted by NHPC vide letter No. NH/DD/D-I/2015/1271 dated 07.09.2015, which is under final stage of clearance by CEA, CWC and GSI. The present memorandum discusses design changes in HM components with respect to DPR having bearing of Project cost in following paragraphs

Change in Spillway Gates in Dam area

During DPR stage, 11.5m x 14.7m opening sized spillway radial gates were envisaged. The crest of spillway was kept at EL 150.0m. During detailed design, hydraulic model studies of spillway area were carried out. As an outcome of the same, the Crest level of spillway was revised to EL 145.0M and size of opening was modified to 11.5m x 14.0m. Accordingly, opening for Spillway bulkhead gates were revised from 11.5m x 17.0m in DPR stage to 11.5m x 16.34m.

Change in HRT/ Pressure shafts:

After finalisation of provision of surface type Power house, revision in pressure shaft No. 2,3,4,5 and 6 was done citing the site conditions and rock support. Accordingly, layout and lengths of above Pressure shafts got revised and re-designed.

Change in HM Components in Power House Area

1. As per MOC on Design changes in HM components submitted to CEA/ CWC, dimensions and type of gates revised for draft tube gates. In view of revised surface Power house, sizes of openings of Draft tube gates have been revised by Civil Design. Accordingly, 3 No. Draft tube gate operated by Gantry crane has been proposed. Further to isolate one generating unit, 3 No. Gantry crane has been envisaged to close the Draft Tube Gates for a generating unit concurrently.

Further, as discussed in Authority meeting held on 08.08.2017 and conveyed vide Gates Dte, CWC letter dated 07.08.2017 (copy enclosed at Annex-A of this section), hoisting arrangement of the gate has been revised to individual rope drum hoists to enable quick isolation of the units under unbalanced head condition, in compliance to CEA guidelines and revised proposal for the same submitted by NHPC to Gates Dte. on 16.08.2017 (copy enclosed at Annex-B of this section). Gates Directorate, CWC has accorded final clearance vis-à-vis Gates Dte vide its letter dated 31.08.2017.

2. Owing to deletion of tailrace structure, 9.5m x 9.6m sized tailrace gates were deleted in construction stage.

- **Spillway Radial Gates :**

Sr. No.	Feature	DPR Stage	Tender Stage
1.	Crest Elevation level.	EL 150m	EL 145m
2.	Opening size	11.5m x 14.7m	11.5m x 14.0m
3.	Operating head (Bulkhead)	55m	60m

- Spillway Bulkhead- Gates :**

Sr. No.	Feature	DPR Stage	Tender Stage
1.	Crest Elevation level.	EL 150m	EL 145m
2.	Opening size	11.5m x 17.0m	11.5m x 16.34m
3.	Operating head (Bulkhead).	55m	60m

- Draft tube gates:**

Sr. No.	Feature	DPR Stage	Tender Stage
1.	No of gates	2 Nos./Unit	3 Nos./Unit
2.	Type of gate	Wheeled type	Slide type
3.	Opening size	5.0m x 10.0m	5.77m x 7.5m
4.	No of Gantry Cranes	1 Nos.	3 Nos.

- Diversion Tunnel gates:**

Sr. No.	Feature	DPR Stage	Tender Stage
1.	Gate Size	3.75m x 9.5m	3.75m x 10.253m

- Pressure Shaft:**

Sr. No.	Feature	DPR Stage	Tender Stage
1.	-	9.5m dia to 8.0m dia travels about 36m horizontally; then	9.5m dia to 8.0m dia travels about 13.5m horizontally; then
2.	-	Drops vertically from 159.5m to 96.0m.	Drops vertically from 139.75m to 114.0m.
3.	-	Bottom horizontal limb, having a length of 35m connects to the reducer cone near MIV gallery.	Bottom horizontal limb, having a length of 35m, the diameter further reduces to 7.0m. From transition after travelling horizontally about 49m liner connects to MIV

- ***Tailrace stop log gates:***

Sr. No.	Feature	DPR Stage	Tender Stage
1.	-	One set of stop logs for opening size of 9.5m x 9.6m	Stands deleted.

CONCLUSIONS:

The proposed modifications would ensure satisfactory performance of the Hydro-Mechanical components on a long term basis for all the prescribed loading conditions as mentioned in relevant IS codes.

S.No.	Details of Items	TEC APPROVED QUANTITIES (DPR Stage)				FINAL QUANTITIES				Remarks
		Size	Nos./Set	Wt./Set (MT)	Total Wt. (MT)	Size	Nos./Set	Wt./Set (MT)	Total Wt. (MT)	
1	DIVERSION TUNNEL WORKS									
	Gate (Fixed Wheel Gate)	3.75m x 9.5m	10	50	500	3.75m x 10.253m	10	38.09	380.9	Height of gate slightly raised
	Embedded Parts		10	17	170		10	17	170	
	Rope Drum Hoist 100 T capacity		10	30	300		10	30	300	
	Host supporting structure & tresties		10	22	220		10	22	220	
2	SPILLWAY STRUCTURE									
a	Radial Gates	11.5m x 14.7m	9	210	1890	11.5m x 14.0 m	9	400	3600	Heights of gates slightly reduced.
	Embedded Parts (including anchorages)		9	105	945		9	150	1350	
	Hydraulic hoist 500 T cap (2 x 250 for each gate)		9		LS		9		LS	
	Power packs									
b	Bulkhead Gates	11.5m x 17.0 m	2	285	570	11.5m x 16.34m	2	285	570	
	Embedded parts		9	90	810		9	90	810	
	Lifting Beam		1	10	10		1	10	10	
	Gantry Crane 410 T Capacity with cross travel		1		LS		1		LS	
3	INTAKE STRUCTURE									
a	Intake Gate (Fixed Wheel Type)	7.3m x 9.5m	8	110	880	7.3m X 9.5m	8	110	880	No Changes
	Embedded Parts for Intake Gate		8	33	264		8	33	264	
	Rope drum hoist 200T Capacity each		8	60	480		8	60	480	
	Hoist Platform & Tresties		8	33	264		8	33	264	
b	Bulkhead gate (Slide type)	7.3m x 9.5m	2	110	220	7.3m x 9.5m	2	110	220	
	Embedded Parts for Bulkhead Gates		8	33	264		8	33	264	
	Gantry Crane 160 T capacity		2		LS		2		LS	
	Lifting Beam		2	5	10		2	5	10	
c	Bypass Filling Valve (Knife Edge Type)	600mm dia	16			600mm dia	16			
	Pipes (Approx Length 50m each)	600mm dia	8	7.5	60	600mm dia	8	7.5	60	
4	TRASH RACKS /TRASH RACK CLEANING MACHINE									
a	Trash Rack Cleaning Machine (1T cap)		2		LS		2		LS	
b	Trash Racks and Embedded Parts	7.5 x 24	16	27	432	7.5 x 24	16	27	432	
5	DRAFT TUBE GATE									
	Gate	5.00 x 10.00	16	50	800	5.77m x 7.5m (M)	24	41	984	Numbers, Width and height of the gates changed. Hoisting arrangement revised.
	Embedded Parts for Draft Tube Gate		16	15	240	5.74m x 7.5m (End)	24	12	288	
	Hoist Arrangement	70T Cap Gantry Crane	1	LS		(60T Cap Rope Drum Hoists)	24	LS		
			1	5	5					
6	TAIL RACE									
a	Outlet Stoplog	9.5m x 9.6m	1	60	60	-	-	-	-	Component has been selected
b	Embedded Parts		8	15	120	-	-	-	-	
c	Lifting Beam		1	3	3	-	-	-	-	
7	STEEL LINER									
	Penstock Liner (incl. bend & transition)		8	1159.375	9275		8	1366.75	10934	Length and weight of steel liner has been increased
8	Instrumentation, Computerised Control and SCADA System	LS	1	LS		LS	1	LS		No changes
9	Diesel Generator Set (500 KVA)		1	LS			1	LS		No changes

6th Floor, Sewa Bhawan
New Delhi-110066

दिनांक: 7/8/2017

विषय: Meeting for approval of Memorandum of changes in respect of Subansiri Lower HEP (2000 MW) in Arunachal Pradesh by M/s. NHPC Ltd.

संदर्भ : Letter No. 2/NHPC/26/CEA/2001-PA(C)/1816-1835 dated 04.08.2017.

Please refer to the letter dated 04.08.2017 on the above mentioned subject. It is mentioned that Memorandum of changes for Subansiri Lower HEP was cleared by CWC vide letter No. 27/04/09/GD(NW&S)/388-390 dated 29.08.2016.

However, following points may be reconsidered in case construction of relevant components have not been taken up:

1. As per the Gazette notification of CEA dated 20th Aug, 2010 (Clause 39, Para 8), provision of individual hoist mechanism for draft tube gates of each unit may be considered for quick closing. The Draft tube Gate shall be capable of closing under unbalanced condition of water pressure.

Project authorities has proposed 3 no's of slide type gate of size 5.77 m x 7.5 m operated by gantry crane for each unit. This provision will not satisfy the requirement of quick lowering under unbalanced condition as defined by the CEA guidelines. Project authorities may be advised to relook these provisions provided the civil construction, fabrication & erection of gate & hoist arrangement permits. Possibility of reducing number of Draft Tube Gates per unit may also be explored.

2. Vide 'Weight estimation for HM works', item no. 2, size of Radial Gate has been reduced from 11.5 m x 14.7 m to 11.5 m x 14.0 m with the increase of water Head by 5m. However, the weight of corresponding gates/embedded has increased from 210 & 105 MT to 400 & 150 MT respectively which appears to be significantly higher. The project authorities may relook the weight estimation.

This issue with the approval of Chief Engineer, Designs (NW&S).

(हरकेश कुमार)

(Harkesh Kumar)

निदेशक /Director

निदेशक /Director

Puram, New Delhi

CWC U.O. No. 27/04/09/GD(NW&S)/388-390 dated 29.08.2016

Copy to:

Director, PAO, Sewa Bhawan, R.K. Puram, New Delhi- 110066



एन एच पी सी लिमिटेड

(भारत सरकार का उद्यम)

NHPC Limited

(A Government of India Enterprise)

संदर्भ सं./Ref. No. No. NH/D&E/ED (D&E) /2017-18/SLP/ 1774

फोन/Phone : _____

दिनांक/Date : 16.08.2017

The Secretary,
Central Electricity Authority,
2nd Floor, Sewa Bhawan, R K Puram
New Delhi-110066.

Sub: - Memorandum of Changes in respect of Subansiri Lower HEP- regarding queries of Gates Design (NW&S) Directorate, CWC dated 07-08-2017.

Sir,

During the meeting held on 08-08-2017 for consideration of clearance of Memorandum of Changes (MOC) of Subansiri Lower Project, letter no. 27/04/2009/GD(NW&S)/216-217 dated 07-08-2017 of Director, Gates Design (NW&S) Directorate was received for reply. In the above mentioned letter Gates Design (NW&S) Directorate, CWC has asked for reconsideration of some points in respect of Draft Tube & Radial gates of the project.

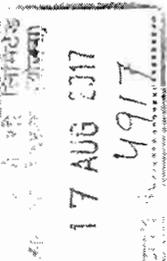
In this regard point wise clarifications are enclosed as **Annexure-1** to this letter. It is requested to consider these clarifications and grant clearance to the Memorandum of Changes.

Thanking You,

Yours Sincerely,
Narendra Kumar
16/8/17
(Narendra Kumar)
Executive Director (D&E)

Copies:-

- ✓ 1. ED(Corporate Planning Division)
2. ED (DEM) - As discussed with Director (Technical), compliance to CEA guidelines is being conveyed through this letter read with Annexure-1. Provision of individual rope drum hoists for draft tube gates will require minor relocation / repositioning of auxiliary transformers & DG sets from their presently envisaged location including provision of access to their revised location. DEM Division in association with Civil Design is requested to take necessary action in this regard.
3. CE (D-1D) - As above.
4. CE(Tech) to Director (Technical)- for kind information please.



का.प्र. वि. सं. 23/08/17
श्री. श्री. वि. सं. 23/08/17

GM (P/9)
17/8/17

पंजीकृत कार्यालय: एन एच पी सी ऑफिस कॉम्प्लेक्स, सेक्टर-33, फरीदाबाद, हरियाणा-121 003 (भारत)

Regd. Office: NHPC Office Complex, Sector-33, Faridabad, Haryana-121 003 (India)

Website : www.nhpcindia.com; E-mail : webmaster@nhpc.nic.in; Fax : 0129-2277941; EPABX No. : 0129-2278421

S. NO.	OBSERVATIONS OF GATES DESIGN, CWC	CLARIFICATIONS OF NHPC Ltd.
	<p>Please refer to the letter dated 04-08-2017 on the above mentioned subject. It is mentioned that Memorandum of Changes for Subansiri Lower HEP was cleared by CWC vide letter no. 27/04/09/GD (NW&S)/388-390 dated 29-08-2016.</p> <p>However, following points may be considered in case construction of relevant components have not been taken up:</p> <p>1. As per the Gazette notification of CEA dated 20th Aug. 2010 (clause 39, Para 8), provision of individual hoist mechanism for draft tube gates of each unit may be considered for quick closing. The Draft tube Gate shall be capable of closing under unbalanced condition of water pressure.</p> <p>Project Authorities has proposed 3 nos. of slide type gate of size 5.77mx7.5m operated by gantry crane for each unit. The provision will not satisfy the requirement of quick lowering under unbalanced condition as defined by the CEA guidelines. Project authorities may be advised to relook these provisions provided the civil construction, fabrication & erection of gate & hoist arrangement permits. Possibility of reducing number of Draft Tube Gates may also be explored.</p> <p>2. Vide "Weight estimation for HM works", item no. 2; size of Radial Gate has been reduced from 11.5mx14.7m to 11.5mx14.0m with increase of water Head by 5m. However, the weight of</p>	<p>Memorandum of Changes (MOC) for HM Works was submitted to CEA vide NHPC letter NH/PD/IP/SLP(RCE)/1810 dated 14-10-2015 explaining changes in the HM provisions during detailed engineering / execution stage from the TEC cleared (13.01.2003) provisions as contained in the DPR. After examination by Gates Design (NW&S) Directorate, CWC, MOC was cleared with the approval of Chief Engineer, Design (NW&S) vide their letter no.3/387/2012-CMDD (NW&S)/272 dated 16-09-2016 issued to NHPC Ltd.</p> <p>DRAFT TUBE GATES</p> <p>As advised by CWC Gates Design Directorate, NHPC agrees to comply with CEA guidelines dated 20th Aug. 2010 (clause 39, Para 8) on Draft tube gate for quick lowering under unbalanced condition.</p> <p>This will require provision of individual hoist rope drum hoist for each draft tube gate and making draft tube gate capable of closing under unbalanced condition of water pressure from river side.</p> <p>At present supply of all 24 Draft tube gates and their embedded parts has been received at site but site installation is still not carried out. Following modifications will be required to make already supplied gates & embedded parts suitable for above requirement:-</p> <ol style="list-style-type: none"> 1. Modifications in already supplied 24 number sliding type gates to wheel type gate and suitable for handling with rope drum hoist. 2. Modifications in already supplied 24 sets of second stage embedded parts to make them compatible for wheeled gate. 3. Providing of 24 sets of rope drum hoists & hoist supporting structures for draft tube gates. 4. Deletion of Gantry crane, Lifting Beam & rail track from the existing contract. <p>These modifications will involve additional financial implication, which is being computed and will be intimated and incorporated in the RCE of the project.</p> <p>RADIAL GATES AND EMBEDDED PARTS</p> <p>Radial gates of Subansiri project are one of the largest under- sluice type radial gates subjected to a water head up to 60.0m above crest level. Combined with</p>

corresponding gates/embedded parts has increased from 210 & 105 MT to 400 & 150 MT respectively which appears to be significantly higher. The project authorities may relook the weight estimation.

This issue with the approval of Chief Engineer, Designs (NW&S).

high seismic parameters & hydrostatic forces on gate are of the order of around 10,000MT. Therefore, keeping in view availability of biggest sized Self lubricating Trunnion Bushing, 4 no. Trunnions were envisaged during detailed design stage resulting in a total of 12 no. radial arms of 20.0m radius. Due to non availability of experience in design & operation requirements of similar sized / load radial gate International Consultants M/s Poyri on Contractor's side and M/s Colenco on NHPC side were engaged to take care of specific design requirements these gates. As per their recommendations in respect of sealing, structural adequacy and safeguarding against excessive vibrations & abrasions various parts of the radial gate have been sized accordingly by the HM Contractor. It was advised to keep compressive stresses in radial arms at lower levels so as to control elastic shortening and its effect on top sealing of the gate. Weight of these arms constitutes around 160 MT. All these stipulations increased the gate weight from estimated value of 210 MT to 400 MT during detailed design stage. Therefore, weight of radial gate as arrived based upon detailed computations may be considered acceptable.

The consultants also advised to provide steel liners in the gate opening area to take care of abrasion and cavitation effects. Sill beams were modified and strengthened with heavier sections and better anchoring provided based upon experience gained from executed projects of NHPC to minimize damage and leakage from gates. Due to increase in gate weight hoist capacity increased from 250MT to 400 MT per cylinder resulting in heavier cylinder supporting structures. All the above factors resulted in increase in weight of embedded parts from 105 MT to 150 MT.

Radial Gates & associated components are under contractor's scope for detailed designs on Lump sum item rate basis. Therefore, weight of radial gate and embedded parts as arrived based upon detailed computations may be considered acceptable.

Clearances from different agencies

Summary of Clearances received from CEA/CWC/GSI/CSMRS

Sl. No.	ASPECTS	STATUS	REMARKS
1	GSI	Cleared	Dam aspect vide letter No. 4559/64/EPE/GSI/ND/2010 dtd. 29.09.14 and Power House aspect vide letter No. 535/64/EPE/GSI/ND/2010 dtd. 17.06.15
2	CSMRS	Cleared	Cleared vide CSMRS letter dated 23.03.17
3	CMDD (CWC)	Cleared	MoC submitted on 05.11.13 cleared vide CWC U.O. No. 4/65/2014-CMDD(NW&S)/282 dtd. 07.11.14. MoC submitted on 14.10.15 cleared vide letter No. 3/387/2012- CMDD(NW&S)/272 dtd. 16.09.16 & letter No. 3/387/2017/ CMDD(NW&S)/201 dtd. 31.08.2017.
4	HCD (CWC)	Cleared	Cleared vide CWC U.O. No. 26/33/2015-HCD(NW&S)/1119-20 dtd. 03.08.16 & U.O. No. 26/33/2015-HCD(NW&S)/2748-49 dtd. 18.08.17.
5	Gates/HM (CWC)	Cleared	Cleared vide letter No. 27/04/09/Gate(NW&S)/389 dtd. 29.08.16 & letter No. 27/04/09/Gate(NW&S)/244-245 dtd. 31.08.17.
6	E&M Design (CEA)	Cleared	Cleared vide letter No. 10/90(1)/HETD/2013/1197-98 dtd. 30.08.16 & letter no. 10/90(1)/HETD/2017/1133 dtd. 24.08.17.
7	Power Evacuation (CEA)	Cleared	Cleared on 05.12.13



Served Date

Government of India
Geological Survey of India

No: 64/EPE/GSI/ND/2010

Dated: 29-09-2014

From
The Director,
EPE Division,
Geological Survey of India
A-II, Pushpa Bhawan
Madangir Road
New Delhi 110062

To
The Director (PAC)
Central Electricity Authority
Sewa Bhawan
R. K Puram
New Delhi 110066

Sub: Memorandum on Changes from DPR in respect of Subansiri Lower HE Project (2000 MW) Arunachal Pradesh.

Ref: CEA Letter. No. 2/NHPC/26/CEA/2001-PAC/6609-11 dated 20.11.2013

Sir,

The Memorandum on changes from DPR for 2000MW Lower Subansiri Project has been received vide the above cited letter. The Memorandum of changes has been examined by EPE division.

The proposed modifications and additional safety measures recommended by Dam Design Review Panel (DDRP) would ensure performance of the concrete dam and spillway on long term basis. Therefore, it is recommended that NHPC may take the project forward on the lines suggested by the DDRP.

Yours faithfully,


(Dr. J. S. Mehta)
Director

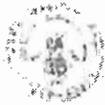
No: 9560 - 4561
64/EPE/GSI/ND/2010

Dated: 29-09-2014

Copy forwarded for information to:

- (1) Dy. D.G & Head Mission IV, GSI, 27 JLN Road, Kolkata-700016
- (2) Dy. D.G. DGCO, GSI, A-II, Pushpa Bhawan, New Delhi


(Dr. J. S. Mehta)
Director



Geological Survey of India
EPE Division
New Delhi

L. No. 535 /64/EPE/GSI/ND/2010

Date: 17-06-2015

From:
Director
EPE Division
Geological Survey of India
A-II, Pushpa Bhawan
New Delhi-110062

To:
General Manager (Geo-Tech)
NHPC Office Complex,
Sector-33, Faridabad,
Haryana-121 003

Sub: GSI Conditional Clearance on memorandum of changes of 2000MW Subansiri Lower HE Project, Arunachal Pradesh.

Ref: Letter no. NH/EG/SLP/102M/2015/72 dated 28-04-2015.

Sir,

With reference to your above mention letter, GSI Clearance is accorded on memorandum of changes made from underground powerhouse to surface powerhouse with following suggestions.

The different suggestions laid by GSI are given below:

1. The perusal of the 'Updated Geological plan of Power House and Surge Chamber area', suggests that Upper Siwalik rock exposed in the area is jointed in nature. Therefore, although, due to its inherent characteristics, the sandstone rock may be non groutable as such, but a significant amount of grout consumption is expected through the discontinuities. Therefore, few groutability test may be conducted.
2. The nala near HLG/DD-2 may debouch significant amount of discharge laden with the sediment load over the slopes above the powerhouse. Therefore, the nala course may be channelized away from the powerhouse area.

Yours faithfully,

(Dr. J.S. Mehta)
Director

L. No. /64/EPE/GSI/ND/2010

Date: 17-06-2015

Copy for kind information to:

- (1) The Dy. D.G. & Head, Mission-IV, GSI, 27 JLN Road, Kolkata-700016 .
- (2) The Dy. D.G. DGCO, GSI, A-II, Pushpa Bhawan, New Delhi.
- (3) The Director (PAC), Central Electricity Authority, Sewa Bhawan, R K Puram, New Delhi -110066.

May like to see M.

Recd for Gm
23/6
ED (AT)
San
23/6
23/6

(Dr. J.S. Mehta)

भारत सरकार
जल संसाधन, नदी विकास और गंगा संरक्षण मंत्रालय
केन्द्रीय मृदा एवं सामग्री अनुसंधानशाला

कलौक पालमें मार्ग
हीजखास नई दिल्ली-16
दिनांक: 23/3/17

सं.- यू0ओ0सं0 29/36/ सुबांसिरी लोअर/आर.एम.-1/सी.एस.एम.आर.एस./2011/202

सेवा में,

निदेशक (पी ए सी)
पी. ए. सी निदेशालय,
केन्द्रीय विद्युत प्राधिकरण
तृतीय तल, सेवा भवन
आर. के. पुरम
नई दिल्ली-66

विषय: सुबांसिरी लोअर जलविद्युत परियोजना, (2000 MW), अरुणाचल प्रदेश/ असम -
अनुमोदित डीपीआर से डिजाइन में परिवर्तन के जापन पर टिप्पणियों के संबंध में।

संदर्भ: NHPC letter No. NH/PD/IP/SLP (RCE)/507 date d 27/02/2017

महोदय,

उपरोक्त विषय के संदर्भ में संलग्न पत्र आपको सूचनार्थ/आवश्यक कार्यवाही हेतु प्रेषित है।

संलग्न: यथोक्त

S 23-3/17
जारी किया
ISSUED

o/c
5/0 कि.
23/3/17
एस0ओ0सं0 29/36/17
(हसन अब्दुल्लाहि)
निदेशक
केन्द्रीय मृदा एवं सामग्री अनुसंधानशाला

Government of India
Ministry of Water Resources, RD&GR
Central Soil & Materials Research Station

Olof Palme Marg, Hauz Khas
New Delhi 110016
Fax No. 011-26853108
Dated 14.12.2009
Phone: 011-26967985, 26961894

Subject: Comments on compliance report of Memorandum of changes from DPR of Subansiri Lower Hydroelectric Power project (2000MW) Arunachal Pradesh/Assam

Reference: NHPC letter No. NH/PD/IP/SLP (RCE)/507 dated 27/02/2017

Subansiri Lower HE Project (2000MW) is a run of river scheme on river Subansiri. The Project is located in Lower Subansiri/Dhemaji district of Arunachal Pradesh/Assam. The present project consists of the construction of concrete gravity dam of 116 m height from river bed level, surface power house, gated orifice type spillway, horse shoe type HRT and other civil structures.

Rock

Following changes in Subansiri Lower hydroelectric power project have been made after TEC.

1. Change in power house area arrangement from underground to surface size 288M X61M X 64M.
2. Changes in surge arrangement from d/s surge chamber cum draft tube to u/s 6 no's surge tunnel/shafts of dia. 9.5M and height varies from 10M to 12M
3. Changes in pressure shafts general arrangement
4. Changes in dam spillway sections as per DDRP.

Considering the above facts/changes it was suggested vide our comment dated 07.12.2017 that Deformability of rock mass using plate load test/ Goodman jack in NX size drill holes should be carried out at surface power house area if it is founded on rock mass.

In this connection Following four report of Subansiri Lower hydroelectric power project at Assam, have been submitted by project authorities. Reports were examined and found satisfactory.

1. Report on Laboratory investigation of rock.
2. Report on determination of in situ deformability parameters of rock mass and shear zone exposed at different locations of surge chamber site
3. Report on Investigation of in-situ rock mass properties of power house site
4. Report on Investigation of in-situ rock mass properties of surface chamber site

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Here, it would be appropriate to mention that report at serial no. 3 fulfill our earlier suggestions and no further comments are offered except that instrumentation programme should also be planned/made for monitoring of surface and underground structures.

Hasan Abdullah
23/3/17

(Hasan Abdullah)
Director

O/c ~~for~~ 23/3/17

Director PAC Directorate, CEA, 3rd Floor, Sewa Bhawan, R.K. Puram, New Delhi-66

U.O.No.: 29/36/ Subansiri lower / CSMRS/2011/

Dated: /03/2017

Scanned by CamScanner

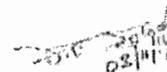
Government of India
Central Water Commission
CMDD (NW&S) Dte.

West Block-2, Wing-2, Ground floor
R.K. Puram, New Delhi-110066.

Subject: Memorandum on Changes from DPR in respect of Subansiri Lower HE Project (2000 MW), Arunachal Pradesh.

Ref: CWC letter No. 32/29/13-PA(S)/219 dated 28.11.2013.

The Memorandum of Changes from DPR in respect of Subansiri Lower Project (2000 MW) (SLP), Arunachal Pradesh received vide the cited reference have been examined. The proposed modifications and changes are primarily based on the recommendations of Dam Design Review Panel (DDRP) made for concrete dam, spillway, energy dissipation arrangement and dam foundation of SLP. These modifications and changes have been found to be necessary by DDRP in view of the existing site conditions. The proposed changes/modifications are found to be in order and, accordingly, the memorandum of changes from DPR of Subansiri Lower Project (2000 MW), Arunachal Pradesh is technically cleared in respect of Dam, Spillway and energy dissipation component of the project.



(S.K. Sibal)

Director, CMDD (NW&S) Dte.

Tel: 011 - 26101188

Email: sksibal@hotmail.com

Director, PA (S), 410 (S), Sewa Bhawan, R.K. Puram, New Delhi
CWC U.O. No. 465/2014-CMDD(NW&S) 282 dated 7-11-14

Government of India
Central Water Commission
CMDD (NW&S) Directorate
Wing II, Ground floor, West Block II,
R.K.Puram, New Delhi 110066
Phone: 011-26100892. e-mail: cmddnws@nic.in

Sub: Subansiri Lower HE Project (2000MW) in Arunachal Pradesh
Memorandum of Changes for Hydro Mechanical Components

Ref: No. 2/NHPC/26/CEA/2001-PAC/578-83 dated 17.08.2016
No. 2/NHPC/26/CEA/2001-PAC/1357 dated 29.08.2016

Reference is invited to the letter No 1) cited above, vide which it has been requested to expedite the clearances of Memorandum of changes (MoC) for Hydro Mechanical Components of the above mentioned work.

On the scrutiny of Memorandum of Changes for Hydro Mechanical Components dated 14.10.2015 submitted vide above referred letter No 2) it is seen that the changes of crest level / gate sizes have already been cleared earlier vide this directorate letter dated 07.11.2014 and there are no new issues pertaining to Concrete dam or its appurtenances.

Therefore, there are no further comments offered from this directorate on the Memorandum of Changes mentioned above and the same may be treated as technically cleared in respect of this directorate.

This issues with the approval of Chief Engineer, Designs (NW&S).

(Signature)
(Kayum Mohammad)
Director, CMDD (NW&S)

Director, (PAC), CEA, Sewa Bhawan, R.K.Puram, New Delhi
No. 3/307/2012-CMDD (NW&S) / 272 dated 16.09.2015

ED (PIS) for issue of PI
of 27/09/15

ED (PHE)
Gm (HM Div) / Gm (DHE)

38

Government of India
 Central Water Commission
 CMDD (NW&S) Directorate
 Sixth Floor (South), Sewa Bhawan
 R.K.Puram, New Delhi 110066
 Phone: 011-29583493, e mail: cmddnws@nic.in

No 3/387/2017/CMDD (NW&S) 201

Dated 31.08.2017

To,
 The Director, PAC,
 322, 3rd Floor,
 Sewa Bhawan (N),
 R.K.Puram,
 New Delhi.

Sub: Subansiri Lower HE Project (2000MW) in Arunachal Pradesh/Assam – regarding.

Ref. No. 2/NHPC/26/CEA/2001-PAC/1881-85 Dated 11.08.2017

Madam,

Kindly refer to your above cited letter, vide which CWC has been requested to examine and comment on conditions stipulated by MoEF&CC in its clearance letter dated 16.07.2003 & 27.04.2016 in respect of Subansiri Lower HEP

The issues have been examined. NHPC ensured vide their letter dated 18.08.2017 that continuous flow of 240 cumecs through turbine shall be joining the original river course very close to dam toe and plunge pool. In lean season the depth of moving back water shall be varying from 5 to 10 m in the downstream of dam and plunge pool, resulting in no stagnation of water. In view of the above, regarding issue of releasing 240 cumecs through turbine and to maintain a substantial flow in the downstream, this directorate has no comments to offer. Regarding discharge arrangement for release of e-flow of 6 cumecs through dam, clarifications were sought from NHPC. Now, NHPC has submitted the design calculations for the proposed discharge arrangement vide their letter dated 25.08.2017 which seems to be in order.

This issues with the approval of Chief Engineer Designs (NW&S).

Yours faithfully,


 (Kayum Mohammad)
 Director, CMDD(NW&S)

Government of India
Central Water Commission
Hydel Civil Designs (NW&S) Directorate

Wing No. I, 1st floor,
West Block-2, R.K Puram,
New Delhi-110066

Date 03.08.2016

Subject : Subansiri Lower HEP (2000MW) – Memorandum of Changes.

- Ref: 1. CEA Letter No. 2/NHPC/26/CEA/2001-PAC/6660-62 dt. 27.11.2013.
2. NHPC Letter No. NH/PD/IP/SLP(RCE)/1748 dt. 06.10.2015.
3. NHPC Letter No. NH/PD/IP/SLP(RCE)/2192 dt. 18.12.2015.
4. CWC Letter No. 26/33/2015-HCD (NW&S)/2922-23 dt. 22.12.2015.
5. NHPC Letter No. NH/PD/IP/SLP(RCE)/121 dt. 18.01.2016.
6. NHPC Letter No. NH/PD/IP/SLP(RCE)/1481 dt. 29.06.2016.
7. NHPC Letter No. NH/PD/IP/SLP(RCE)/1725 dt. 01.08.16.

In reply to this office observations vide CWC letter at Reference No. 2 regarding memorandum of changes of Subansiri Lower HEP, NHPC submitted details vide references at 5,6 & 7.

No further comment is being offered in respect of memorandum of changes of Subansiri Lower HEP.

This issues with the approval of Chief Engineer, Designs (NW&S).



Director

Director(PAC), 3rd Floor, CEA, Sewa Bhawan, R.K.Puram, New Delhi
CWC U.O.No. 26/33/2015-HCD (NW&S)/ 1114-25 dt. 03.08.2016

Copy to:

Chief Engineer (Plg.), NHPC, NHPC Office Complex, Sector-33, Faridabad,
Haryana, PIN-121003.

Handwritten initials: WPS

Handwritten signature and date: 03/08/2016

Government of India
Central Water Commission
Hydel Civil Designs (NW&S) Directorate

6th Floor, Sewa Bhawan
R K Puram
New Delhi-110066

Sub: Subansiri Lower HEP (2000MW) in Arunachal Pradesh – Memorandum of Changes.

Ref: i) CEA Letter No. 2/NHPC/26/CEA/2001-PAC/1759-62 dated 01.08.2017.
ii) CWC U.O No. 26/33/2015-HCD(NW&S)/2660-61 dated 04.08.2017
iii) NHPC letter no. NH/PD/IP/SLP(RCE/2052 dated 10.08.2017

Please refer letter under reference iii vide which head loss calculation alongwith requisite details for Lower Subansiri HEP was submitted to this office for vetting. The same has been examined in this office.

As per the details submitted by Project Authority, head loss in longest water conductor system may be taken as 5.102 m and in shortest water conductor system it may be taken as 4.41 m.

S K Das
18/8/2017
S K Das
Director

Director(PAC), 3rd Floor, CEA, Sewa Bhawan, R.K.Puram, New Delhi
CWC U.O.No. 26/33/2015-HCD (NW&S)/ 2748-49 dt. 18.08.2017

Copy to:

✓ Chief Engineer (Plg.), NHPC, NHPC Office Complex, Sector-33, Faridabad,
Haryana, PIN-121003.

आदेश संख्या: 27/09/GD(NW&S)/203-205
 भारत सरकार / Government of India
 केन्द्रीय जल आयोग / Central Water Commission
 गेट डिजाइन (न.प.एच.द.) निदेशालय / Gates Design (NW&S) Directorate

कक्ष-7, प्रथम तल, पतिलभी कॉम्प्लेक्स-2,
 रा. क. पुरम, नई दिल्ली-110066

दिनांक: 24/08/2016

To,
 Director-PAC Directorate,
 Central Electricity Authority,
 3rd Floor, Sewa Bhavan,
 R K Puram, New Delhi-110066

Sub : Subansiri Lower HEP Project(2000MW) In Arunachal Pradesh-Memorandum on design
 Changes In Hydro-Mechanical Components(with reference to DPR).

Ref : (i) Letter No. 27/4/09/GD(NW&S)/203-205 dated 26/4/2016
 (ii) Letter No. NH/PD/IP/SLP-RCE/101/1601 dated 14.07.16.

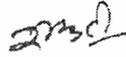
In reply to this office observations vide letter under reference (i) regarding "Memorandum on design changes for HM components of Subansiri Lower HEP", NHPC has submitted the compliance vide letter under reference (ii).

Project authorities stated that they have made the provision of 3 numbers of Gantry to handle the 3 draft tube gates simultaneously to isolate at least one generating unit to cater any emergent eventuality.

Compliance has been examined. Here, it is mentioned that the size of the Gantry crane shall be such that the smooth operation of three Gantry cranes simultaneously is ensured.

No further comment is being offered except the above suggestions as far as this directorate is concerned.

This issue with the approval of Chief Engineer, Designs (NW&S).


 (राहुल कुमार सिंह)
 (Rahul Kumar Singh)
 निदेशक /Director

Copy to:

1. The Chief Engineer (Plg), NHPC Ltd, NHPC Office Complex, Sector-33, Faridabad, Haryana-121003
2. Director-PA(N), CWC, Sewa Bhavan, R K Puram, New Delhi-110066

244-245

संघीय सरकार / Government Of India
 मध्यम जल आयोग / Central Water Commission
 गेट डिजाइन (न.प. एवं व.) निदेशालय / Gates Design (NW&S) Directorate.

6th Floor, Sewa Bhawan
 New Delhi-110066

दिनांक: 31/08/17

विषय: Memorandum of changes in respect of Subansiri Lower HEP-reg.

संदर्भ: CWC Letter No. 27/4/09/GD(NW&S)/216-217 dated 07.08.2017

2. Letter No. 2/NHPC/26/के.वि.सा/2001-फॉ.ऐ.सी/19.10-12 dated 17.08.2017.
3. CWC Letter No. 27/4/09/GD(NW&S)/238-239 dated 23.08.2017.
4. No. NH/PO/IP/SLP(RCC)/2161 dated 25.08.2017.

Please refer to the letter under reference dated 17.08.2017 on the above mentioned subject vide which reply to the observations of CWC issued on 07.08.2017 was furnished. Further copies of the detail design computations & general arrangement drawings of Radial Gate and their embedded parts were sought from the project authorities vide letter dated 23.08.2017. The project authorities have submitted the above sought detail design calculations and general arrangement drawing vide letter dated 25.08.2017.

The submissions of the project authorities have been examined and there are no further comments. Therefore, the Memorandum of changes (MoC) is considered acceptable as far as this directorate is concerned subject to incorporation of modifications/changes in draft tube gates & their hoisting arrangement as agreed by the project authorities.

This issues with the approval of Chief Engineer Designs (NW&S)

(हार्केश कुमार)
 (Harkesh Kumar)
 निदेशक / Director

Director PA(N) CWC, Sewa Bhawan, R.K. Puram, New Delhi
 CWC U.O. No. 27/04/2009/GD(NW&S)/244-245, dated 31/08/17

Copy to:

Director PA(N) CEA, 3rd Floor, Sewa Bhawan R.K. Puram, New Delhi-60



केंद्रीय विद्युत प्राधिकरण
जल विद्युत अभियान्त्रिकी व प्रौद्योगिकी विकास प्रभाग



(आइ.एस.आर. 9001-2008 प्रमाणित)

Subject: - Subansiri Lower HEP (8x250~2000MW) in Arunachal Pradesh - Memorandum of changes-
Reg.

- Ref: i) HPA Division, CEA letter dt. 21.11.14,
ii) HE&TD Dvn., CEA letter dt. 25.11.14,
iii) HPA Division, CEA letter dt. 05.02.15,
iv) HE&TD Dvn., CEA letter dt. 13.02.15,
v) PAC Dte., CEA letter dt. 15.07.2016

A copy of document on Memorandum of Changes from DPR on the above subject was received vide letter cited under ref.-i). The extract of the major items pertaining to E&M design has been tabulated as under:

Items	As per TEC	As Executed
Power house type	Underground	Surface (Type of PH changed as per CWC suggestions)
Installed capacity	2000MW	2000MW
Number of units	8	8
Size of power house	Power house cavern: 24m x 62.4m x 33.7m Transformer cum MIV cavern: 15m x 47m x 32.7m	28.8m x 61 m x 64m
Type of turbine	Francis	Francis
Operating gross head	91m	91m
Diameter of MIV	7m	7m

Keeping in view of the above changes, our comments were sent vide letters cited under ref.-ii) & (iv).

PAC Dte., CEA vide their letter dt. 15.07.2016 have furnished a copy of parawise clarification in reply to our letter dt. 13.02.2015. The same has been examined and found to be generally in order and we have no further comment.

(Signature) 2016
(Pankaj Gupta)
Director

मुख्य अभियन्ता (एस.ई. सु.टी.डी.) 20/8/2016

मुख्य अभियन्ता, HPA प्रभाग, के.वि.प्रा
सं. 10/90(1)/एच.ई.टी.डी./2013/198

दिनांक: 08.08.2016

Copy to: निदेशक (PAC), के.वि.प्रा

may. 1. 2016
20/8/16
21/9/16

Pls forward to Proj. Auth.
under intimation to HPA-II.

Stamp: 02 SEP 2016
12:30



भारत सरकार

Government of India

विद्युत मंत्रालय

Ministry of Power

केन्द्रीय विद्युत प्राधिकरण

Central Electricity Authority

जल विद्युत अभियांत्रिकी व प्रौद्योगिकी विकास पभाग

Hydro Engg. & Technology Development Division

Sub: Subansiri Lower HEP (2000 MW) – Memorandum of Changes – reg

Please refer to PAC dte letter NO. 2/NHPC/26/CEA/2001-PAC/944-45 dated 21 August 2017 on the subject. It may be mentioned in his regard that the values of Gross Head, Net Head and head loss are same in Memorandum of Changes submitted by NHPC to that of TEC as given below:

Values	At the time of TEC	At the time of MoC
Gross Head	91.0 m	91.0m
Net Head	86.0 m	86.0 m
Head Losses	4.909m	4.909m

As such, we have no comments to offer.


(Pankaj Gupta)
Director

Chief Engineer (HE&TD)

Director (PAC), CEA

No. 10/90(1)/HE&TD/2017/1133

Dated: 24.08.2017

सेवा भवन, आर. के. पुरम-1, नई दिल्ली-110066 टेलीफोन: 011-26732203 ईमेल: ceahetd@gmail.com वेबसाइट: www.cea.nic.in

Sewa Bhawan, R. K. Puram, New Delhi-110066 Telefax-011-26732203 Email : ceahetd@gmail.com Website : www.cea.nic.in

Amey 17 *Amey 17*



भारत सरकार / Government of India
 विद्युत मंत्रालय / Ministry of Power
 केन्द्रीय विद्युत प्राधिकरण / Central Electricity Authority
 प्रणाली योजना एवं परियोजना मूल्यांकन विभाग
 System Planning & Project Appraisal Division
 सेवा भवन आरण के.पु. नई दिल्ली-110066
 Sewa Bhawan, R. K. Puram, New Delhi-110066 [ISO: 9001:2008]
 वेबसाइट / Website: www.cea.nic.in



Subject: Subansiri Lower HEP Project (2000 MW) in Arunachal Pradesh-
 Memorandum of Changes.

Please refer to your letter no. 2/NHPC/26/CEA/2001-PAC/6660-65 dated 27th November, 2013 enclosing a copy of NHPC letter no. NH/PD/IP/SLP/3025 dated 22nd November, 2013 along with copy of Memorandum of Changes from DPR of Subansiri Lower HEP Project (2000 MW).

It is noted that earlier the powerhouse was underground and now it is surface type. There is no change in ratings and no. of generating units. Therefore, power evacuation arrangement remains the same as earlier. We have no comments.

रवीन्द्र गुप्ता
 (Ravinder Gupta)
 Director

Director (PAC), CEA

No: 82/13/2013-SP&PA/2174-75

Date: 05.12.2013

Copy to: Chief Engineer (HPA), CEA-for kind information please

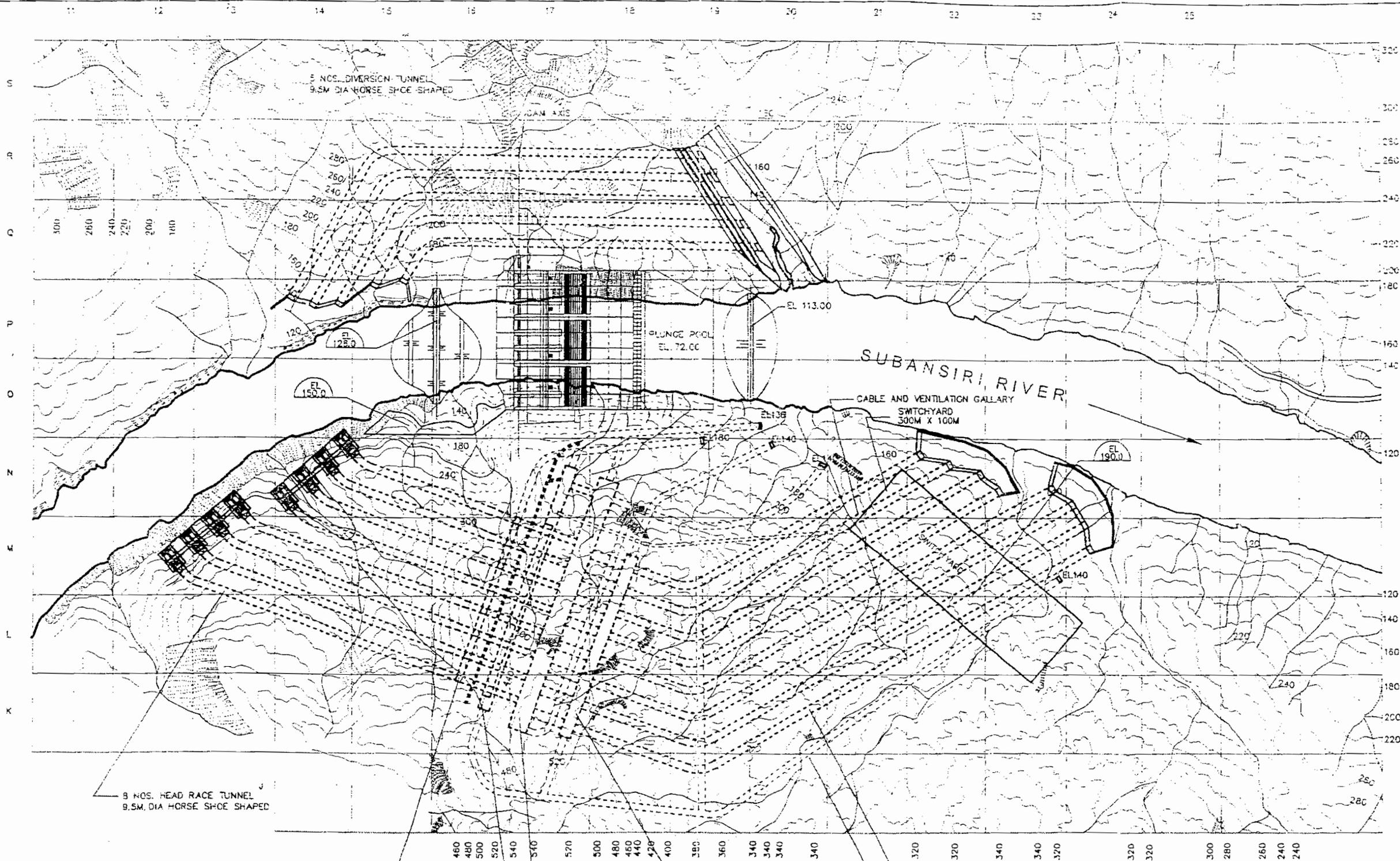
5/12/13

in response
6/11/13
HPA

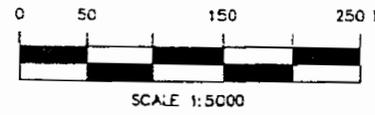
Drawings

SUBANSIRI LOWER H E PROJECT
LIST OF DPR DRAWINGS

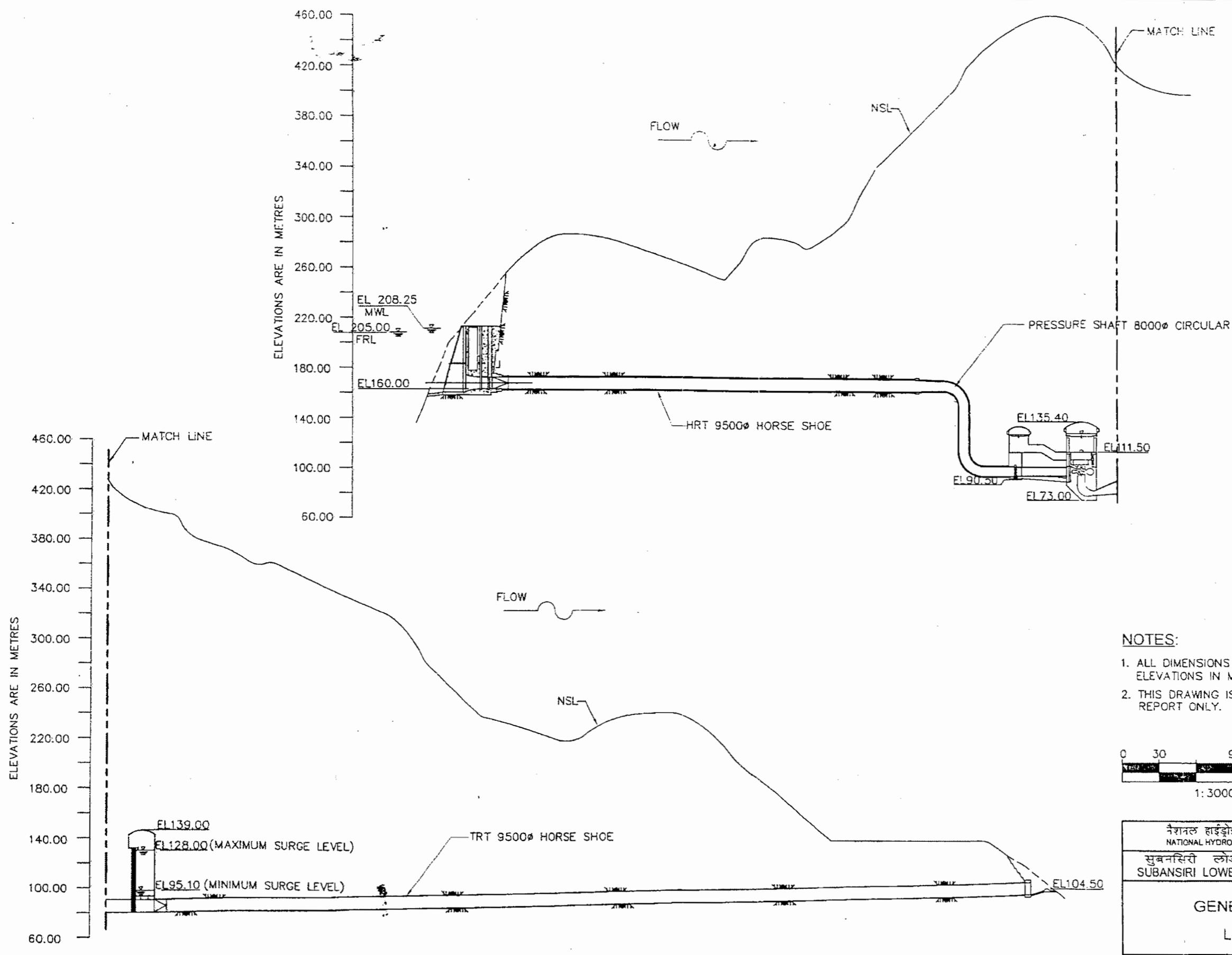
S.No.	DESCRIPTION	DRAWING NO.	REFERENCE
1	LAYOUT PLAN	NHSB-1AA2-41-GA-002	Aa per MOC submitted on 05.11.13
2	GENERAL LAYOUT L-SECTION	NHSB-1AA2-41-GA-003	
3	CONCRETE DAM GENERAL ARRANGEMENT PLAN	NHSB-2DA2-41-GA-007	
4	DAM EXCAVATION PLAN & SECTIONS	NHSB-2DA2-41-GA-008	
5	DAM CROSS SECTIONS	NHSB-2DA2-41-GA-009	
6	DAM LONGITUDINAL SECTION	NHSB-2DA2-41-GA-010	
7	HRT INTAKE PLAN AND SECTION	NHSB-3CA2-41-GA-012	
8	POWER HOUSE COMPLEX PLAN AT EL.129.00 AND SECTIONS	NHSB-4CA2-41-GA-017	
9	POWER HOUSE COMPLEX CROSS SECTIONS	NHSB-4CA2-41-GA-018	



- NOTES:**
- 1 ALL CONTOUR LEVELS AND DIMENSIONS ARE IN METRES.
 - 2 THIS DRAWING IS FOR DPR PURPOSE ONLY.

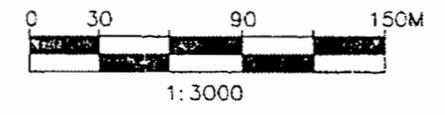


नेशनल हाइड्रोइलेक्ट्रिक पावर कॉर्पोरेशन लि. NATIONAL HYDROELECTRIC POWER CORPORATION LTD.			
सुबानसिरी लोअर जलविद्युत परियोजना SUBANSIRI LOWER HYDROELECTRIC PROJECT			
LAYOUT PLAN			
ड्रॉवर श्री R.N. SHARMA	सबमिटर श्री S. CHANDRY	रेकॉर्डर श्री Y.K. CHAUBEY	अप्रुवर श्री V.K. GUPTA
दिनांक MAR.2001	ड्रॉग. नं. NHSB-1AA2-41-GA-002		

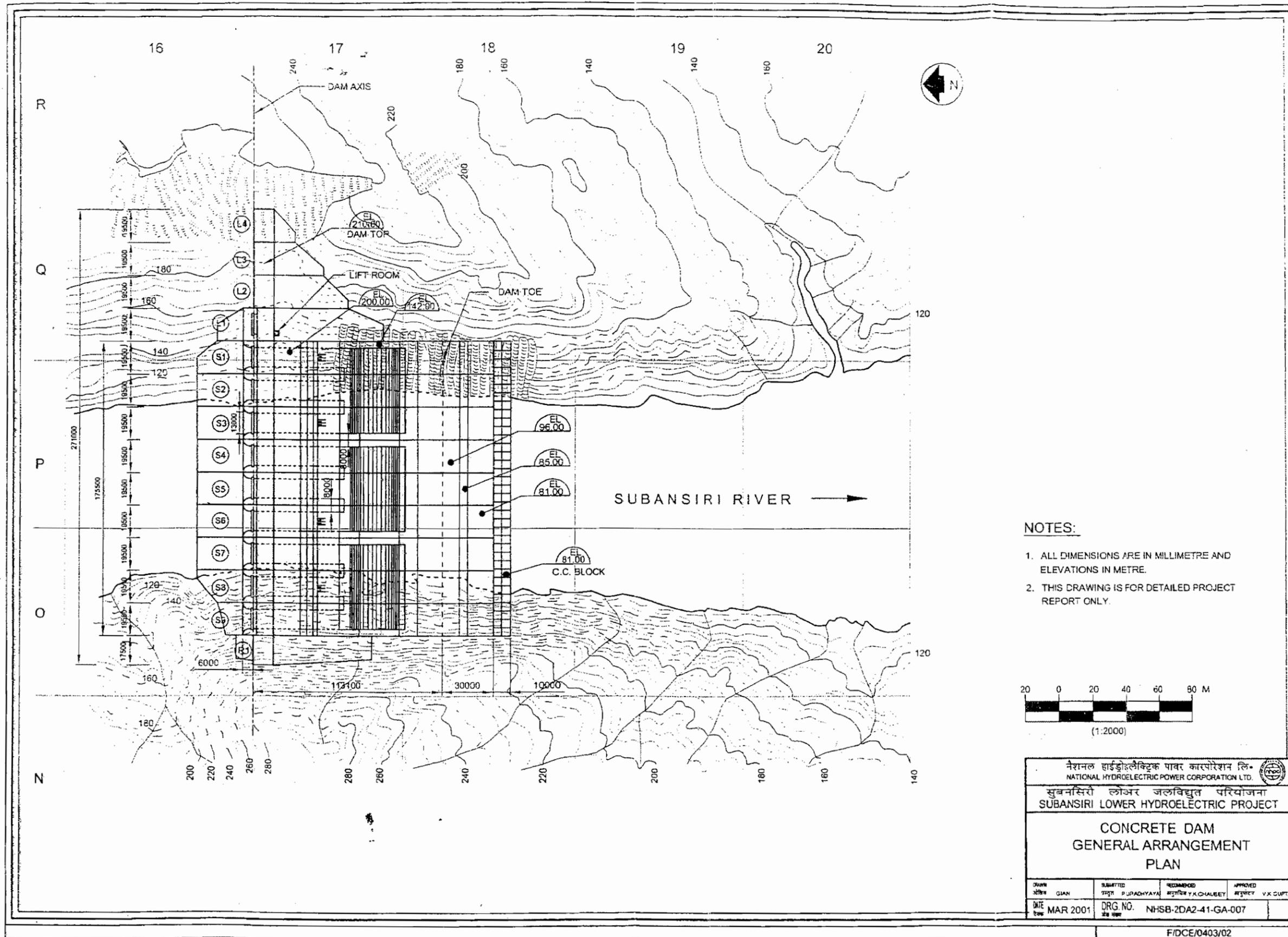


NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRE AND ELEVATIONS IN METRE.
2. THIS DRAWING IS FOR DETAILED PROJECT REPORT ONLY.

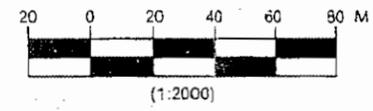


नेशनल हाईड्रोइलेक्ट्रिक पावर कारपोरेशन लि. NATIONAL HYDROELECTRIC POWER CORPORATION LTD.			
सुबनसिरी लोअर जलविद्युत परियोजना SUBANSIRI LOWER HYDROELECTRIC PROJECT			
GENERAL LAYOUT L-SECTION			
DRAWN SATYABIR	SUBMITTED P. UPADHYAYA	RECOMMENDED Y.K. CHAUBEY	APPROVED Y.K. GUPTA
DATE MAR. 2001	DRG. NO. NHSB-1AA2-41-GA-003		

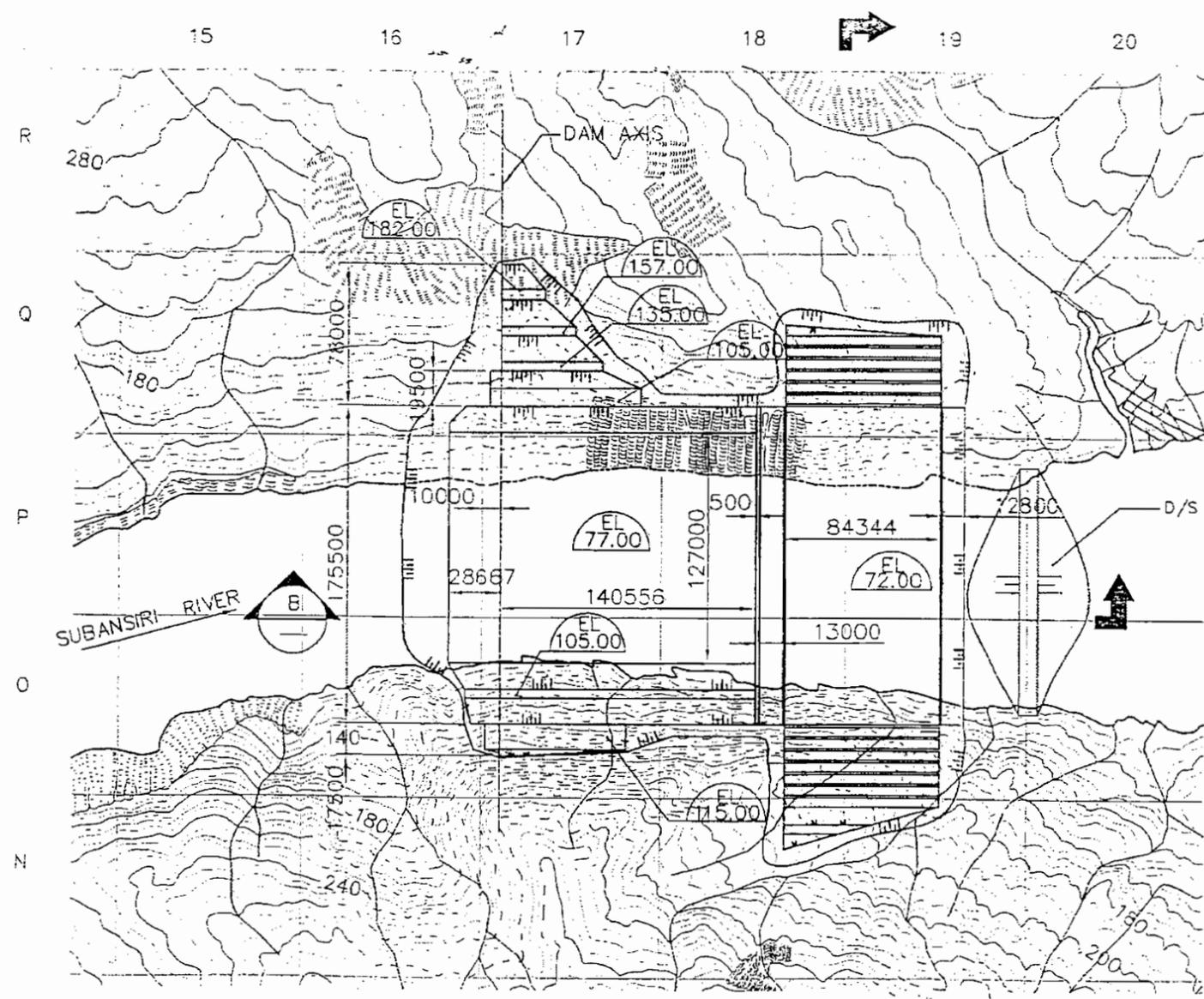


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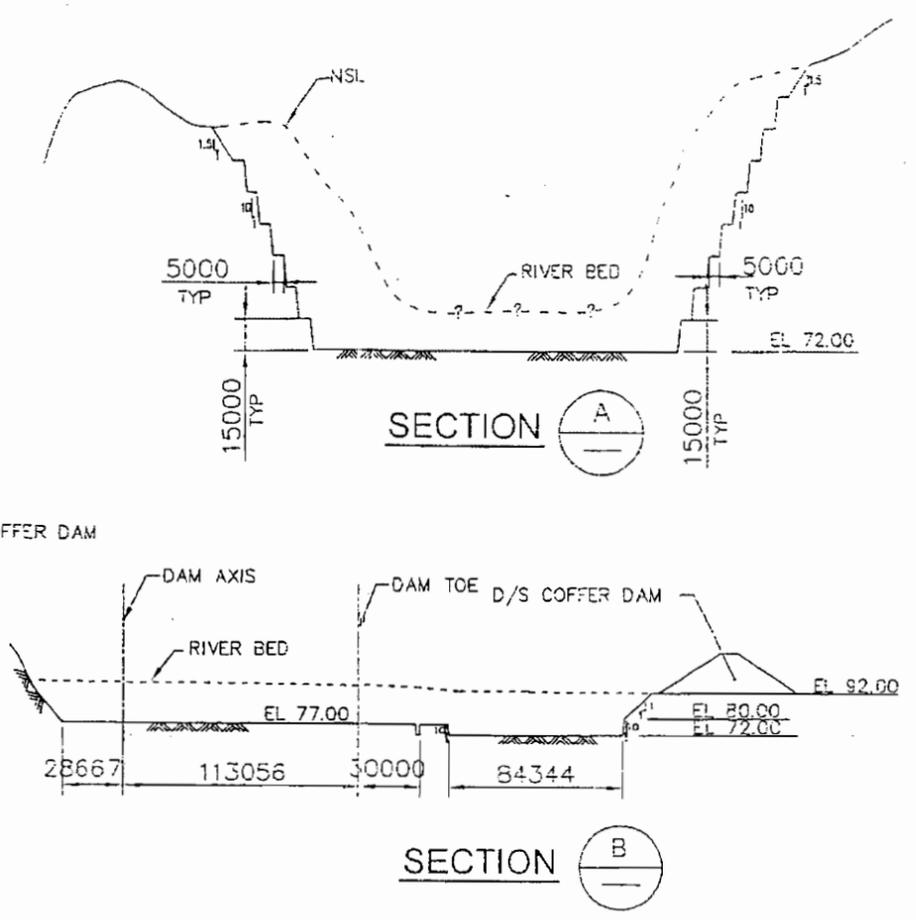
- 1. ALL DIMENSIONS ARE IN MILLIMETRE AND ELEVATIONS IN METRE.
- 2. THIS DRAWING IS FOR DETAILED PROJECT REPORT ONLY.



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सुबनसिरी लोअर जलविद्युत परियोजना SUBANSIRI LOWER HYDROELECTRIC PROJECT			
CONCRETE DAM GENERAL ARRANGEMENT PLAN			
ड्रावर श्रीमान GIAN	SUBMITTED ११/०३/०१ P. PADHYAYA	RECOMMENDED ११/०३/०१ Y.K. CHAUBEY	APPROVED ११/०३/०१ V.K. GUPTA
DATE ११/०३/०१ MAR 2001	DRG. NO. २४९६	NHSB-2DA2-41-GA-007	
F/DCE/0403/02			



EXCAVATION PLAN



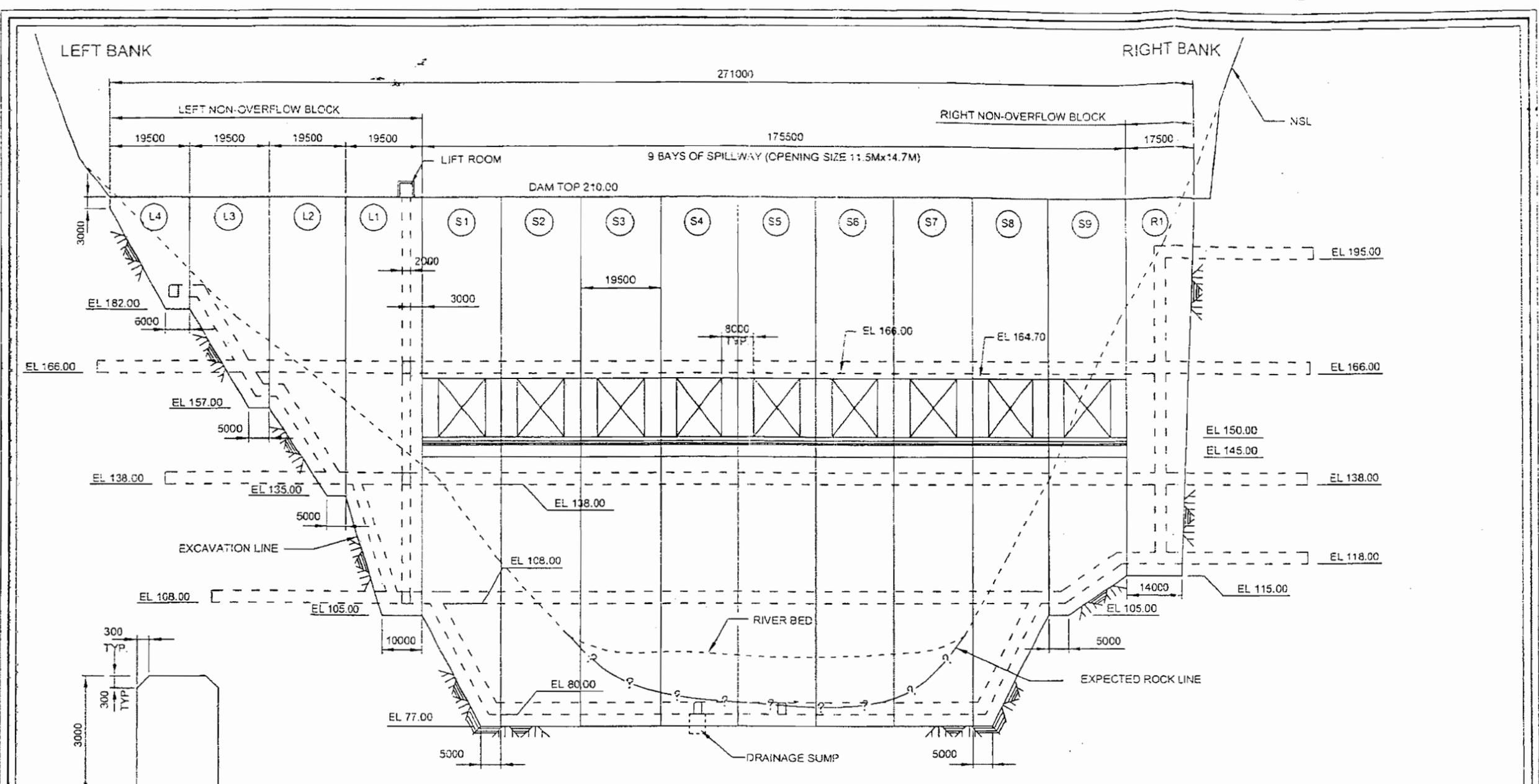
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- 1. ALL DIMENSIONS ARE IN MILLIMETRE AND ELEVATIONS IN METRE.
- 2. THIS DRAWING IS FOR DETAIL PROJECT REPORT ONLY.



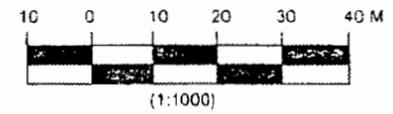
नेशनल हाइड्रोइलेक्ट्रिक पावर कॉर्पोरेशन लि. NATIONAL HYDROELECTRIC POWER CORPORATION LTD.			
सुबानसिरी लोअर जलविद्युत परियोजना SUBANSIRI LOWER HYDROELECTRIC PROJECT			
DAM EXCAVATION PLAN & SECTIONS			
DRAWN BY EL. BISHAR	SUBMITTED BY S.C. JOSHI	RECOMMENDED BY T.K. CHAKRABORTY	APPROVED BY V.K. GUPTA
DATE MAR. 2001	DRG. NO. NHSB-2DA2-41-GA-008	00	

FIDCE/0403/02



LONGITUDINAL SECTION (UPSTREAM VIEW)

GALLERY SECTION TYP.

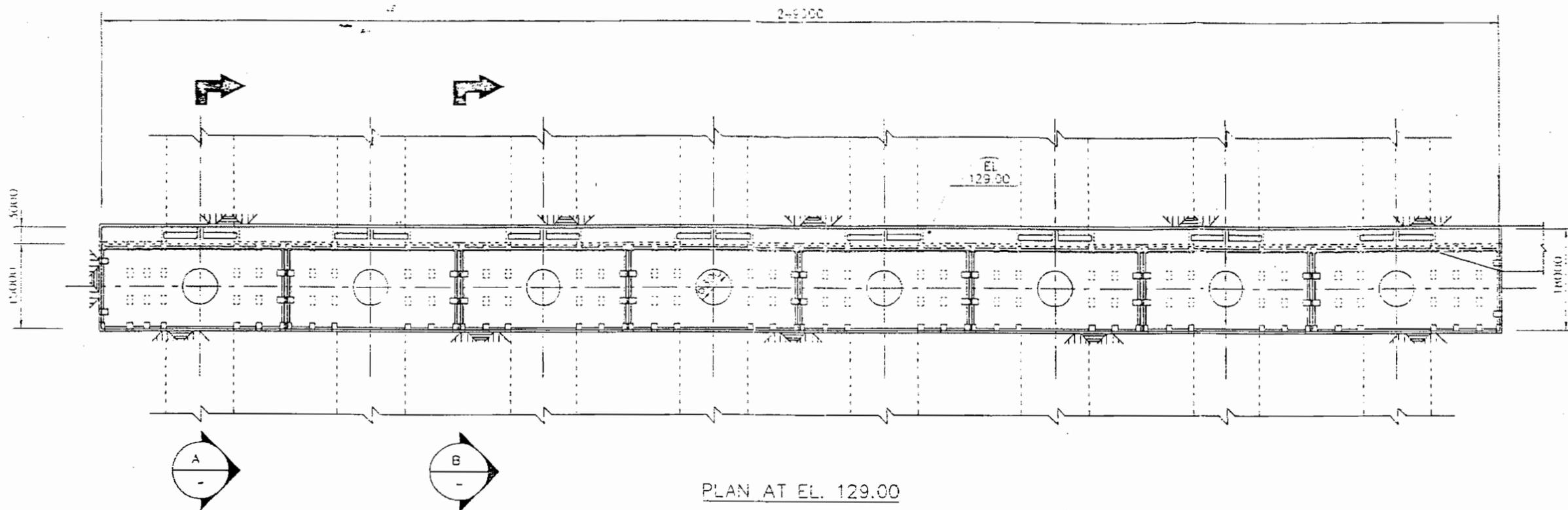


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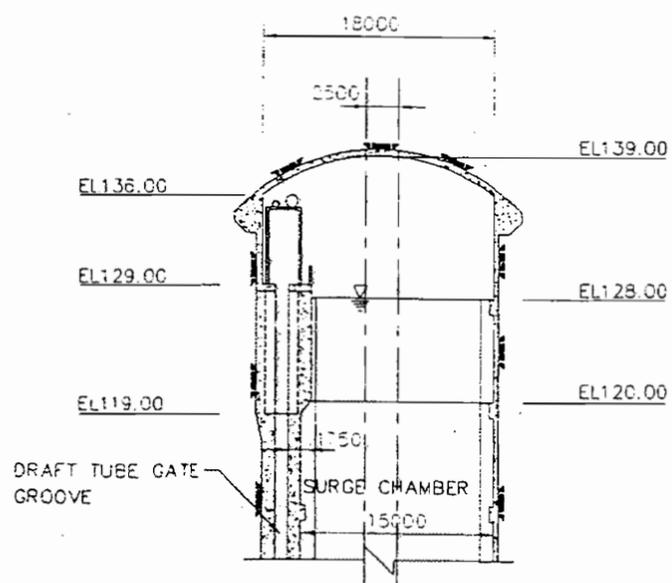
1. ALL DIMENSIONS ARE IN MILLIMETRE AND ELEVATIONS IN METRE.
2. THIS DRAWING IS FOR DETAILED PROJECT REPORT ONLY.

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सुबनसिरी लोअर जलविद्युत परियोजना SUBANSIRI LOWER HYDROELECTRIC PROJECT			
DAM LONGITUDINAL SECTION			
DRAWN 2001 DATE MAR 2001	SUBMITTED 2001 DRG. NO NHSB-2DA2-41-GA-010	RECOMMENDED 2001 Y.K. CHAUBEY	APPROVED 2001 V.K. GUPTA

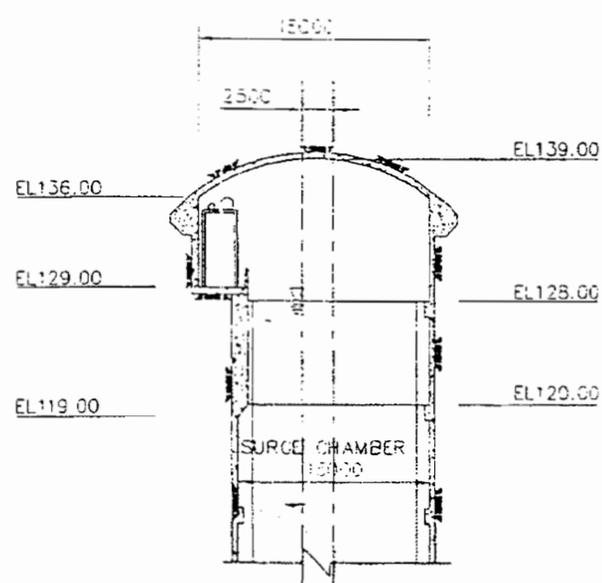
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PLAN AT EL. 129.00



SECTION A-A
1:500



SECTION B-B
1:500

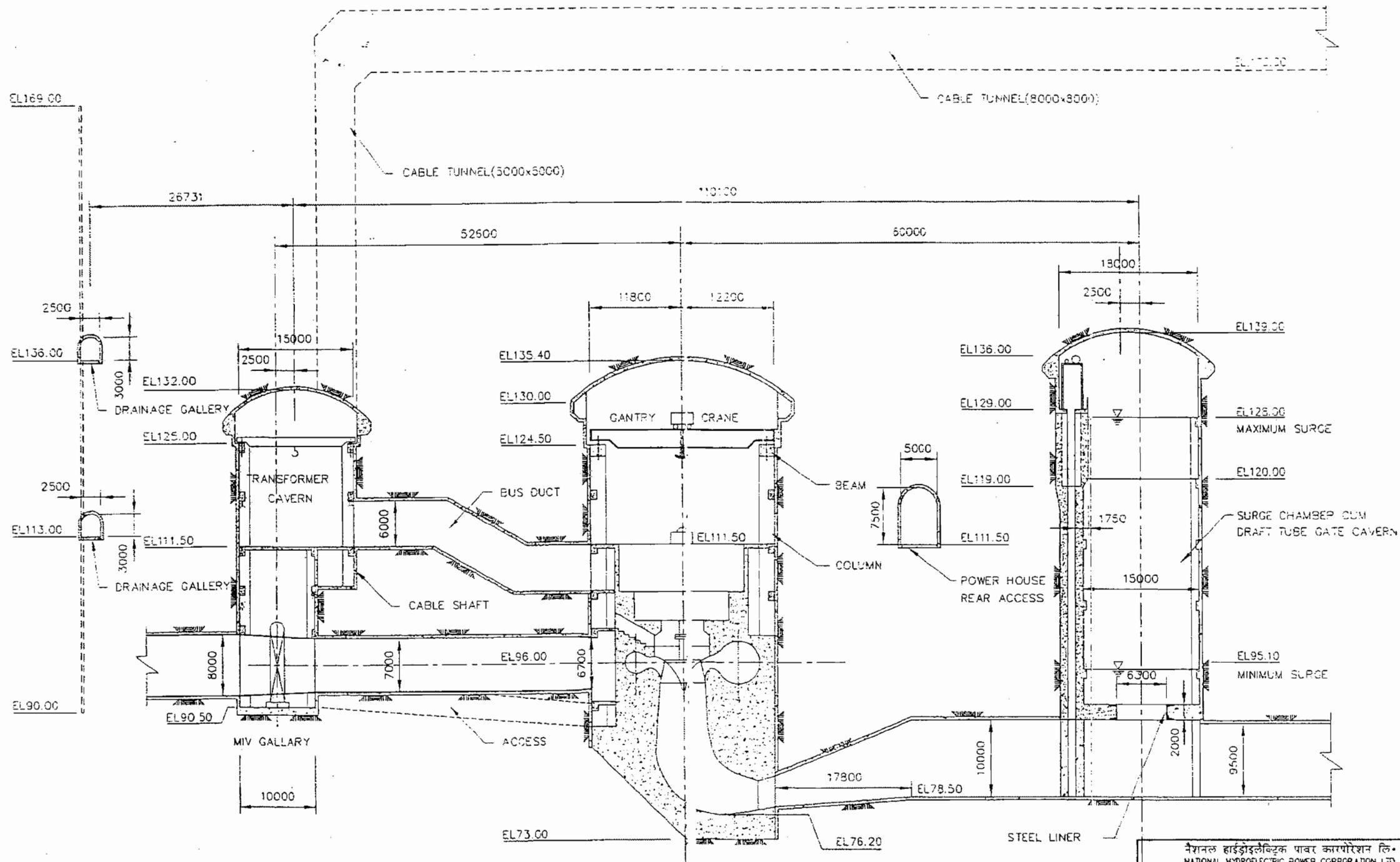
NOTES

- 1 ALL DIMENSIONS ARE IN MILLIMETRE AND ELEVATION ARE IN METRE.
- 2 THIS DRG. IS FOR DETAILED PROJECT REPORT ONLY.



नेशनल हाईड्रोइलेक्ट्रिक पावर कारपोरेशन लि. NATIONAL HYDROELECTRIC POWER CORPORATION LTD.			
सुबानसिरी लोअर जलविद्युत परियोजना SUBANSIRI LOWER HYDROELECTRIC PROJECT			
POWER HOUSE COMPLEX PLAN AT EL. 129.00 AND SECTIONS			
ड्रॉवर रजि. र.न. शर्मा	सहायक एच.ए. एस.	रीवाइज्ड एच.ए. एस.	एप्रोव्ड एच.ए. एस.
डेटा मार्च 2001	ड्रॉग. नं. 1/3	नेशनल हाईड्रोइलेक्ट्रिक पावर कारपोरेशन लि. NHSB-4CA2-41-GA-017	

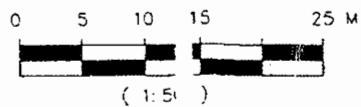
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NOTES

- 1 ALL DIMENSIONS ARE IN MILLIMETRE AND ELEVATIONS ARE IN METRE.
- 2 THIS DRG IS FOR DETAILED PROJECT REPORT ONLY.

CROSS SECTION



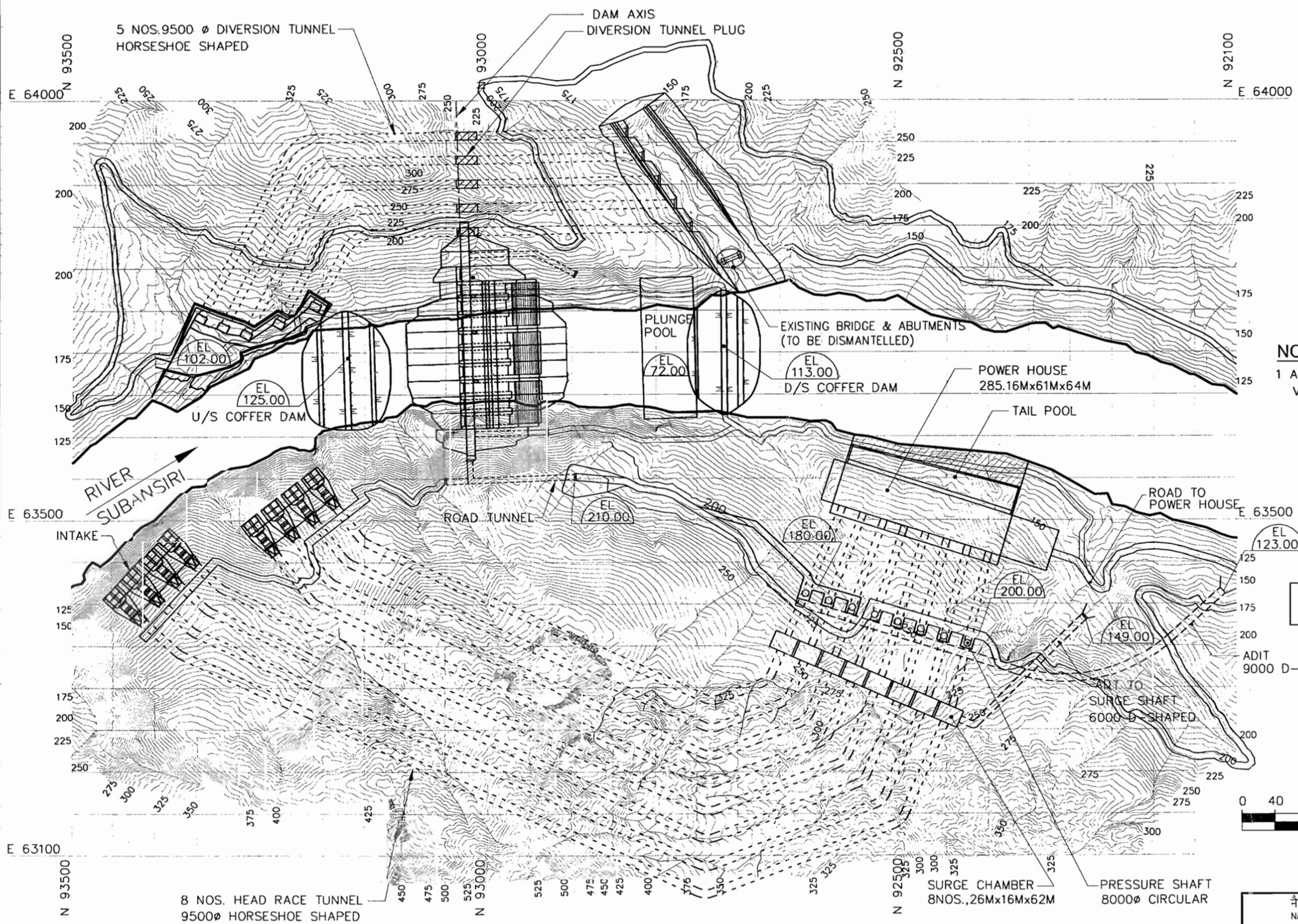
नेशनल हाइड्रोइलेक्ट्रिक पावर कॉर्पोरेशन लि. NATIONAL HYDROELECTRIC POWER CORPORATION LTD			
सुबनसिरी लोअर जलविद्युत परियोजना SUBANSIRI LOWER HYDROELECTRIC PROJECT			
POWER HOUSE COMPLEX CROSS SECTION			
DRAWN BY R.N. SHARMA	SUBMITTED BY S.C. AGNI	RECOMMENDED BY Y.K. CHAUBEY	APPROVED BY V.K. DAPTA
DATE MAR 2001	DRG. NO. 29	NHSB-4CA2-41-GA-018	

F/DCE/0403/02

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SUBANSIRI LOWER H E PROJECT

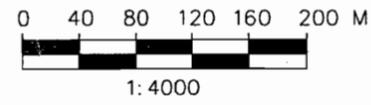
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1	GENERAL LAYOUT	NHSRL-1AT2-41-GA-002-00	Aa per MOC submitted on 05.11.13
2	SURGE CHAMBER PLAN AND SECTION	NHSRL-3DT2-41-GA-009-00	
3	SURGE CHAMBER EXCAVATION AND ROCK SUPPORT FROM EL 205.00 TO EL 160.50 (Sheet 1 of 2)	NHSRL-3DC2-41-DD-330-00	
4	SURGE CHAMBER EXCAVATION AND ROCK SUPPORT FROM EL 205.00 TO EL 160.50 (Sheet 2 of 2)	NHSRL-3DC2-41-DD-331-00	
5	DAM CROSS SECTIONS	NHSRL-2DT1-41-GA-016-00	
	CONSTRUCTION DRAWINGS		
1	DAM GENERAL ARRANGEMENT MODIFIED LAYOUT PLAN	NHSRL-2DC1-41-GA-188-00	Aa per MOC submitted on 05.11.13
2	SURGE TUNNELS GENERAL ARRANGEMENT LAYOUT PLAN	NHSRL-3DC2-41-GA-333-01	
3	SURGE TUNNELS GENERAL ARRANGEMENT SECTIONS	NHSRL-3CC2-41-GA-334-00	
4	SURGE TUNNELS GENERAL ARRANGEMENT SECTIONS	NHSRL-3DC2-41-GA-335-00	
5	HEAD RACE TUNNELS ROCK SUPPORT DETAILS NEAR SURGE TUNNELS/SHAFT PLAN & SECTIONS	NHSRL-3CC2-41-GA-335-00	
6	SURGE TUNNELS EXCAVATION AND ROCK SUPPORT PLAN & SECTIONS	NHSRL-3DC2-41-DD-336-01	
7	SURGE TUNNELS SETTING OUT L-SECTIONS	NHSRL-3DC2-41-DD-338-00	
8	SURGE TUNNELS EXCAVATION AND ROCK SUPPORT SECTIONS	NHSRL-3DC2-41-DD-509-00	
9	SURGE TUNNELS AND SURGE SHAFT JUNCTION ABOVE EL.160.50 FOR ST1 TO 4 REINFORCEMENT-PLAN	NHSRL-3DC5-41-DD-531-00	
10	SURGE TUNNELS AND SURGE SHAFT JUNCTION ABOVE EL.160.50 FOR ST1 TO 4 REINFORCEMENT-SECTIONS	NHSRL-3DC5-41-DD-532-00	
11	SURGE TUNNELS CONCRETE	NHSRL-3DC5-41-DD-519-00	
12	SURGE TUNNELS LINING REINFORCEMENT- SECTIONS	NHSRL-3DC5-41-DD-520-00	
13	PRESSURE SHAFTS EXCAVATION PLAN (SHEET 1 OF 2)	NHSRL-3KC2-41-DD-317-04	
14	PRESSURE SHAFTS EXCAVATION LONGITUDINAL SECTION THROUGH PRESSURE SHAFT-2 (SHEET 3 OF 12)	NHSRL-3KC2-41-DD-320-03	
15	PRESSURE SHAFTS EXCAVATION LONGITUDINAL SECTION THROUGH PRESSURE SHAFT-3 (SHEET 4 OF 12)	NHSRL-3KC2-41-DD-321-05	
16	POWER HOUSE GENERAL ARRANGEMENT CROSS-SECTIONS	NHSRL-4CC2-41-GA-416-01	
17	POWER HOUSE GENERAL ARRANGEMENT LONGITUDINAL SECTIONS	NHSRL-4CC2-41-GA-417-01	
18	POWER HOUSE - HILL SLOPE MODIFIED EXCAVATION SECTIONS	NHSRL-4CC2-41-DD-115-00	
19	POWER HOUSE-HILL SLOPE MODIFIED EXCAVATION PLAN	NHSRL-4CC2-41-DD-112-01	
20	POWER HOUSE-PIT EXCAVATION PLAN	NHSRL-4CC2-41-DD-118-02	
21	POWER HOUSE- HILL SLOPE MODIFIED EXCAVATION (BELOW EL 126.00) SECTION ALONG C/L OF PS-4	NHSRL-4CC2-41-DD-126-01	
22	INTAKE AND HEAD RACE TUNNEL SETTING OUT PLAN	NHSRL-3CT6-41-GA-006-00	
23	INTAKE AND HEAD RACE TUNNEL-1 SETTING LONGITUDINAL SECTION	NHSRL-3CT6-41-GA-007-00	
	DDRP DRAWINGS		
1	PLAN SHOWING CONCRETING STATUS OF THE DAM	FIG2	Aa per MOC submitted on 05.11.13
2	MODIFIED LAYOUT PLAN	FIG3	
3	TYPICAL PROFILE FOR S4,S5,S6 & S7 SPILLWAY BLOCKS	FIG4	
4	TYPICAL PROFILE FOR S3 & S8 SPILLWAY BLOCKS	FIG5	
5	TYPICAL PROFILE FOR S1,S2 & S9 SPILLWAY BLOCKS	FIG6	
6	LAYOUT PLAN OF EXTENSION OF U/S CUT-OFF WALL UNDER NOF BLOCKS	FIG7	
7	ELEVATION OF EXTENSION OF U/S CUT-OFF WALL UNDER NOF BLOCKS	FIG8	
	UPDATED GEOLOGICAL PLAN AND SECTION OF POWER HOUSE AREA		
1	LONGITUDINAL SECTION THROUGH PRESSURE SHAFT-4		
2	UPDATED GEOLOGICAL PLAN OF POWER HOUSE AND SURGE CHAMBER AREA	NH/SLP/GEO/PH/04	
3	GEOLOGICAL PLAN		
4	GEOLOGICAL SECTION ALONG WATER CONDUCTOR SYSTEM AND SURFACE POWER HOUSE A-A		

TENDER DRAWINGS



NOTES:
 1 ALL DIMENSIONS ARE IN MILLIMETRE, GRID VALUES AND ELEVATIONS IN METRE.

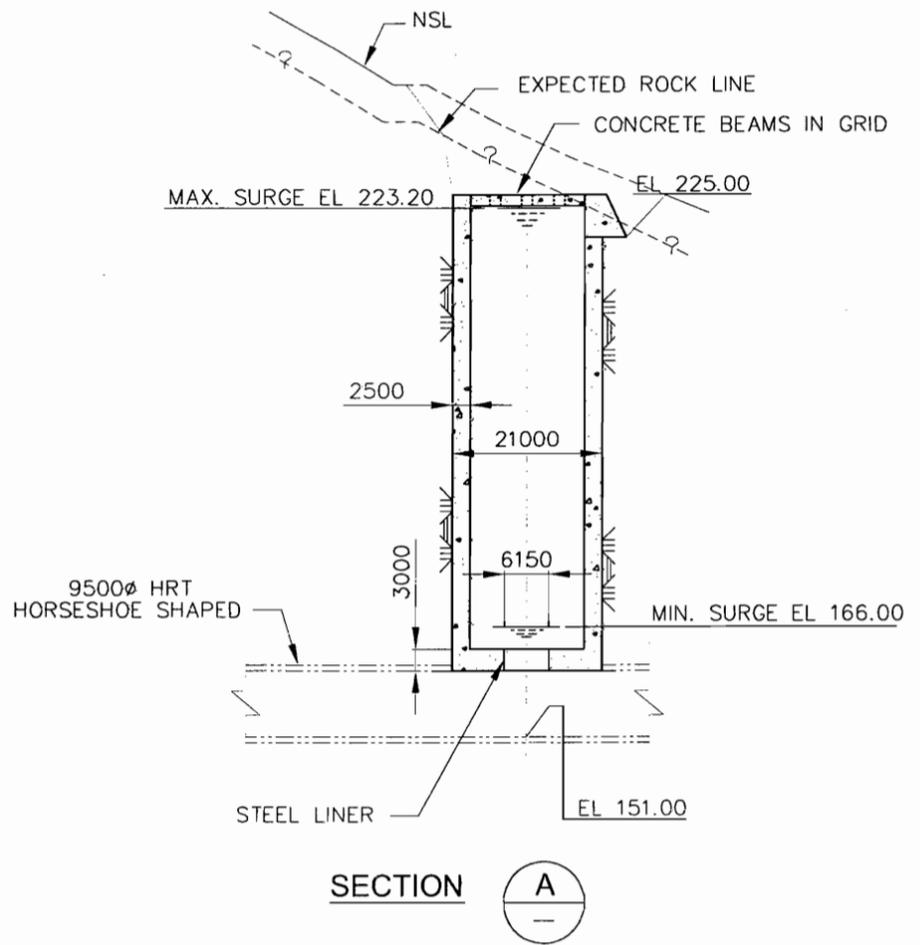
TENDER PURPOSE ONLY



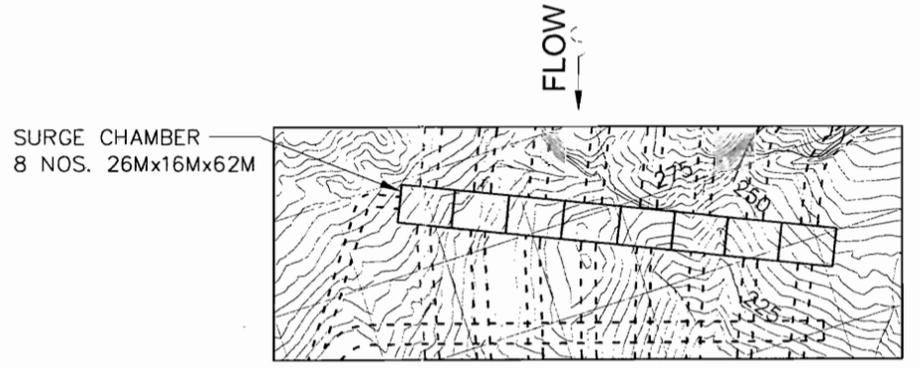
नेशनल हाईड्रोइलेक्ट्रिक पावर कारपोरेशन लि.
 NATIONAL HYDROELECTRIC POWER CORPORATION LTD.
 मुबनसिरी लोअर जलविद्युत परियोजना
 SUBANSIRI LOWER HYDROELECTRIC PROJECT

GENERAL LAYOUT

30.05.03	00	ISSUED FOR TENDER							
DATE	NO.	REVISION OR ISSUES	BY	CH.	APP.	DRAWN	SUBMITTED	RECOMMENDED	APPROVED
MAR 03						GIAN	S C JOSHI	Y K CHAUBEY	V K GUPTA
							DRG. NO.	NHSRL-1AT2-41-GA-002	00



SECTION A

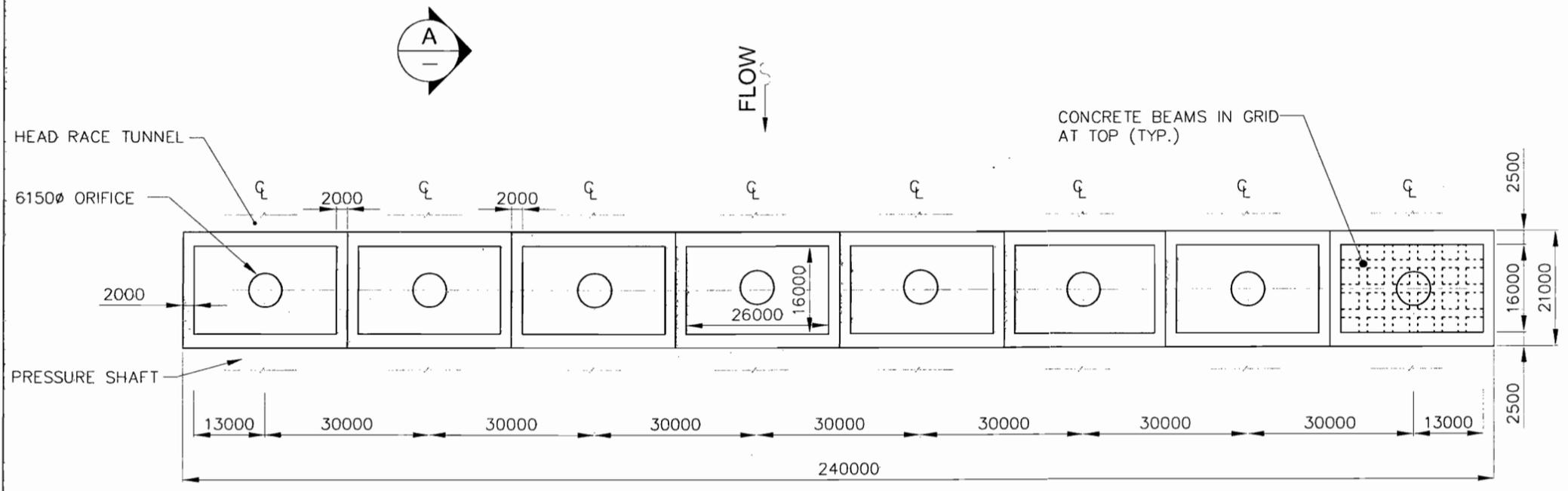


KEY PLAN

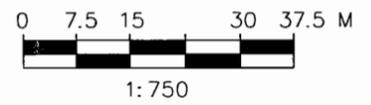
NOTES

1 ALL DIMENSIONS ARE IN MILLIMETRE AND ELEVATIONS IN METRE.

TENDER PURPOSE ONLY



PLAN



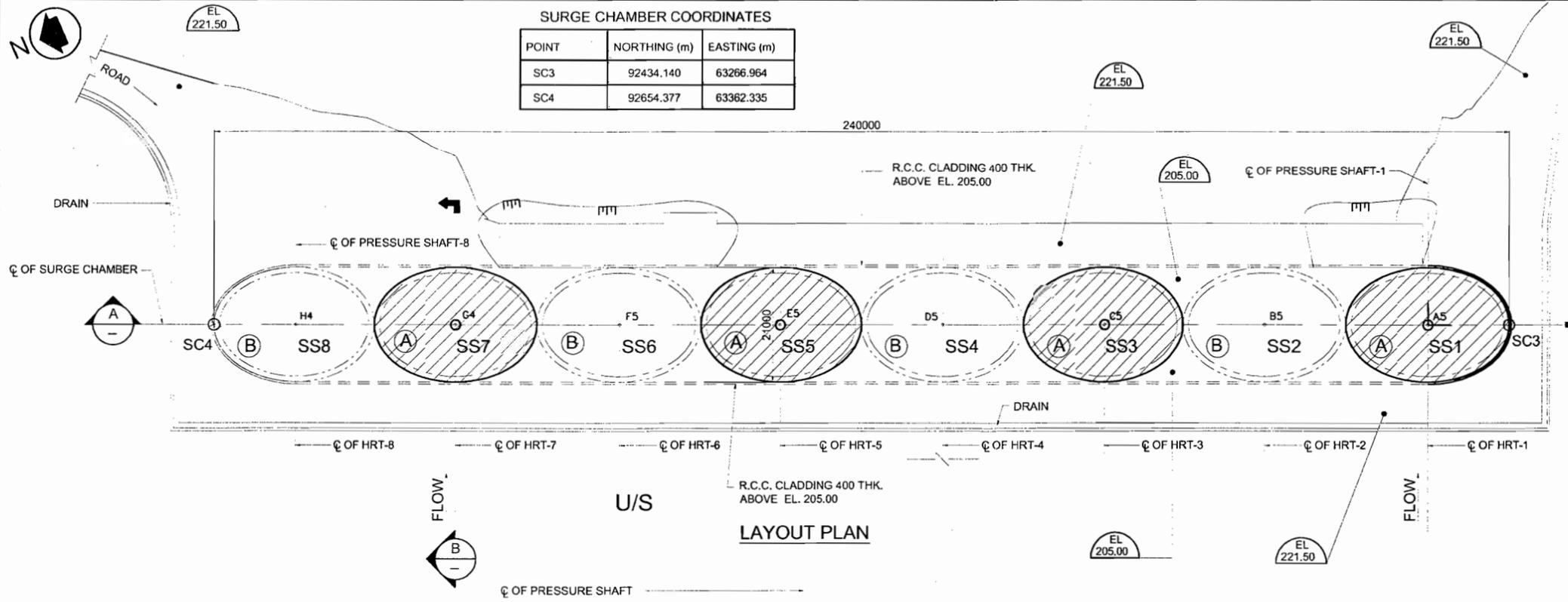
नेशनल हाईड्रोइलेक्ट्रिक पावर कारपोरेशन लि.
NATIONAL HYDROELECTRIC POWER CORPORATION LTD.
सुबनसिरी लोअर जलविद्युत परियोजना
SUBANSIRI LOWER HYDROELECTRIC PROJECT

SURGE CHAMBER
PLAN AND SECTION

10.06.03	00	ISSUED FOR TENDER							
DATE	NO.	REVISION OR ISSUES	BY	CH.	APP.	DATE	DRG. NO.		
MAR 2003							NHSRL-3DT2-41-GA-009		00

SURGE CHAMBER COORDINATES

POINT	NORTHING (m)	EASTING (m)
SC3	92434.140	63266.964
SC4	92654.377	63362.335



- NOTES :**
- ALL DIMENSIONS ARE IN MILLIMETRE GRID VALUES AND LEVELS IN METRE.
 - ROCK EXCAVATION SHALL BE CARRIED OUT BY MECHANICAL MEANS ONLY i.e. BY USING ROCK BREAKER & CUTTER ETC. NO BLASTING IS PERMITTED.
 - EXCAVATION SHALL BE CARRIED OUT IN 3.0 m. STAGES ONLY. FURTHER EXCAVATION SHALL START ONLY AFTER INSTALLATION OF ROCK SUPPORTS.
 - EXCAVATION AND ROCK SUPPORT BETWEEN EL 205.0M & EL.160.50M SHALL BE UPDATED BASED UPON THE FEEDBACK FROM EXCAVATION AND ROCK SUPPORT BETWEEN EL 221.50 AND 205.00M.
 - ADDITIONAL ROCK SUPPORT MEASURES AS PER THE REQUIREMENTS OF GEOLOGICAL /CONSTRUCTION CONDITIONS , IF ANY , MAY BE PROVIDED WITH APPROVAL OF THE ENGINEER-IN-CHARGE.
 - SEQUENCE OF EXCAVATION AND REINFORCED CONCRETE LINING OF SURGE SHAFTS / CHAMBER SHALL BE OF ALTERNATIVE SHAFTS ONLY. SEQUENCE OF (A) & (B) AS SHOWN IN LAYOUT PLAN MAY BE INTERCHANGED AS PER SITE / CONSTRUCTION REQUIREMENT AS APPROVED BY THE ENGINEER-IN-CHARGE BEFORE STARTING EXCAVATION BELOW EL 205.0M.
 - THE SURGE CHAMBER SLOPES & ROCK SURFACES FROM EL 205.0M TO ± EL. 300.00 SHALL BE CONTINUOUSLY MONITORED FOR ANY DISTRESS DURING THE EXCAVATION OF THESE SHAFTS BELOW EL 205.0M.
 - FACE LOGS OF THE EXPOSED ROCK SURFACE SHALL BE PREPARED REGULARLY & OBSERVED FOR ANY SHEAR OR WEAK ZONES & SAME SHALL BE INTIMATED TO EG & GEOTECH DIVISION & DESIGN DIVISION .
 - THE DETAILED CONSTRUCTION METHODOLOGY & IT'S METHOD STATEMENT FOR EXCAVATION & ROCK SUPPORT FOR SURGE SHAFTS / CHAMBER UPTO HRT LEVEL SHALL BE WORKED OUT BY THE CONTRACTOR. THE SAME SHALL BE FINALISED & APPROVED BY THE ENGINEER -IN-CHARGE AS PER SITE & CONSTRUCTION CONDITIONS WITH INTIMATION TO DESIGN DIVISION.
 - FOR INSTRUMENTATION, REFER SEPARATE DRGS.
 - FOR REINFORCEMENT & CONCRETE LINING, REFER SEPARATE DRGS.

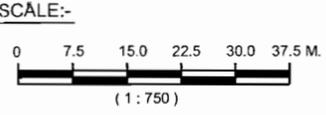
LEGEND

(A) SURGE SHAFTS / CHAMBER TO BE EXCAVATED IN STAGE-I

(B) SURGE SHAFTS / CHAMBER TO BE EXCAVATED IN STAGE-II (AFTER EXCAVATION AND CONCRETING OF SURGE SHAFTS / CHAMBER OF STAGE-I)

REFERENCE DRGS :

Sr. NO.	DESCRIPTION	DRAWING NO.
1	SURGE CHAMBER - SURFACE EXCAVATION PLAN & SECTIONS	NHSRL-3DC2-41-DD-307
2	SURGE CHAMBER - SURFACE EXCAVATION SECTIONS	NHSRL-3DC2-41-DD-308
3	SURGE CHAMBER - ADDITIONAL SURFACE EXCAVATIONAL & ADDITIONAL MONITORING MEASURES	NHSRL-3DC2-41-DD-325
4	SURGE CHAMBER - ADDITIONAL SURFACE EXCAVATIONAL & ADDITIONAL MONITORING MEASURES	NHSRL-3DC2-41-DD-326
5	SURGE CHAMBER - ADDITIONAL SURFACE EXCAVATIONAL & ADDITIONAL MONITORING MEASURES	NHSRL-3DC2-41-DD-327
	SURGE CHAMBER - EXCAVATION & ROCK SUPPORTS FROM EL.221.50 TO EL.205.00	NHSRL-3DC2-41-DD-328 & 329



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SUBANSIRI LOWER HYDROELECTRIC PROJECT

SURGE CHAMBER EXCAVATION AND ROCK SUPPORTS FROM EL.205.00 TO EL.160.50 PART-A

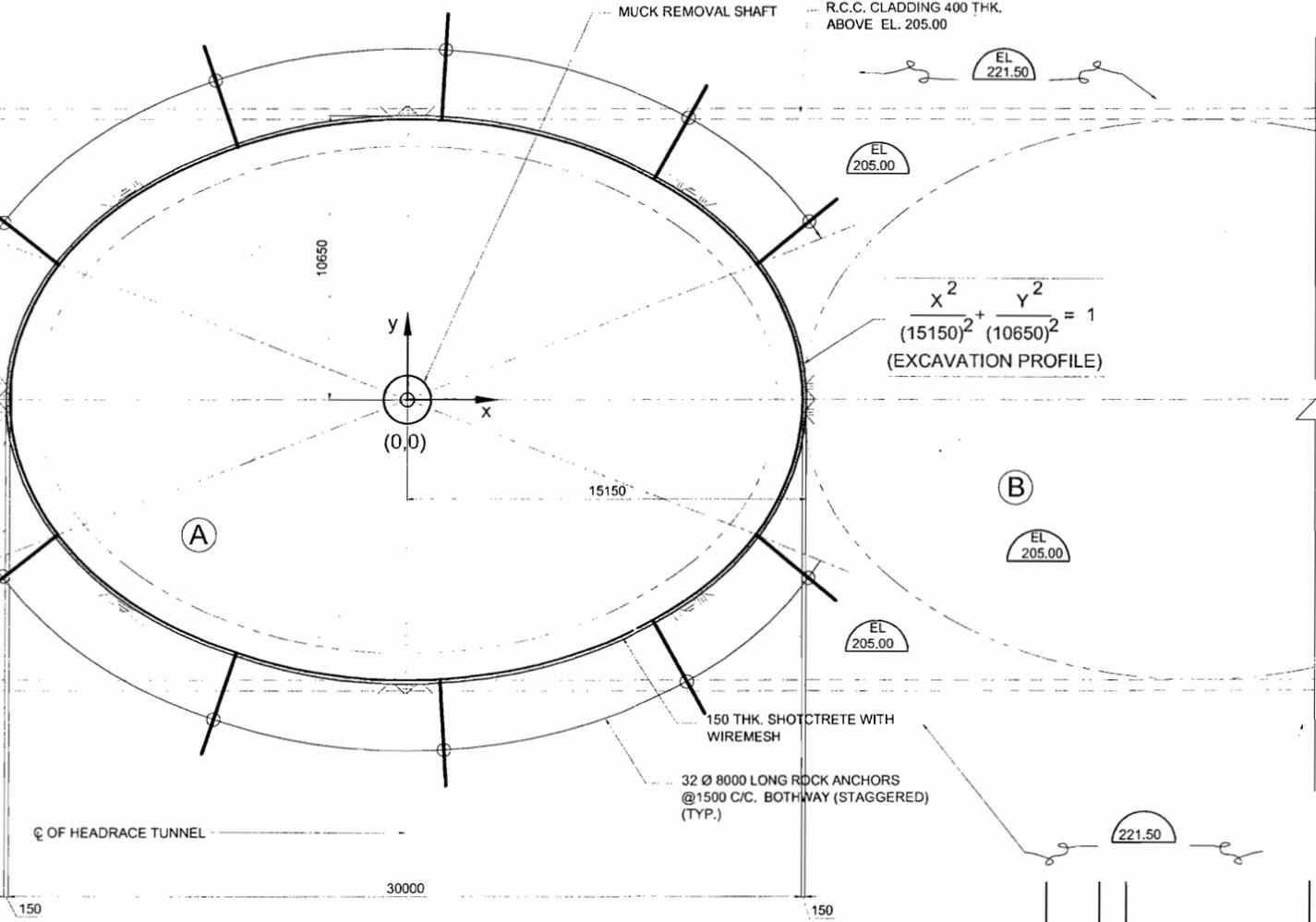
(SHEET 1 OF 2)

05-09-07	00	ISSUED FOR CONSTRUCTION				
DATE	NO.	REVISION OR ISSUES	BY.	CH.	APP.	

DRAWN	MOHINDER SINGH	SUBMITTED	अनुमोदन	RECOMMENDED	अनुमोदन	APPROVED	अनुमोदन
DATE	SEP., 2007	DRG. NO.	NHSRL 3DC2 41 DD 330 00				

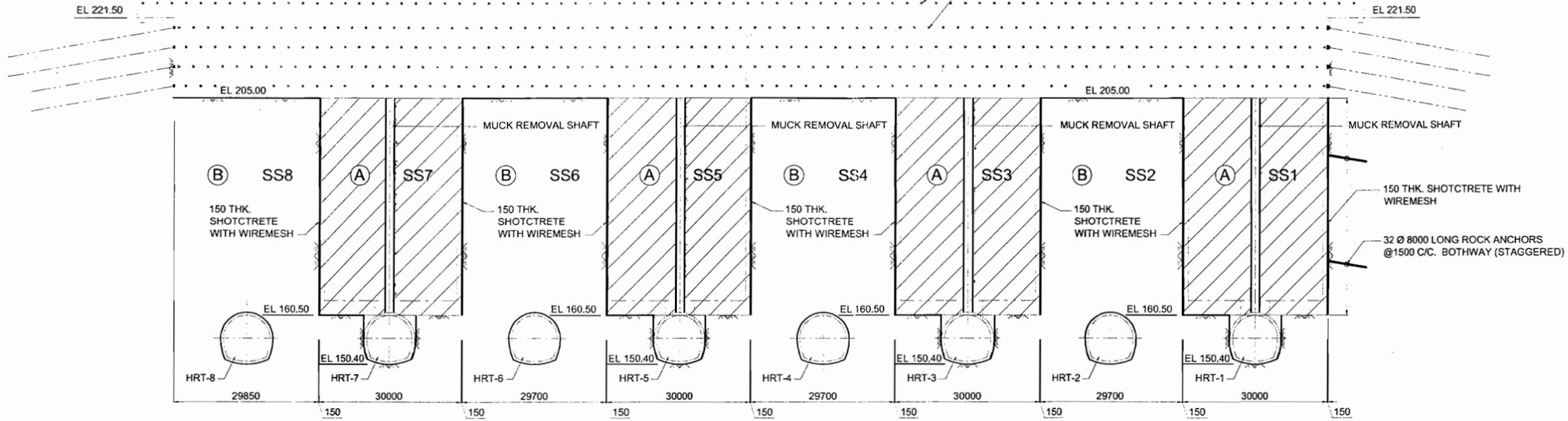
F / DCE / 730 / 01 / 02
REV. NO. 0.0
EFF. DATE 01.08.02

DRG. NO. NHSRL - 3DC2 - 41 - DD - 330 - 00



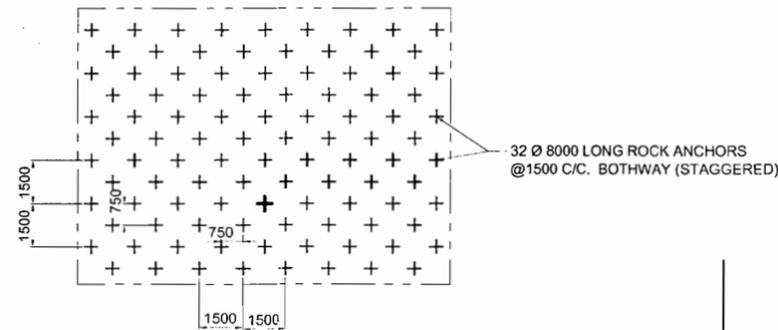
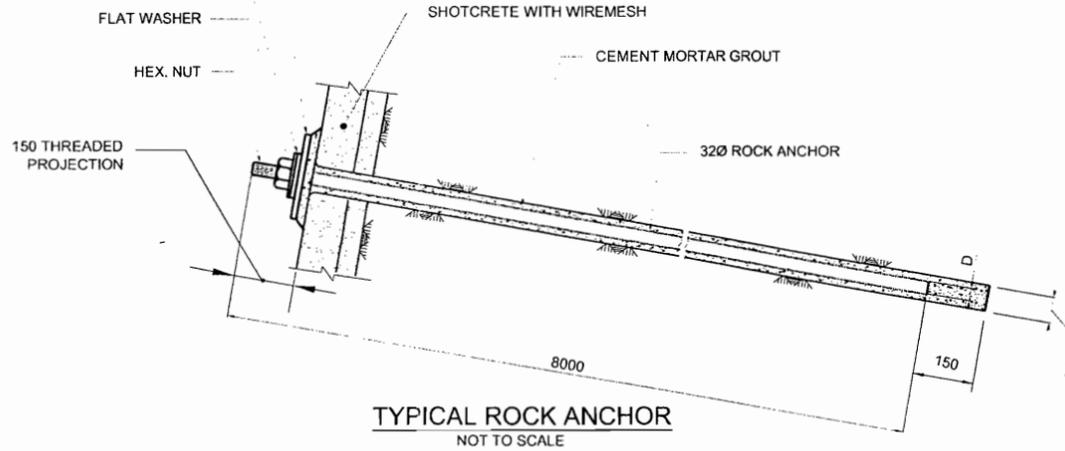
TYPICAL PLAN FOR ROCK SUPPORT DETAILS BELOW EL.205.00

FOR EXCAVATION & ROCK SUPPORTS FROM EL. 221.50 TO EL.205.00 REFER DRG.NO.NHSRL-3DC2-41-DD-328 & 329



SECTIONAL VIEW A-A

- BEARING PLATE 150X150X10
- BEVELLED WASHER
- FLAT WASHER
- HEX. NUT
- 150 THREADED PROJECTION
- QUICK SET MORTAR BEARING PAD ON IRREGULAR SURFACE
- SHOTCRETE WITH WIREMESH
- CEMENT MORTAR GROUT
- 32Ø ROCK ANCHOR

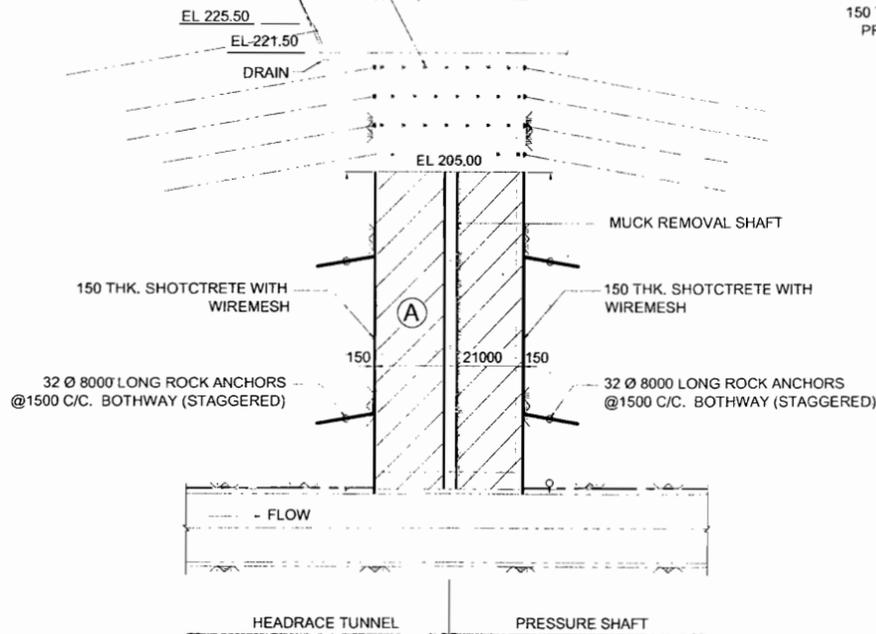


ROCK ANCHORS PATTERN DETAIL

NOTES :

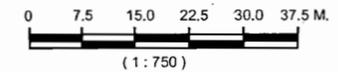
1. ALL DIMENSIONS ARE IN MILLIMETRE AND LEVELS IN METRE.
2. FOR OTHER NOTES REFER DRG. NO. NHSRL-3DC2-41-DD-330.

FOR EXCAVATION & ROCK SUPPORTS FROM EL. 221.50 TO EL.205.00 REFER DRG.NO.NHSRL-3DC2-41-DD-328 & 329



SECTION B-B

SCALE:-



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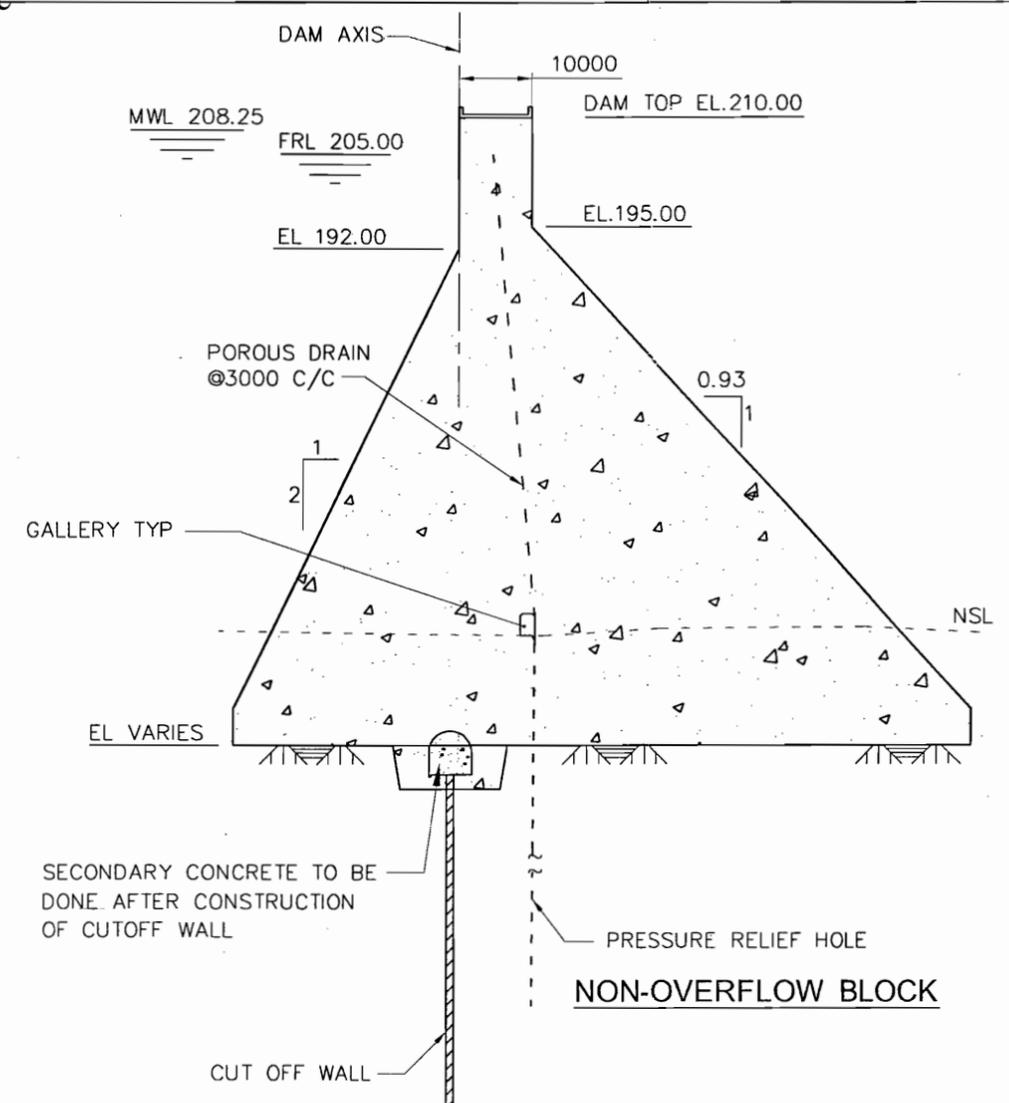
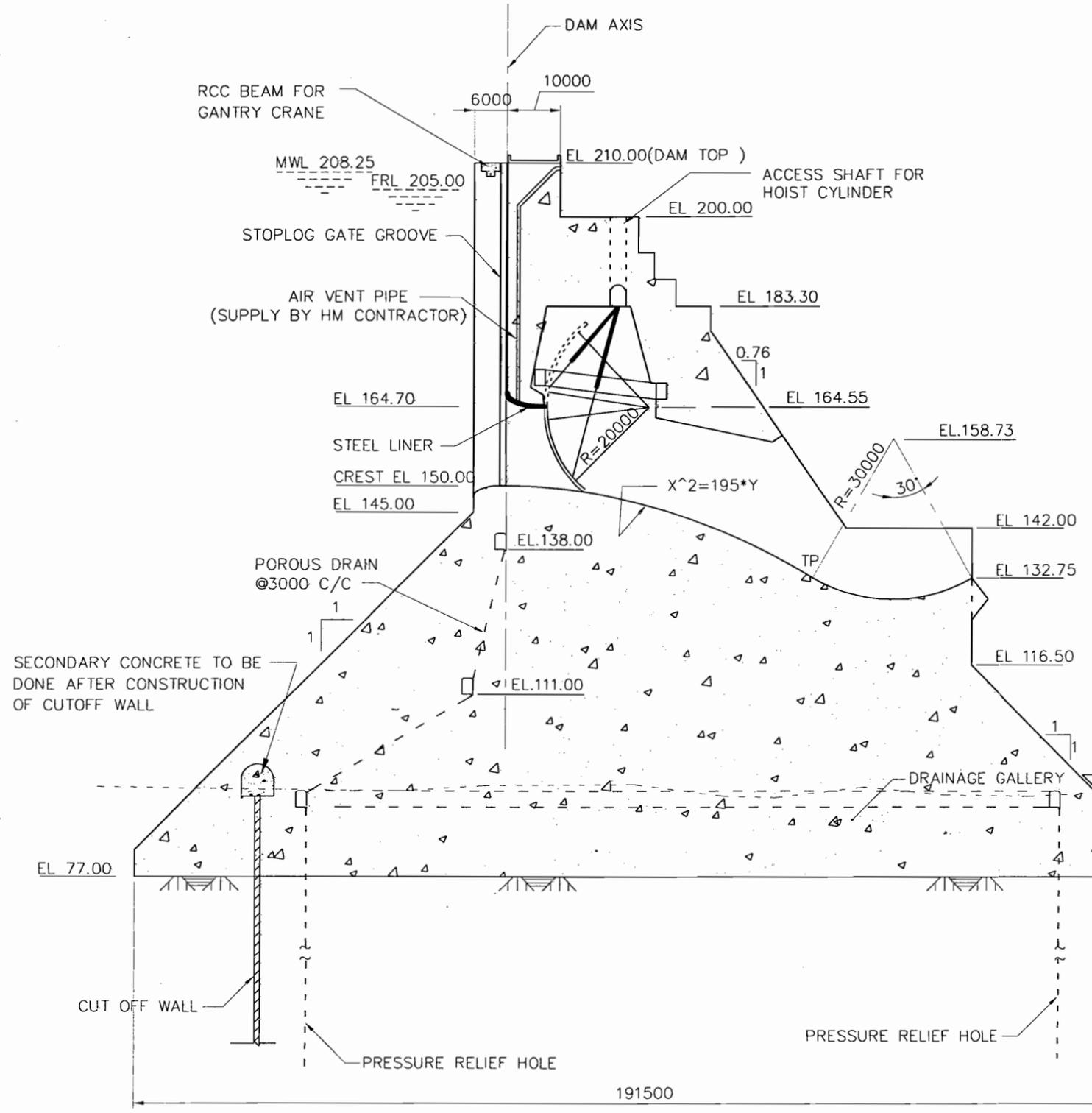
सुबनसिरी लोअर जलविद्युत परियोजना
SUBANSIRI LOWER HYDROELECTRIC PROJECT

SURGE CHAMBER
EXCAVATION AND ROCK SUPPORTS
FROM EL.205.00 TO EL.160.50
PART-A

(SHEET 2 OF 2)

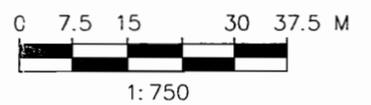
05.09.07	00	ISSUED FOR CONSTRUCTION																		
DATE	NO.	REVISION OR ISSUES	BY.	CH.	APP.	DATE	SEPT., 2007	DRG. NO.	NHSRL	3DC2	41	DD	331	00						

F / DCE / 730 / 01 / 02
REV. NO. 0.0
EFF. DATE 01.08.02



NOTE:-
 1. ALL DIMENSIONS ARE IN MILLIMETRE AND ELEVATIONS IN METRE.

TENDER PURPOSE ONLY



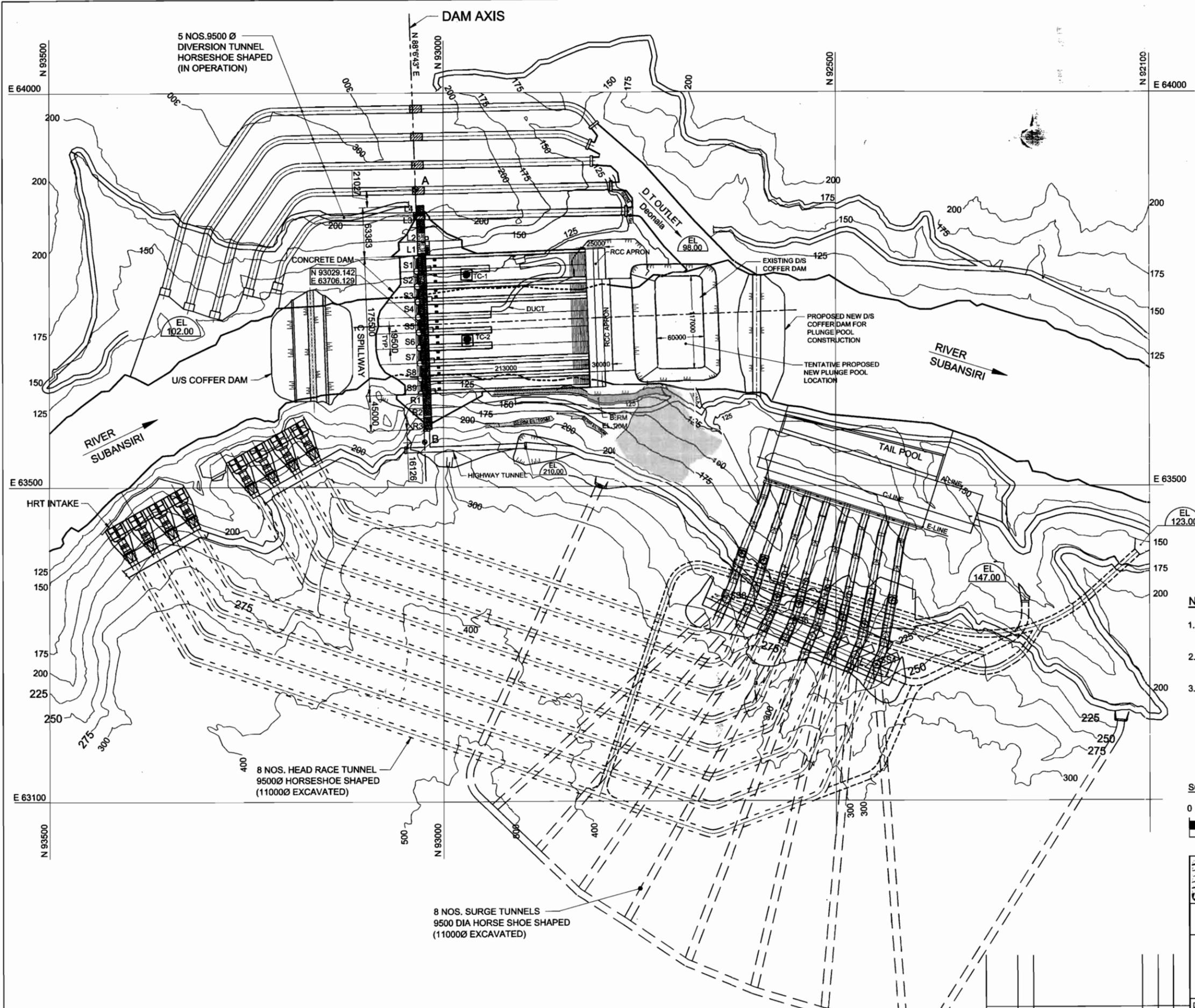
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नैशनल हाईड्रोइलेक्ट्रिक पावर कारपोरेशन लि.
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 SUBANSIRI LOWER HYDROELECTRIC PROJECT

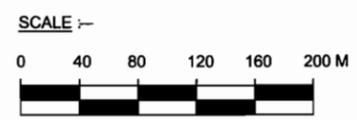
**DAM
 CROSS SECTIONS**

DATE	NO.	REVISION OR ISSUES	BY	CH.	APP.	DATE	DRG. NO.	00
30.05.03	100	ISSUED FOR TENDER				MAR 03	NHSRL-2DT1-41-GA-016	00
DRAWN			SUBMITTED			RECOMMENDED		
रिडर R. N. SHARMA			प्रस्तुत S. C. JOSHI			अनुमोदित Y.K. CHAUBEY		
APPROVED			अनुमोदित V.K. GUPTA					

CONSTRUCTION DRAWINGS



- NOTE :-**
1. ALL DIMENSIONS ARE IN MILLIMETRE, GRID VALUES AND ELEVATIONS IN METRE.
 2. THE LAYOUT HAS BEEN MODIFIED AS PER THE RECOMMENDATIONS OF DAM DESIGN REVIEW PANEL.
 3. THE PRESENT LAYOUT PLAN IS SHOWN ON TOPOGRAPHICAL SURVEY AS RECEIVED FROM PROJECT VIDE LETTER NO.NH/SLP/ED/15/2013/581/ DATED 09-07-2013.



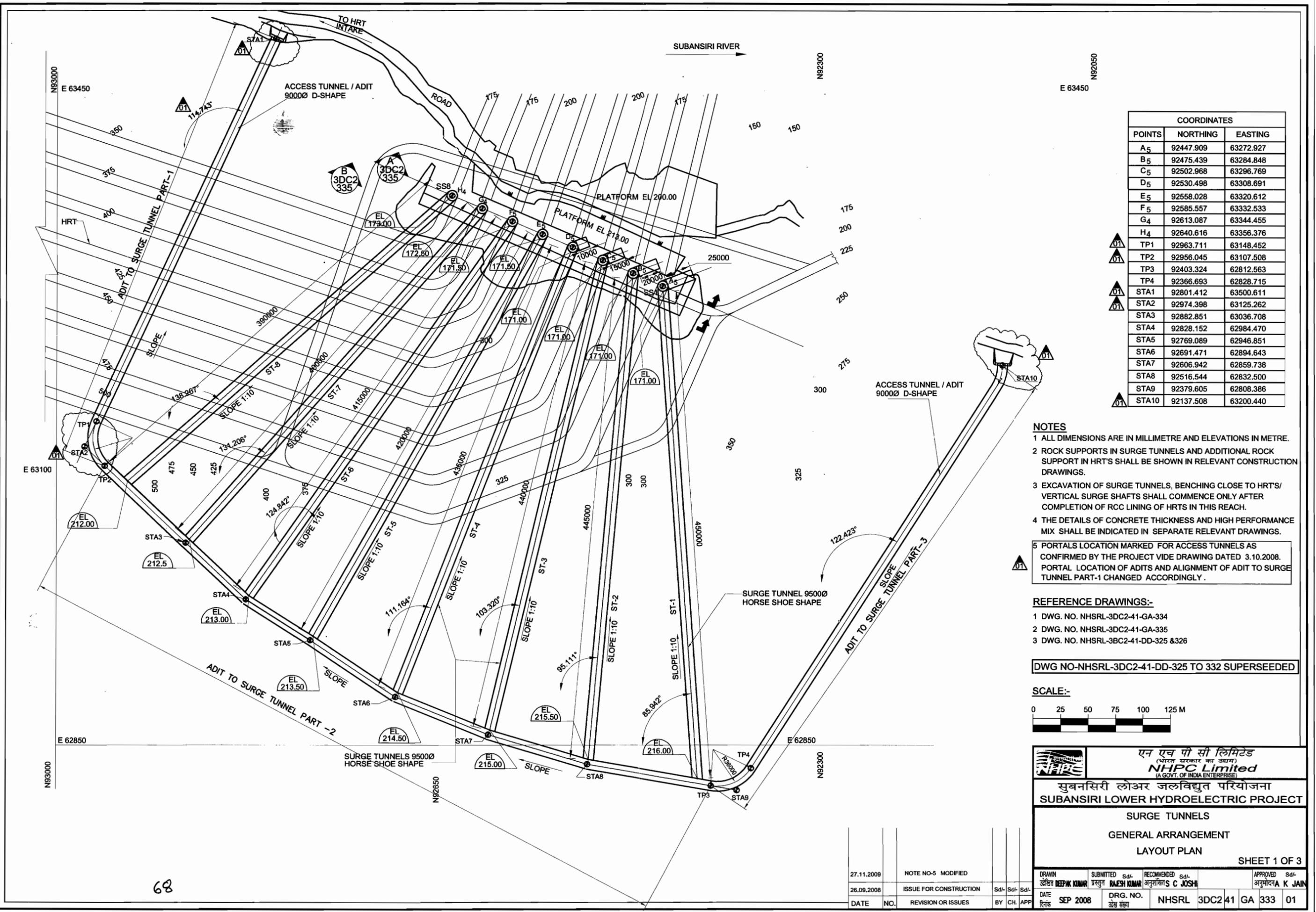
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SUBANSIRI LOWER HYDROELECTRIC PROJECT

DAM
GENERAL ARRANGEMENT
MODIFIED LAYOUT PLAN

19.08.13	00	ISSUED FOR COMMENTS				DRWN	SUBMITTED	RECOMMENDED	APPROVED
						अश्विन RAN SINGH	प्रस्तुत	अनुशुभित R M A KHAN	H M DESIGN
						अनुमोदन A K JAIN			
DATE	NO.	REVISION OR ISSUES	BY.	CH.	APP.	DATE	DRG. NO.		
19.08.13	00					AUG., 2013	अश्विन संख्या	NHSRL	2DC1 41 GA 188 00

MODIFIED LAYOUT PLAN

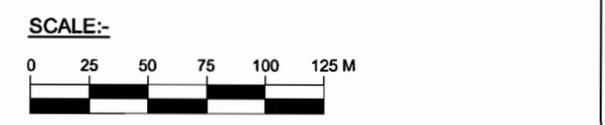


COORDINATES		
POINTS	NORTHING	EASTING
A ₅	92447.909	63272.927
B ₅	92475.439	63284.848
C ₅	92502.968	63296.769
D ₅	92530.498	63308.691
E ₅	92558.028	63320.612
F ₅	92585.557	63332.533
G ₄	92613.087	63344.455
H ₄	92640.616	63356.376
TP1	92963.711	63148.452
TP2	92956.045	63107.508
TP3	92403.324	62812.563
TP4	92366.693	62828.715
STA1	92801.412	63500.611
STA2	92974.398	63125.262
STA3	92882.851	63036.708
STA4	92828.152	62984.470
STA5	92769.089	62946.851
STA6	92691.471	62894.643
STA7	92606.942	62859.738
STA8	92516.544	62832.500
STA9	92379.605	62808.386
STA10	92137.508	63200.440

- NOTES**
- 1 ALL DIMENSIONS ARE IN MILLIMETRE AND ELEVATIONS IN METRE.
 - 2 ROCK SUPPORTS IN SURGE TUNNELS AND ADDITIONAL ROCK SUPPORT IN HRT'S SHALL BE SHOWN IN RELEVANT CONSTRUCTION DRAWINGS.
 - 3 EXCAVATION OF SURGE TUNNELS, BENCHING CLOSE TO HRT'S/ VERTICAL SURGE SHAFTS SHALL COMMENCE ONLY AFTER COMPLETION OF RCC LINING OF HRT'S IN THIS REACH.
 - 4 THE DETAILS OF CONCRETE THICKNESS AND HIGH PERFORMANCE MIX SHALL BE INDICATED IN SEPARATE RELEVANT DRAWINGS.
 - 5 PORTALS LOCATION MARKED FOR ACCESS TUNNELS AS CONFIRMED BY THE PROJECT VIDE DRAWING DATED 3.10.2008. PORTAL LOCATION OF ADITS AND ALIGNMENT OF ADIT TO SURGE TUNNEL PART-1 CHANGED ACCORDINGLY.

- REFERENCE DRAWINGS:-**
- 1 DWG. NO. NHSRL-3DC2-41-GA-334
 - 2 DWG. NO. NHSRL-3DC2-41-GA-335
 - 3 DWG. NO. NHSRL-3DC2-41-DD-325 & 326

DWG NO-NHSRL-3DC2-41-DD-325 TO 332 SUPERSEDED



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SUBANSIRI LOWER HYDROELECTRIC PROJECT

SURGE TUNNELS
GENERAL ARRANGEMENT
LAYOUT PLAN

SHEET 1 OF 3

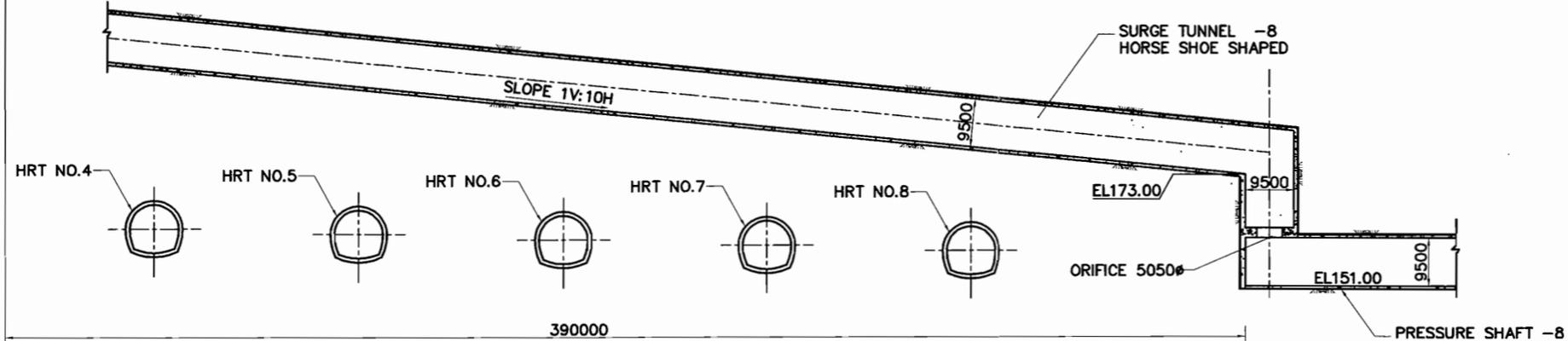
DRAWN अंकित DEEPAK KUMAR	SUBMITTED Sd/- प्रस्तुत RAJESH KUMAR	RECOMMENDED Sd/- अनुमोदित S C JOSHI	APPROVED Sd/- अनुमोदन A K JAIN
DATE दिनांक SEP 2008	DRG. NO. अंक संख्या NHSRL 3DC2 41 GA 333	01	

27.11.2009	NOTE NO-5 MODIFIED	Sd/-	Sd/-	Sd/-
26.09.2008	ISSUE FOR CONSTRUCTION	BY	CH	APP
DATE	NO.	REVISION OR ISSUES	BY	CH

DRG. NO. NHSRL-3DC2-41-GA-333-01

ADIT TO TOP OF SURGE TUNNEL
9000 D SHAPE

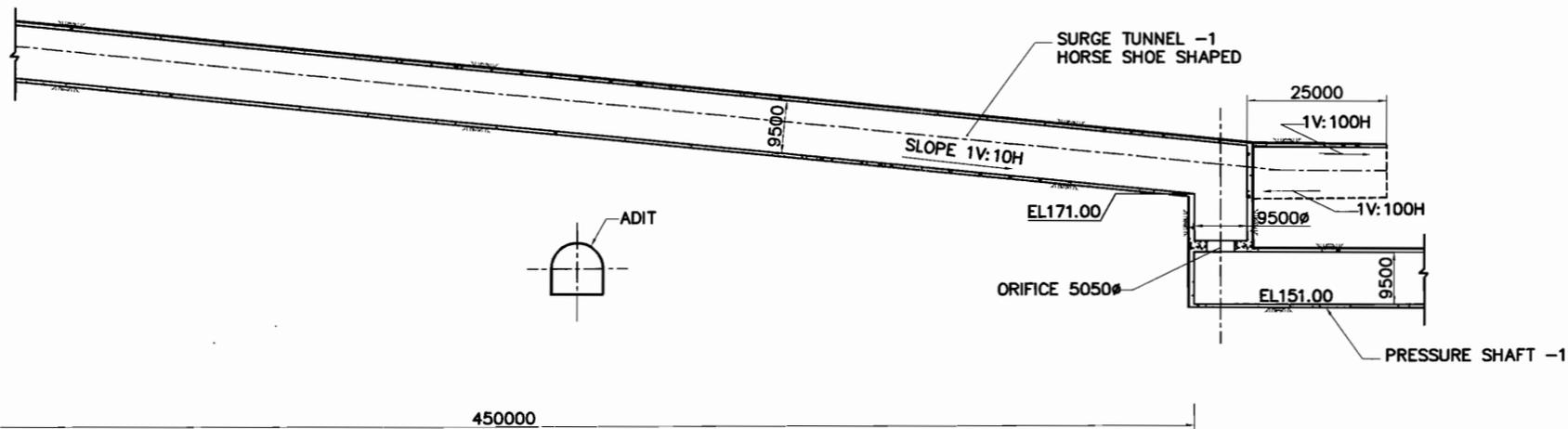
EL 212.00



L-SECTION ALONG SURGE TUNNEL NO. -8

ADIT TO TOP OF SURGE TUNNEL
9000 D SHAPE

EL 216.00



L-SECTION ALONG SURGE TUNNEL NO. -1

NOTES:-

- 1- ALL DIMENSIONS ARE IN MILLIMETRE AND ELEVATIONS IN METRE.
- 2-FOR OTHER NOTES REFER DRAWING NO-NHSRL-3DC2-41-GA-333

REFERENCE DRAWINGS:-

- 1- DWG. NO. NHSRL-3DC2-41-GA-333
- 2- DWG. NO. NHSRL-3DC2-41-GA-335

DWG NO-NHSRL-3DC2-41-DD-325 TO 332 SUPERSEDED

SCALE:-

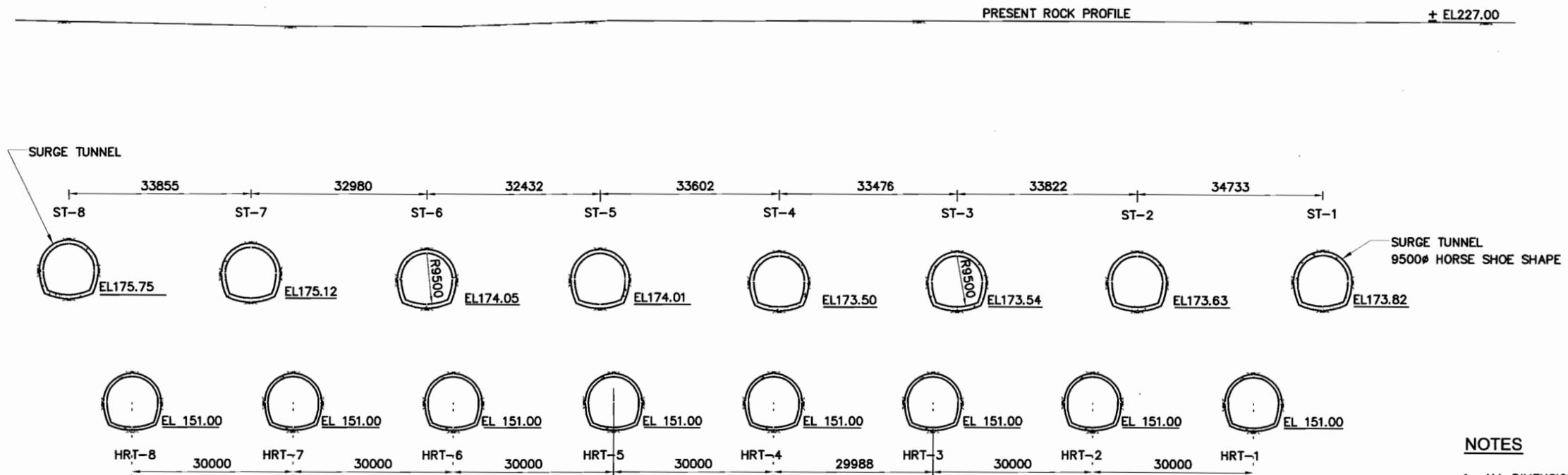


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सुबनसिरी लोअर जलविद्युत परियोजना SUBANSIRI LOWER HYDROELECTRIC PROJECT			
SURGE TUNNELS GENERAL ARRANGEMENT SECTIONS			
SHEET 2 OF 3			
DRAWN अभिषेक DEEPAK KR	SUBMITTED प्रस्तुत RAJESH KR	RECOMMENDED अनुमोदित S C JOSHI	APPROVED अनुमोदित A K JAIN
DATE दिनांक SEP 08	DRG. NO. अंक संख्या NHSRL	3DC2 41 GA	334 00

26.09.2008	ISSUE FOR CONSTRUCTION	BY	CH. APP
DATE	NO.	REVISION OR ISSUES	BY

69

DRG. NO. NHSRL-3DC2-41-GA-334-00



SECTION B-B AT 25M U/S OF SURGE TUNNELS

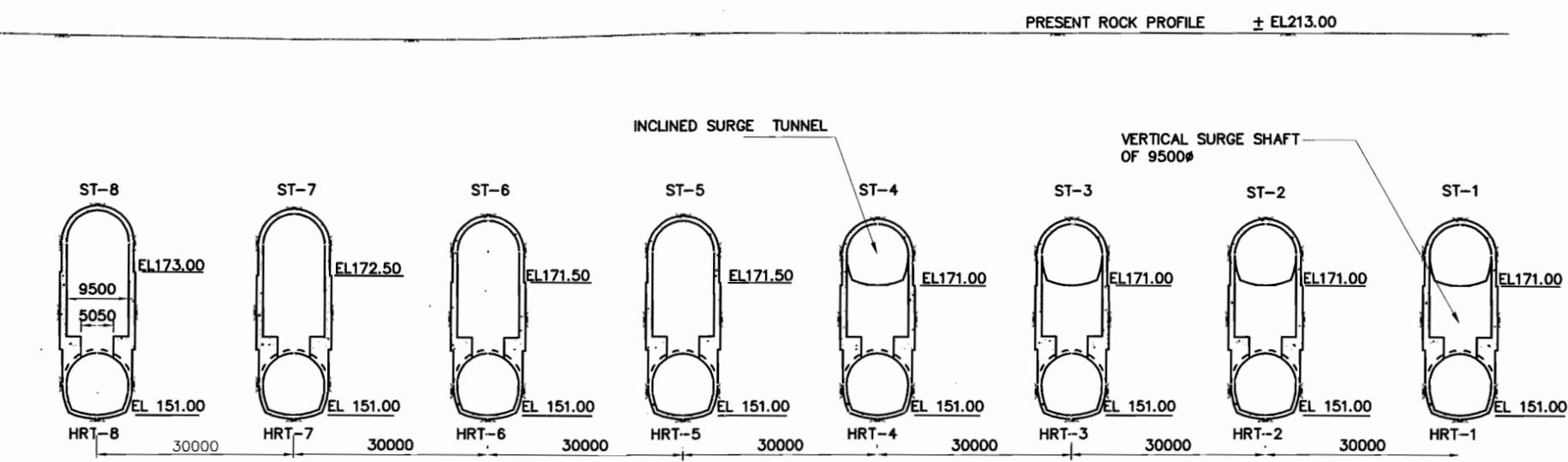
NOTES

- 1 ALL DIMENSIONS ARE IN MILLIMETRE AND ELEVATIONS IN METRE.
- 2 FOR OTHER NOTES REFER DWG NO. NHSRL-3DC2-41-GA-333.

REFERENCE DRAWINGS

- 1 DWG NO. NHSRL-3DC2-41-GA-333
- 2 DWG NO. NHSRL-3DC2-41-GA-334

DWG NO-NHSRL-3DC2-41-DD-325 TO 332 SUPERSEDED



SECTION A-A AT C OF SURGE TUNNELS

SCALE:-



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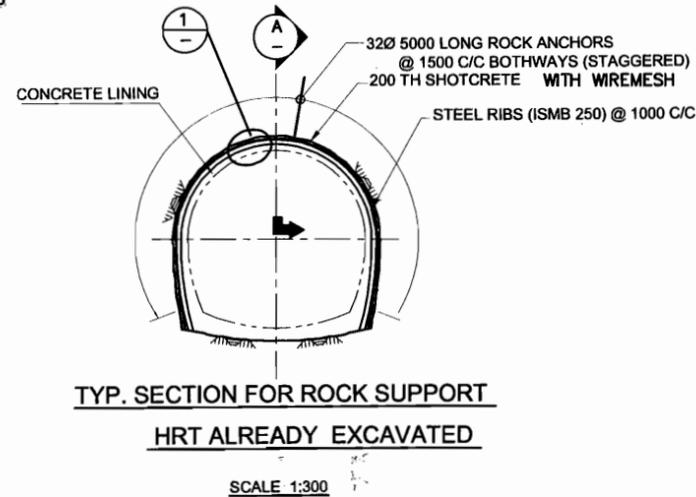
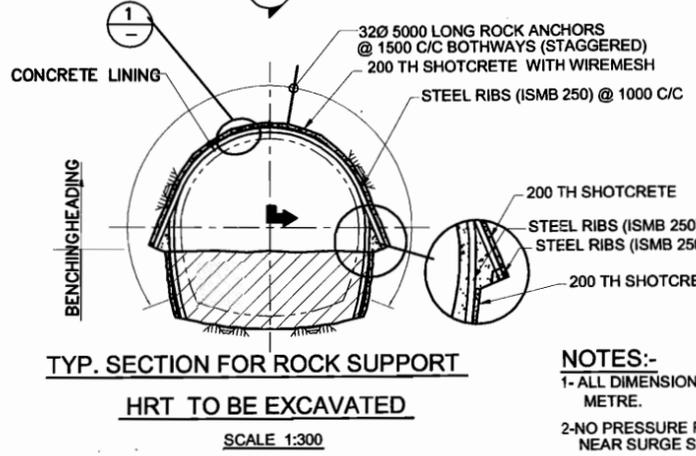
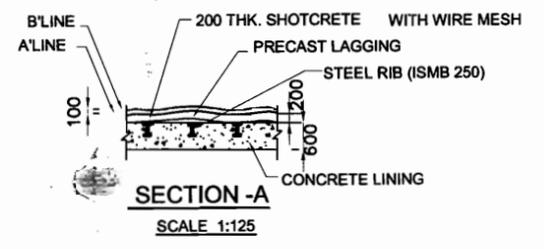
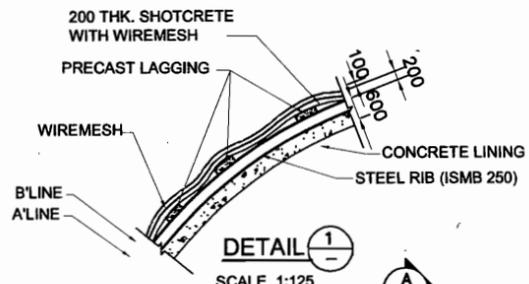
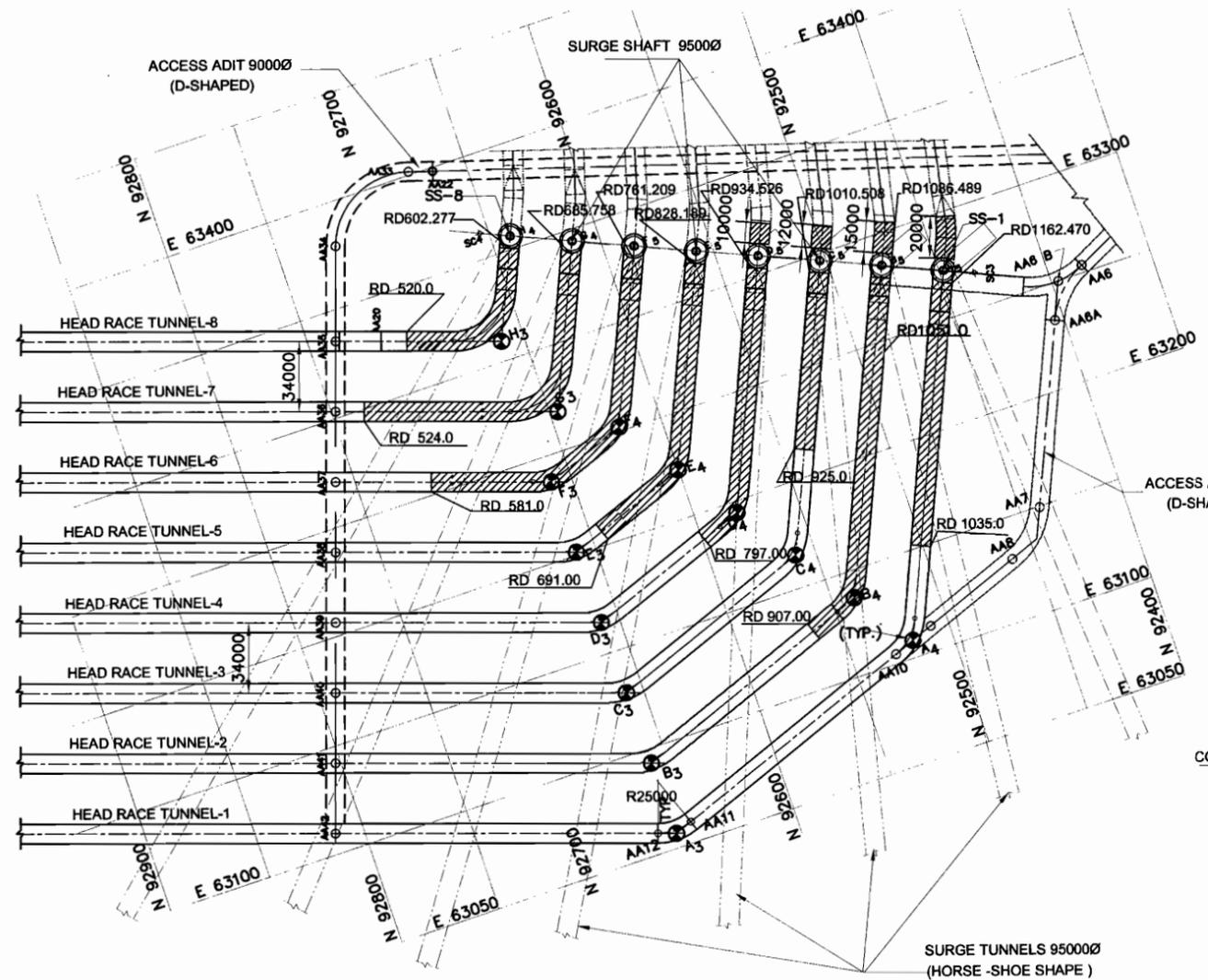
सुबनसिरी लोअर जलविद्युत परियोजना
SUBANSIRI LOWER HYDROELECTRIC PROJECT

SURGE TUNNELS
GENERAL ARRANGEMENT
SECTIONS SHEET 3 OF 3

DATE	NO.	REVISION OR ISSUES	BY	CH.	APP.
26.09.2008		ISSUE FOR CONSTRUCTION			
DATE	NO.	REVISION OR ISSUES	BY	CH.	APP.
SEP 2008					

DRG. NO. 333 NHSRL-3DC2-41-GA-335-00

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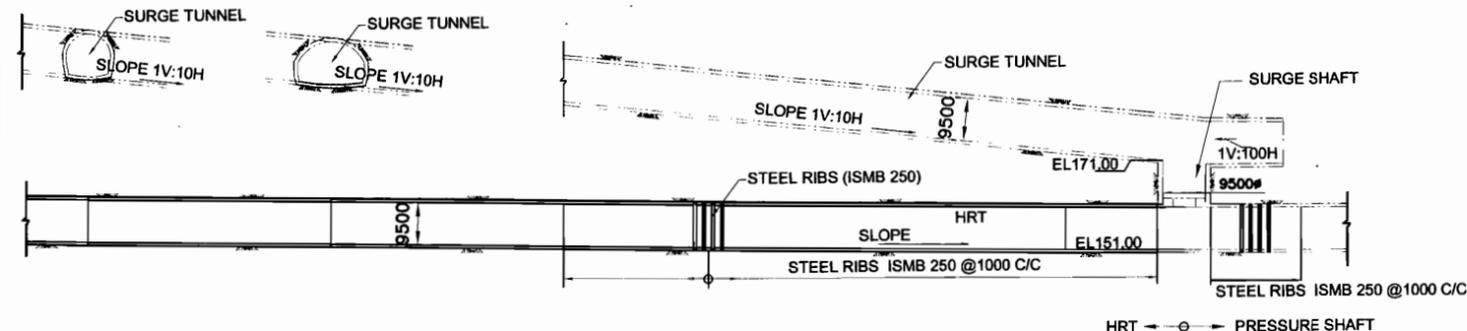


- NOTES:-**
- 1- ALL DIMENSIONS ARE IN MILLIMETRE AND ELEVATIONS IN METRE.
 - 2- NO PRESSURE RELIEF HOLES SHALL BE PROVIDED IN HRT NEAR SURGE SHAFT.
 - 3- LENGTH OF HRT WITH STEEL RIB SHOWN INCLUDES ALREADY INSTALLED STEEL RIBS IN HRT DUE TO GEOLOGICAL CONDITION.
 - 4- FOR ROCK SUPPORT DETAILS IN SURGE TUNNELS REFER SEPARATE DRAWINGS.
 - 5- FOR SUPPLY, FABRICATION & INSTALLATION OF STEEL RIBS REFER SECTION B.4 OF T.S.
 - 6- FOR CONSOLIDATION GROUTING REFER SEPARATE DRAWINGS.
 - 7- FOR OTHER NOTES REFER DRAWING NO-NHSRL-3CC2-41-DD-314 & 315

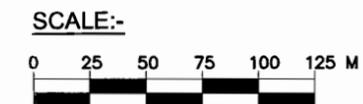
- REFERENCE DRAWINGS:-**
- 1- DWG. NO. NHSRL-3AC2-41-DD-309
 - 2- DWG. NO. NHSRL-3AC2-41-DD-330 TO 334
 - 3- DWG. NO. NHSRL-3CC2-41-DD-314
 - 4- DWG. NO. NHSRL-3CC2-41-DD-315

LEGEND

HRT LENGTH WITH STEEL RIB SUPPORT



SL NO	HRT	EXTENT OF STEEL RIB	
		FROM(RD)	TO(RD)
1	HRT-1	1035.00	1162.470
2	HRT-2	907.00	1086.489
3	HRT-3	925.00	1010.508
4	HRT-4	797.00	934.526
5	HRT-5	691.00	828.189
6	HRT-6	581.00	761.209
7	HRT-7	524.00	685.758
8	HRT-8	520.00	602.277



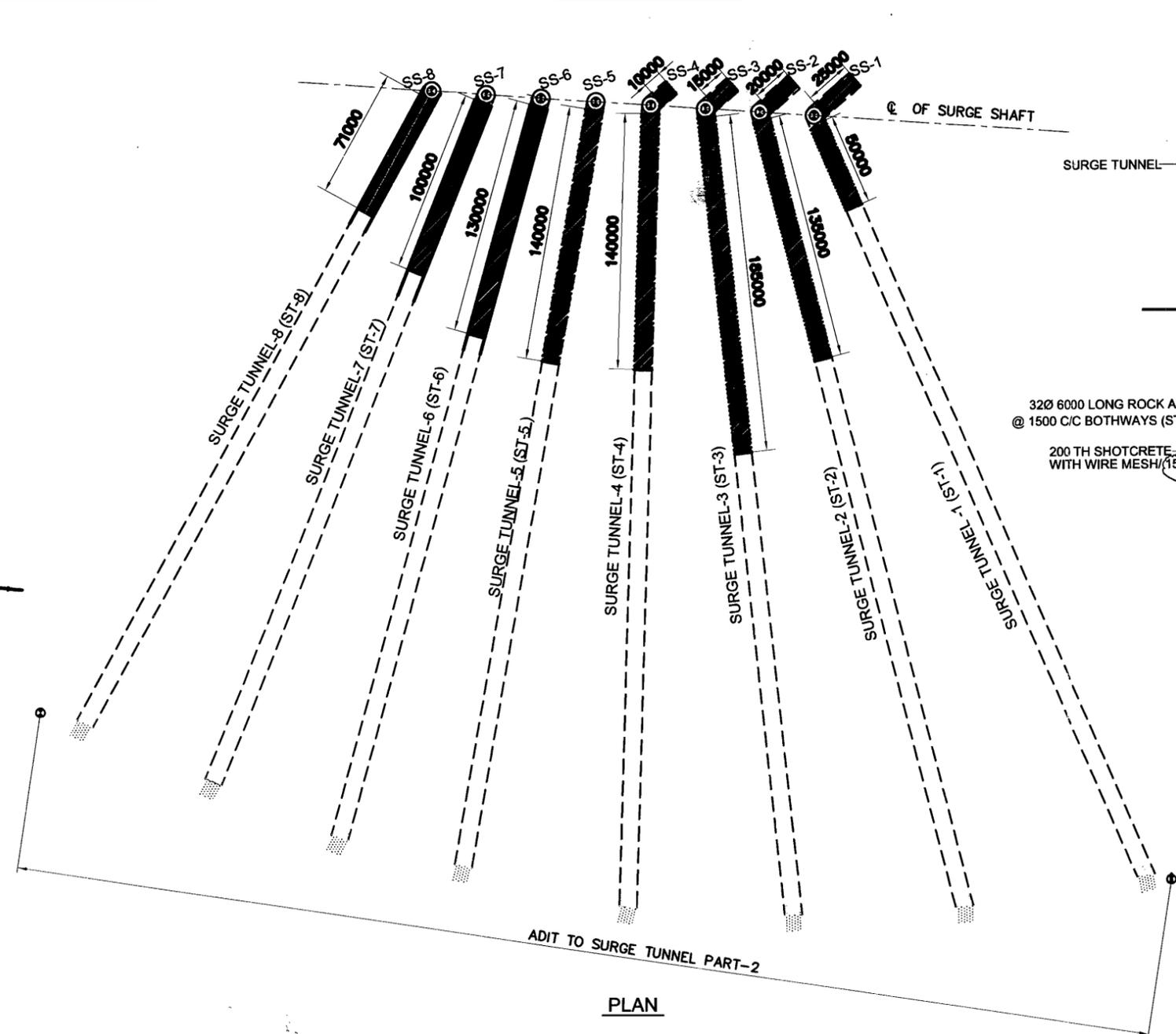
TYPICAL L-SECTION
SCALE 1:1250

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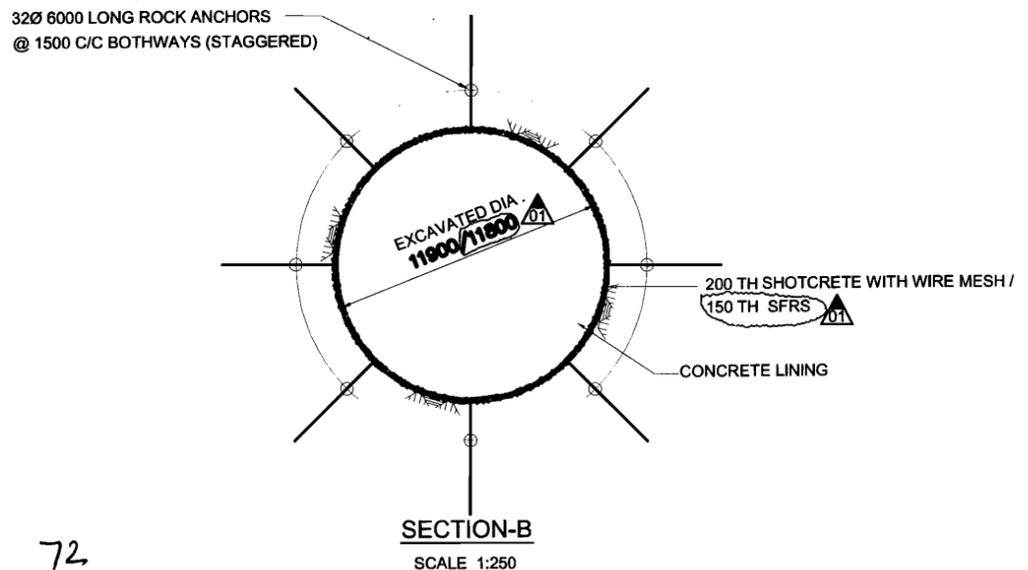
सुबानसिरी लोअर जलविद्युत परियोजना
SUBANSIRI LOWER HYDROELECTRIC PROJECT

HEAD RACE TUNNELS
ROCK SUPPORT DETAILS
NEAR SURGE TUNNEL/SHAFT
PLAN & SECTIONS

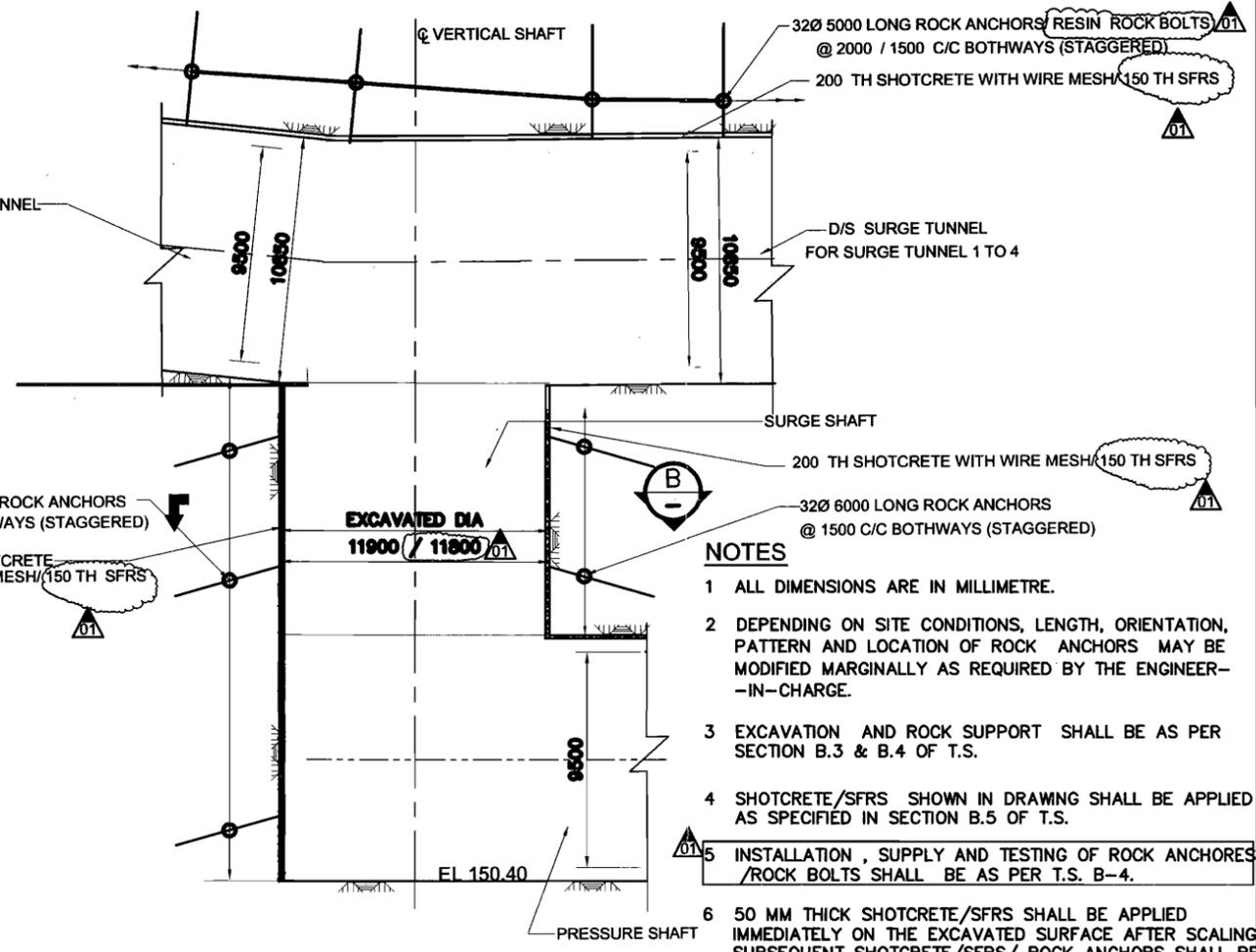
DATE	6.11.2008	ISSUE FOR CONSTRUCTION	BY	CH. APP
REVISION OR ISSUES				
DATE	OCT. 08	DRG. NO.	NHSRL 3CC2 41 GA 335	00
REVISION OR ISSUES				



PLAN



SECTION-B
SCALE 1:250



SURGE SHAFT (TYP.)
SCALE 1:250

- NOTES**
- 1 ALL DIMENSIONS ARE IN MILLIMETRE.
 - 2 DEPENDING ON SITE CONDITIONS, LENGTH, ORIENTATION, PATTERN AND LOCATION OF ROCK ANCHORS MAY BE MODIFIED MARGINALLY AS REQUIRED BY THE ENGINEER-IN-CHARGE.
 - 3 EXCAVATION AND ROCK SUPPORT SHALL BE AS PER SECTION B.3 & B.4 OF T.S.
 - 4 SHOTCRETE/SFRS SHOWN IN DRAWING SHALL BE APPLIED AS SPECIFIED IN SECTION B.5 OF T.S.
 - 5 INSTALLATION, SUPPLY AND TESTING OF ROCK ANCHORS / ROCK BOLTS SHALL BE AS PER T.S. B-4.
 - 6 50 MM THICK SHOTCRETE/SFRS SHALL BE APPLIED IMMEDIATELY ON THE EXCAVATED SURFACE AFTER SCALING. SUBSEQUENT SHOTCRETE/SFRS / ROCK ANCHORS SHALL BE PROVIDED AFTER REMOVAL OF MUCK.
 - 7 EXCAVATION OF VERTICAL SHAFT SHALL BE AFTER THE EXCAVATION OF ENTIRE SURGE TUNNELS.
 - 8 LOCATION AND SPACING OF STEEL RIBS OTHER THAN JUNCTION AND AS SHOWN IN DRAWING MAY BE DECIDED BY THE ENGINEER-IN-CHARGE AS PER SITE CONDITION.
 9. FOR TYPICAL SECTIONS OF ROCK SUPPORT FOR DIFFERENT CLASSES REFER DRAWING NO NHSRL-3DC2-41-DD-337
 10. STEEL RIBS SHALL BE ERECTED ALONG WITH ROCK SUPPORT MEASURES AT THE JUNCTION BEFORE EXCAVATION OF SURGE TUNNELS.
 - 11 FOR TYPE (HPC ETC) GRADE, EXTENT AND REINFORCEMENT OF RCC LINING REFER SEPARATE DRAWING.
 12. SUITABILITY OF ROCK ANCHORS / RESIN ROCK BOLTS IN SURGE TUNNELS FOR EXISTING ROCK CONDITIONS SHALL BE ESTABLISHED BY IN-SITU TESTS AS DECIDED BY ENGINEER-IN-CHARGE.

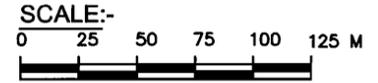
REFERENCE DRAWINGS

- 1 NHSRL-3DC2-41-GA-333.
- 2 NHSRL-3DC2-41-DD-334.
- 3 NHSRL-3DC2-41-DD-335.
- 4 NHSRL-3DC2-41-DD-337.

LEGEND

█ SURGE TUNNEL LENGTH ESSENTIALLY WITH STEEL RIB SUPPORT & AS PER CLASS.

DRAWING REVISED WITH RESPECT TO NEW ITEMS / CHANGES



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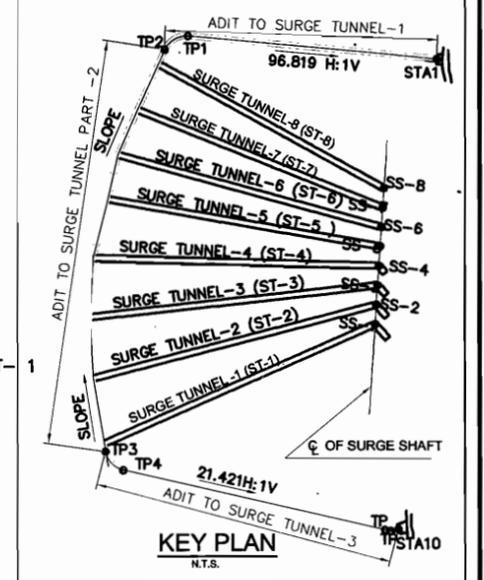
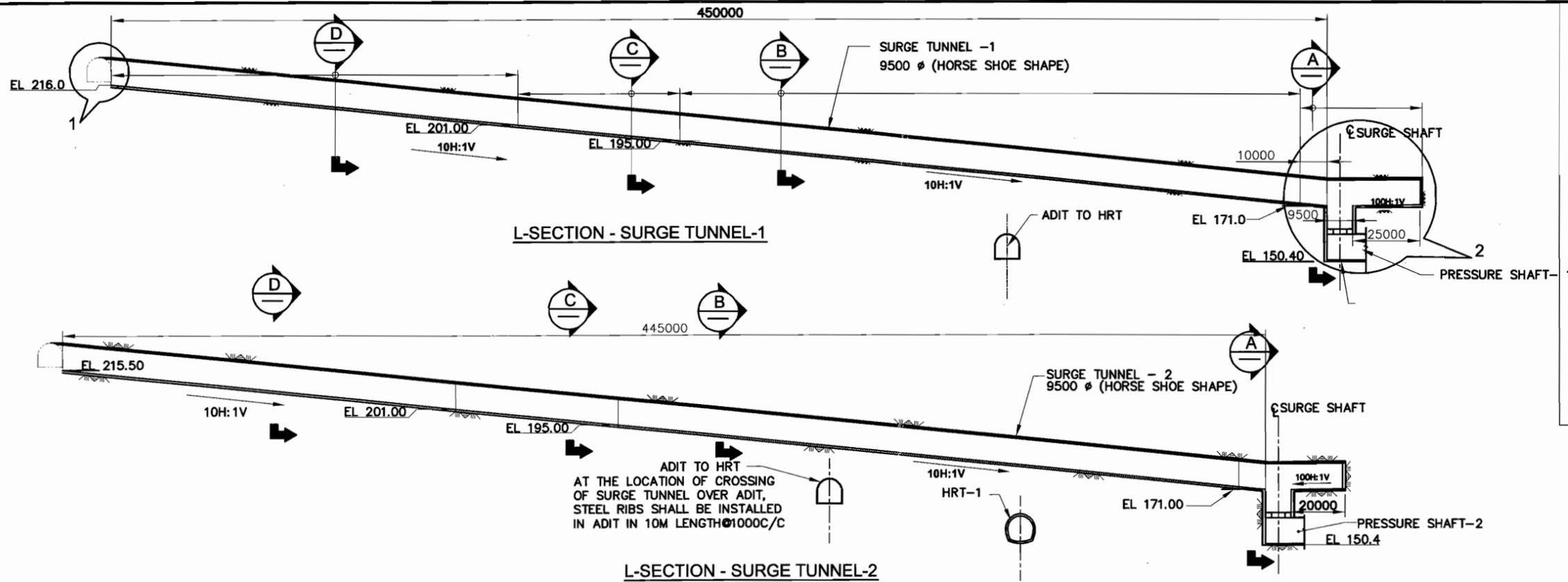
सुबनसिरी लोअर जलविद्युत परियोजना
SUBANSIRI LOWER HYDROELECTRIC PROJECT

**SURGE TUNNELS
EXCAVATION AND ROCK SUPPORT
PLAN & SECTIONS**

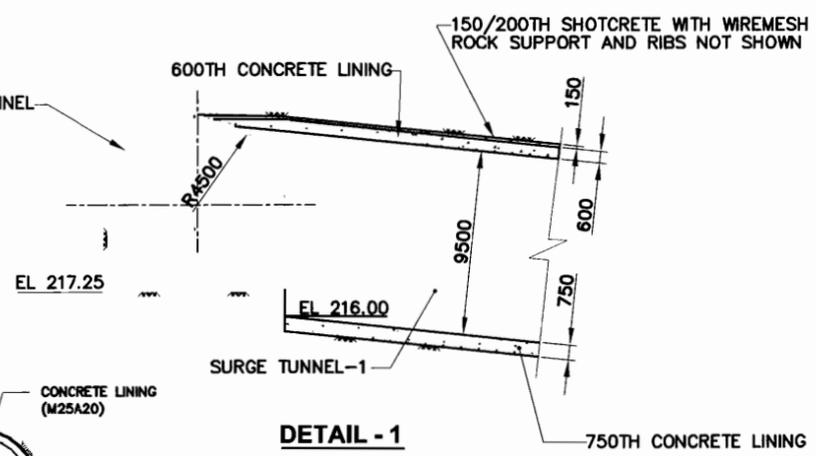
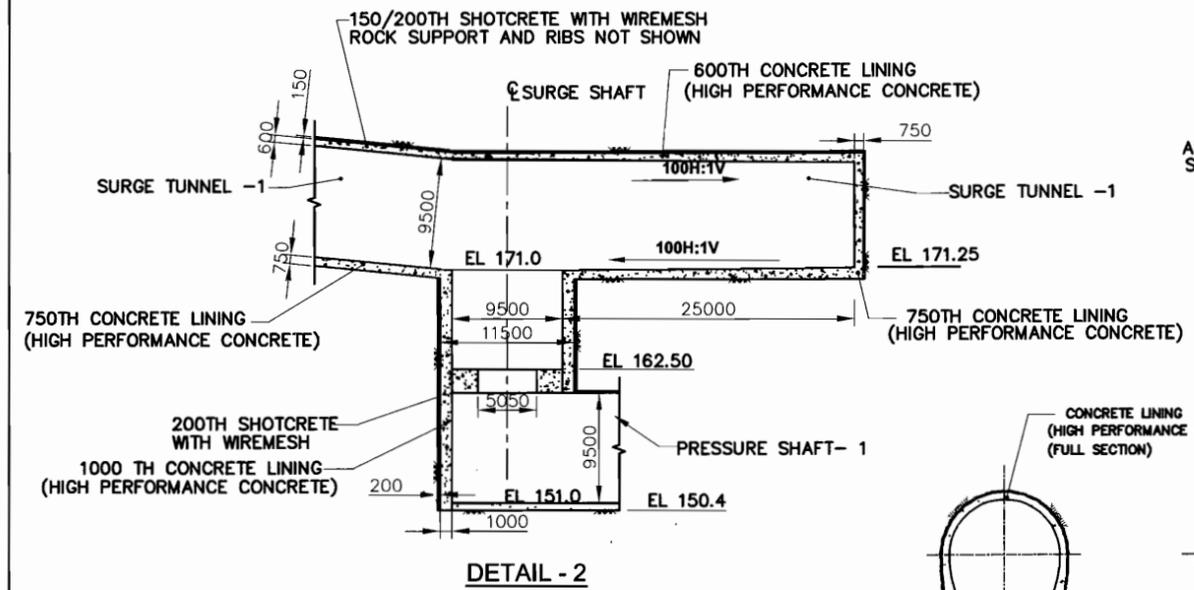
SHEET 1 OF 2

DRAWN	SUBMITTED Sd/-	RECOMMENDED Sd/-	APPROVED Sd/-
अमित	अमित	अमित	अमित
DATE	DRG. NO.	APPROVED Sd/-	
NOV. 2008	NHSRL 3DC2 41 DD 336 01	अमित	

DATE	NO.	REVISION OR ISSUES	BY	CH. APP
16.04.09	01	NEW ITEMS INTRODUCED		
28.11.08	00	ISSUED FOR CONSTRUCTION		

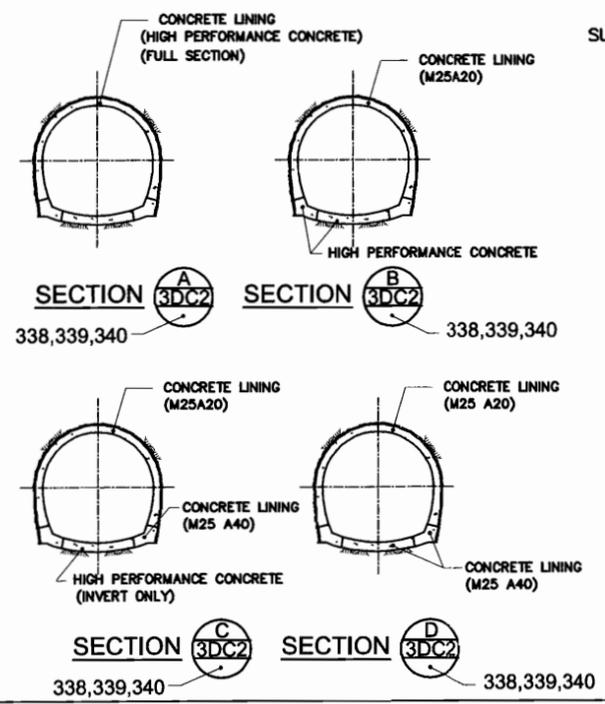
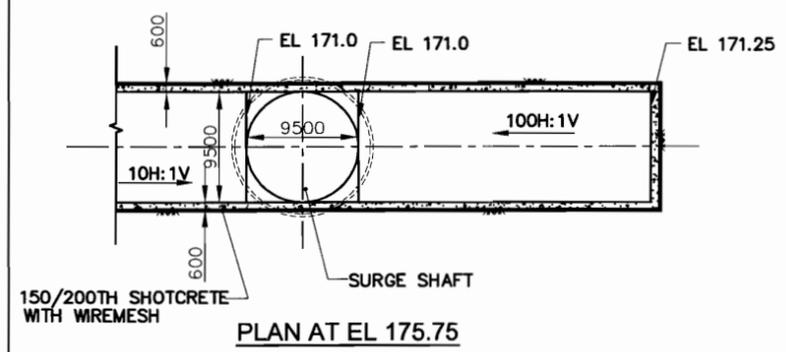
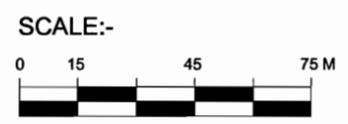


ADIT TO HRT
AT THE LOCATION OF CROSSING
OF SURGE TUNNEL OVER ADIT,
STEEL RIBS SHALL BE INSTALLED
IN ADIT IN 10M LENGTH @ 1000C/C



- NOTES**
- 1 ALL DIMENSIONS ARE IN MILLIMETRE AND ELEVATIONS IN METRE.
 - 2 BENCHING OF SURGE TUNNEL SHALL BE CARRIED OUT AFTER CONCRETE LINING OF HRT IN THIS REACH.
 - 3 EXCAVATION OF VERTICAL SHAFT SHALL BE CARRIED OUT ONLY AFTER THE FULL SECTION EXCAVATION OF ENTIRE SURGE TUNNEL.
 - 4 FOR EXCAVATION & ROCK SUPPORTS REFER DRAWING NO NHSRL-3DC2-41-DD-336 & 337.
 - 5 FOR OTHER NOTES REFER DRG. NO. NHSRL-3DC2-41-DD-336&337.

- REFERENCE DRAWINGS:-**
- 1 DRG. NO. NHSRL-3DC2-41-DD-333
 - 2 DRG. NO. NHSRL-3DC2-41-DD-334
 - 3 DRG. NO. NHSRL-3DC2-41-DD-335
 - 4 DRG. NO. NHSRL-3DC2-41-DD-336
 - 5 DRG. NO. NHSRL-3DC2-41-DD-337
 - 6 DRG. NO. NHSRL-3DC2-41-DD-339
 - 7 DRG. NO. NHSRL-3DC2-41-DD-340



DRG. NO. NHSRL-3DC2-41-DD-338-00

73

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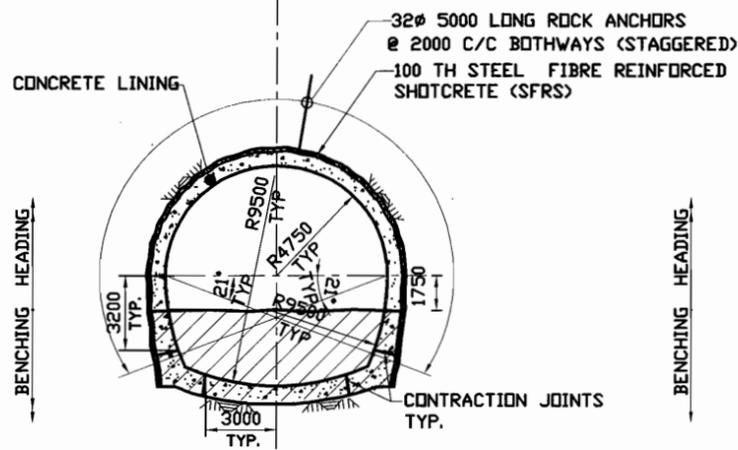
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SUBANSIRI LOWER HYDROELECTRIC PROJECT

**SURGE TUNNELS
SETTING OUT
L-SECTIONS**

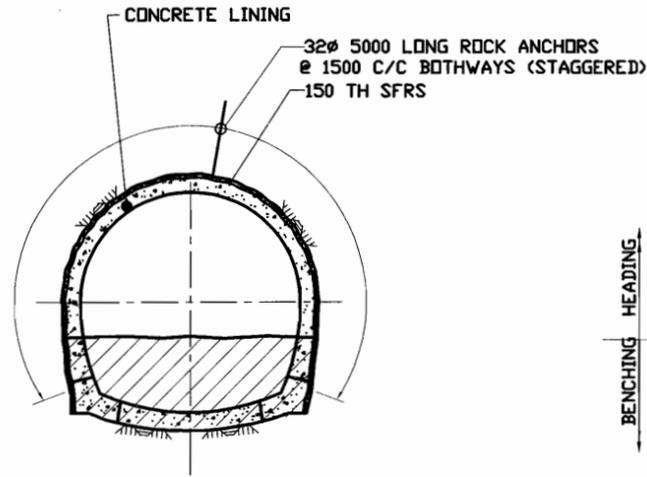
SHEET 1 OF 3

DRAWN अशोक कुमार	SUBMITTED प्रसून राजेश कुमार	RECOMMENDED अनुशुक्ति S C JOSHI	APPROVED अनुमोदन A K JAIN
DATE DEC. 2008	DRG. NO. उत्तर संख्या	NHSRL 3DC2 41 DD 338 00	

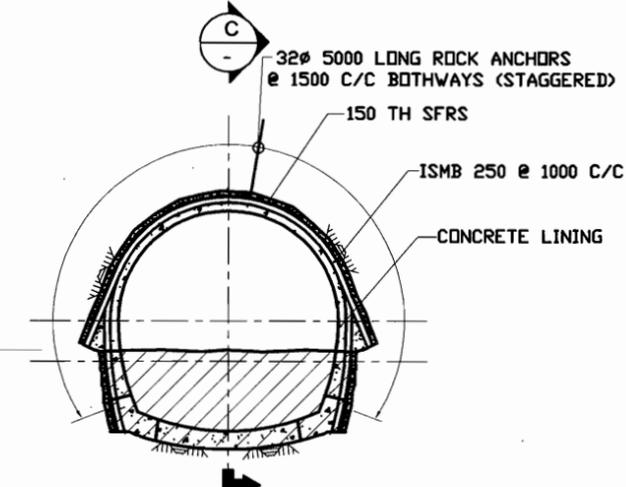
19-12-08 00	ISSUE FOR CONSTRUCTION	BY	CH.	APP.
	REVISION OR ISSUES			



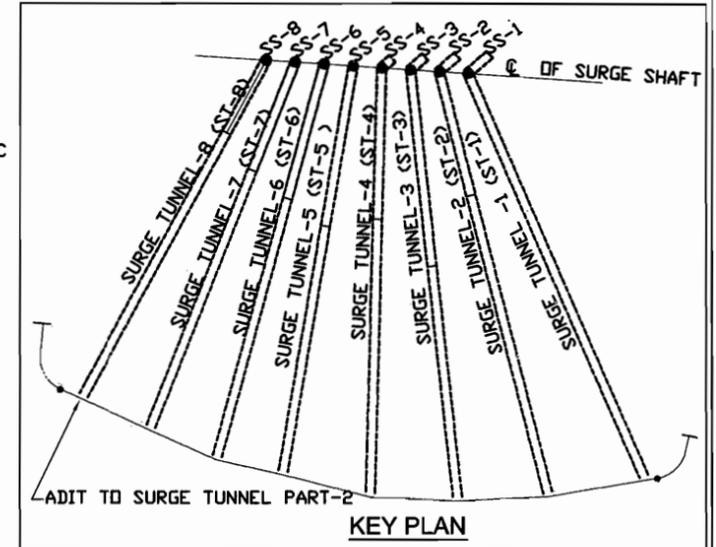
TYP. SECTION FOR ROCK SUPPORT
(FOR CLASS IIIA)



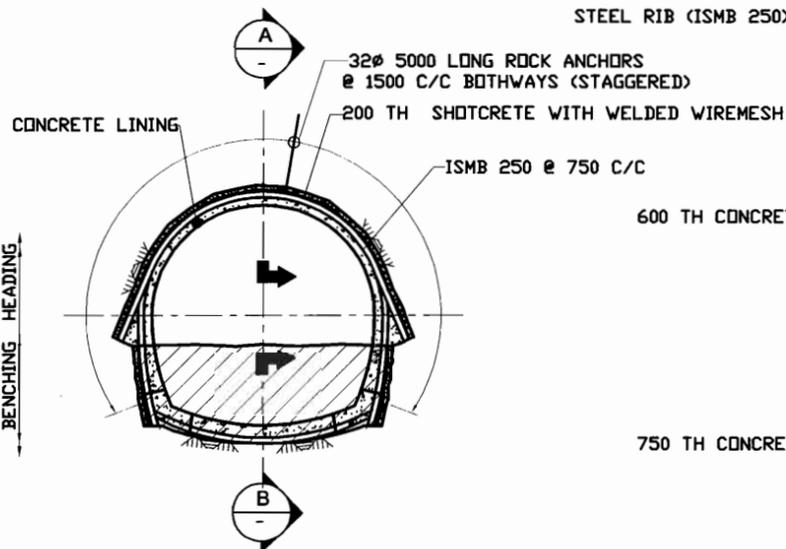
TYP. SECTION OF ROCK SUPPORT
(FOR CLASS IIIB)



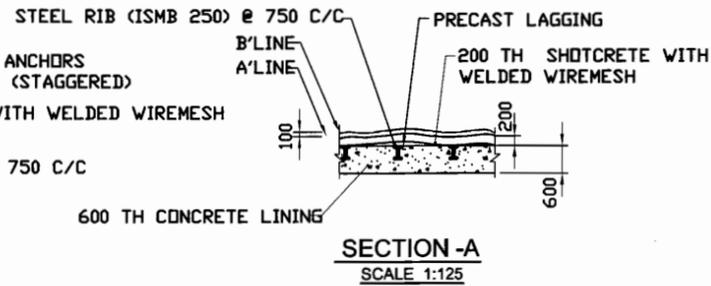
TYP. SECTION OF ROCK SUPPORT
(FOR CLASS IV)



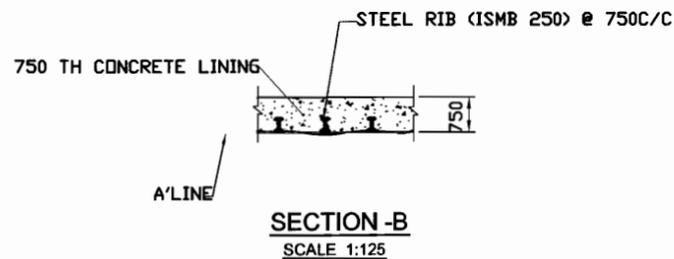
KEY PLAN



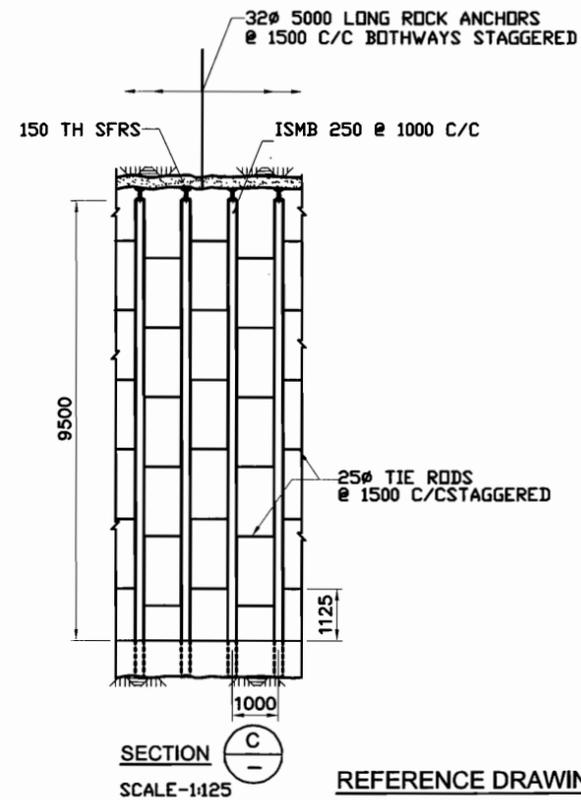
TYP. SECTION FOR ROCK SUPPORT
(FOR CLASS V)



SECTION-A
SCALE 1:125



SECTION-B
SCALE 1:125



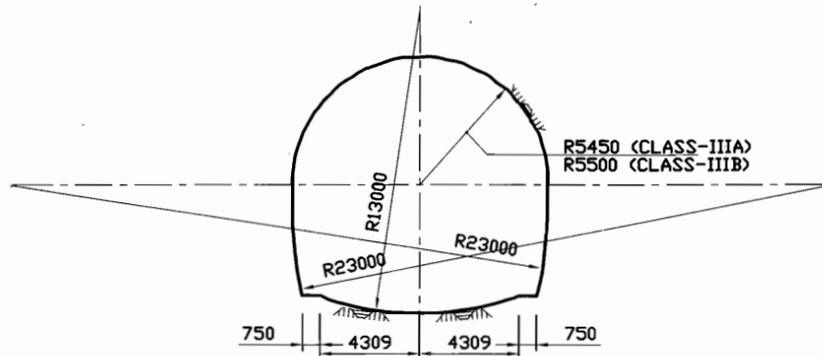
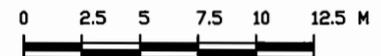
SECTION C
SCALE-1:125

REFERENCE DRAWINGS

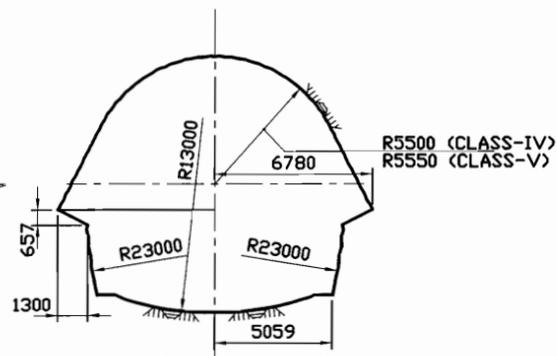
- NHSRL-3DC5-41-DD-501
- NHSRL-3DC5-41-DD-502
- NHSRL-3DC5-41-DD-503
- NHSRL-3DC5-41-DD-510
- NHSRL-3CC2-41-DD-314
- NHSRL-3CC2-41-DD-315

NOTES

- ALL DIMENSIONS ARE IN MILLIMETRE AND ELEVATIONS IN METRES.
- BENCHING OF SURGE TUNNEL SHALL BE CARRIED OUT AFTER CONCRETE LINING OF HRT IN THIS REACH.
- FOR ROCK ANCHORS & MESH SECURING DETAILS REFER DRAWING NHSRL-3CC2-41-DD-314.
- FOR STEEL RIB SUPPORT DETAIL REFER DRAWING NHSRL-3CC2-41-DD-315.
- EXCAVATION, ROCK SUPPORT AND SHOTCRETE/SFRS SHALL BE AS PER SECTION B-3, B-4, AND B-5 OF TECHNICAL SPECIFICATION RESPECTIVELY.
- ALL CONTRACTION JOINTS PERPENDICULAR TO LENGTH OF TUNNEL CENTRE LINE SHALL BE AS DIRECTED BY THE ENGINEER-IN-CHARGE. CONTRACTION JOINTS PARALLEL TO THE LENGTH OF TUNNEL CENTRE LINE SHALL BE AS SHOWN IN THE DRAWING AND SHALL NOT BE CHANGED.
- FOR OTHER NOTES REFER DRAWING NO -NHSRL-3DC5-41-DD-510.
- MIX DESIGN OF SFRS WITH MAX. CUBE STRENGTH M45 SHALL BE BASED ON TRIALS TO BE CONDUCTED BY SPECIALIST TO BE ENGAGED BY CONTRACTOR AS APPROVED BY ENGINEER-IN-CHARGE.
- REQUIREMENT OF ADDITIONAL ROCK SUPPORT IN THE FORM OF SPECIALISED MEANS LIKE CHEMICAL GROUTING, PIPE ROOFING, PREGROUTING AND ADVANCE PROBING SHALL BE ESTABLISHED AS PER SITE CONDITIONS AND AS DIRECTED BY ENGINEER-IN-CHARGE.
- THE USE OF MICROFINE CEMENT & NO. OF HOLES FOR CONSOLIDATION GROUTING IN CLASS IV/V SHALL BE DECIDED BASED ON GEOLOGICAL LOGS, WATER PRESSURE TEST RESULTS AS DECIDED BY ENGINEER-IN-CHARGE.
- SUITABILITY OF RESIN ROCK BOLTS IN SURGE TUNNELS FOR EXISTING ROCK CONDITIONS SHALL BE ESTABLISHED BY IN- SITU TESTS AS DECIDED BY ENGINEER-IN-CHARGE.



TYP. EXCAVATION PROFILE
(CLASS III-A AND III-B)



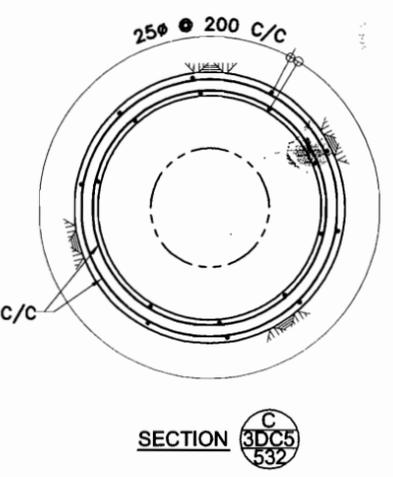
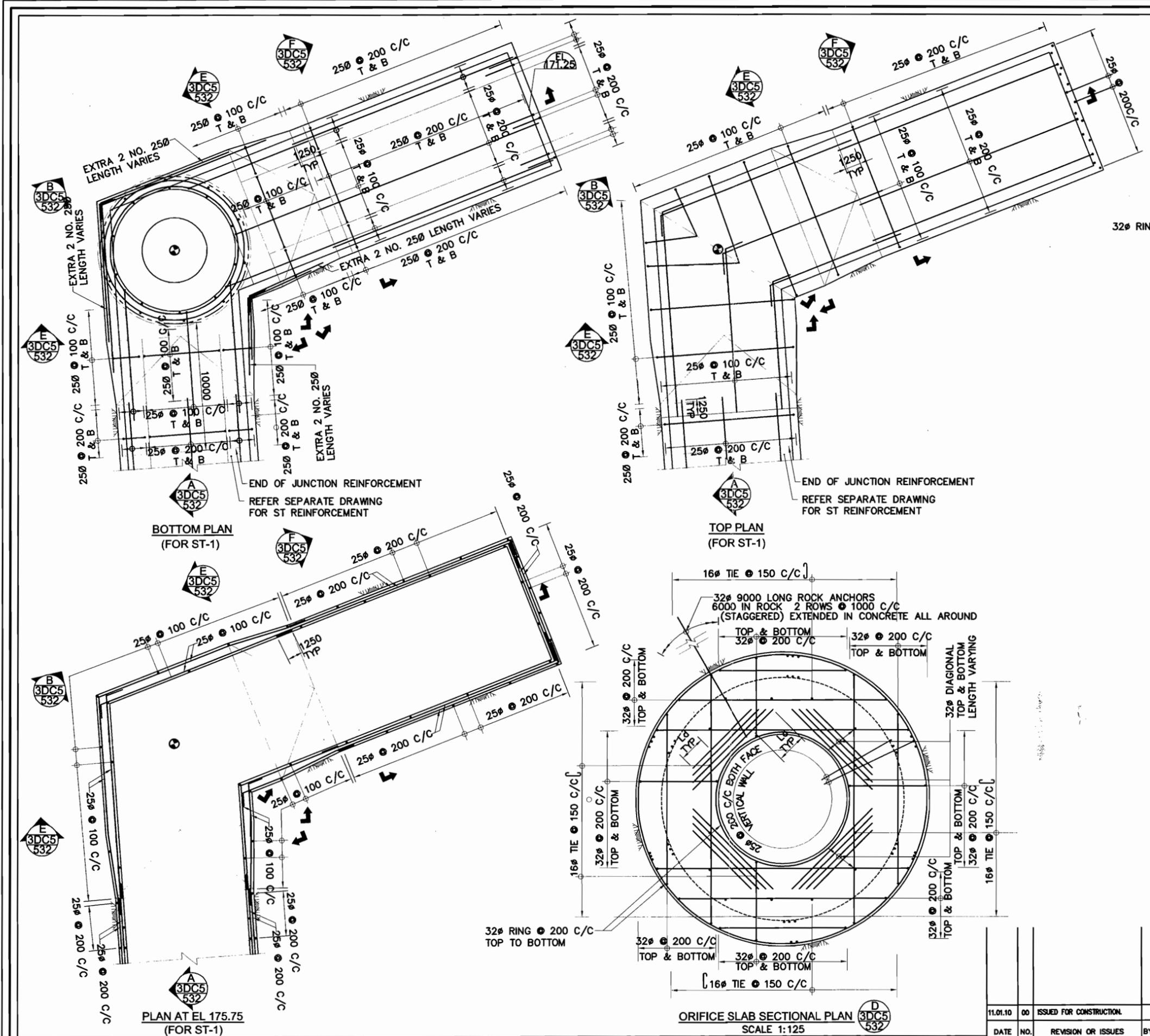
TYP. EXCAVATION PROFILE
(CLASS IV AND V)

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SUBANSIRI LOWER HYDROELECTRIC PROJECT

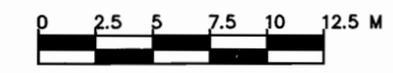
SURGE TUNNELS
EXCAVATION AND ROCK SUPPORT
SECTIONS

DRAWN अंकित RUSHARMA	SUBMITTED प्रस्तुत RAJESH KUMAR	RECOMMENDED अनुमोदित S.C. JOSHI	APPROVED अनुमोदित A.K. JAIN
DATE 06.11.09	NO. 00	REVISION OR ISSUES ISSUED FOR CONSTRUCTION	BY CH. APP
DATE NOV. 2009	DRG. NO. अंकित	NHSRL 3DC5 41 DD 509	00



- NOTES**
- 1 ALL DIMENSIONS ARE IN MILLIMETRE AND LEVELS IN METRE.
 - 2 CLEAR COVER TO REINFORCEMENT SHALL BE 50mm UNLESS OTHERWISE SPECIFIED.
 - 3 ALL REINFORCEMENT BARS SHALL BE HYSD Fe-500 CONFORMING TO IS-1786.
 - 4 STANDARD LAP LENGTH AND ANCHORS LENGTH SHALL BE 50 TIMES DIAMETRE OF BARS UNLESS SPECIFIED.
 - 5 LAPS AND SPLICES PROVIDED IN REINFORCING BARS SHALL BE STAGGERED.
 - 6 REINFORCEMENT SHALL BE PLACED AS SPECIFIED IN T.S. B-10.
 - 7 SURGE TUNNEL CONCRETE NEAR SURGE SHAFT OPENING SHALL BE PLACED MONOLITHICALLY WITH SURGE SHAFT LINING.
 - 8 PLANS SHOWN IN THIS DRAWING ARE FOR ST-1. REINFORCEMENT FOR ST-2 TO ST-4 SHALL BE SIMILAR.
 - 9 THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH DRAWING NHSRL-3DC5-41-DD-532 .

- REFERENCE DRAWINGS**
- NHSRL-3DC5-41-DD-532
 - NHSRL-3DC2-41-DD-333
 - NHSRL-3DC2-41-DD-338 TO 340
 - NHSRL-3DC5-41-DD-342
 - NHSRL-3DC5-41-DD-518
 - NHSRL-3CC2-41-DD-406 TO 409



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SUBANSIRI LOWER HYDROELECTRIC PROJECT

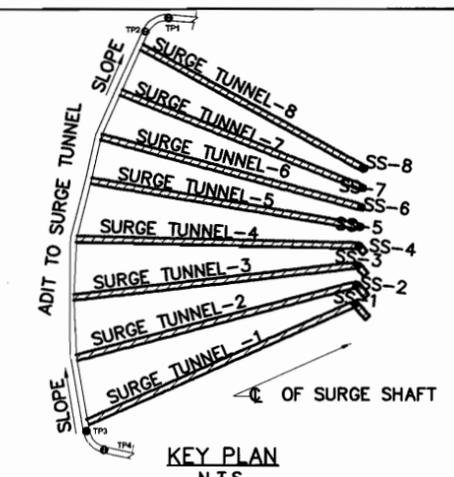
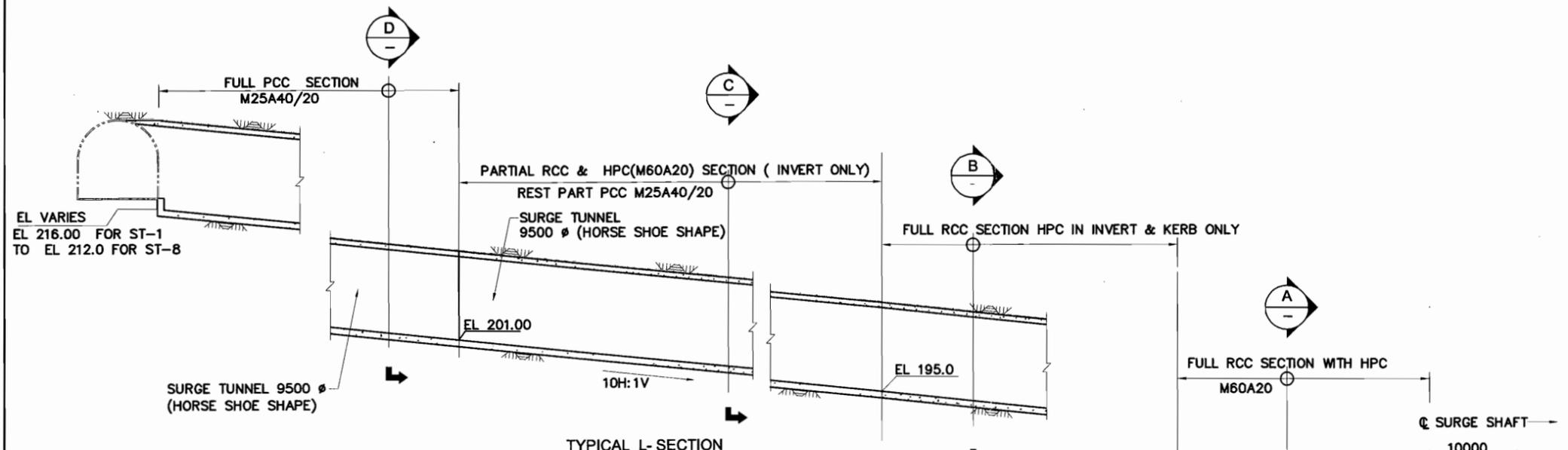
SURGE TUNNEL AND SURGE SHAFT JUNCTION
ABOVE EL 160.50
FOR ST 1 TO 4
REINFORCEMENT- PLAN

SHEET 1 OF 2

DATE	NO.	REVISION OR ISSUES	BY.	CH.	APP.
JAN 2009	00	ISSUED FOR CONSTRUCTION.			

DRAWN	SUBMITTED	RECOMMENDED	APPROVED
रविशंकर R N SHARMA	प्रमोद RAJESH K	अनुराग S C JOSHI	अनुराग A K JAIN
DATE	DRG. NO.	NHSRL	3DC5 41 DD 531 00
2009 संवत्	328 संवत्		

DRG. NO. NHSRL-3DC5-41-DD-531-00

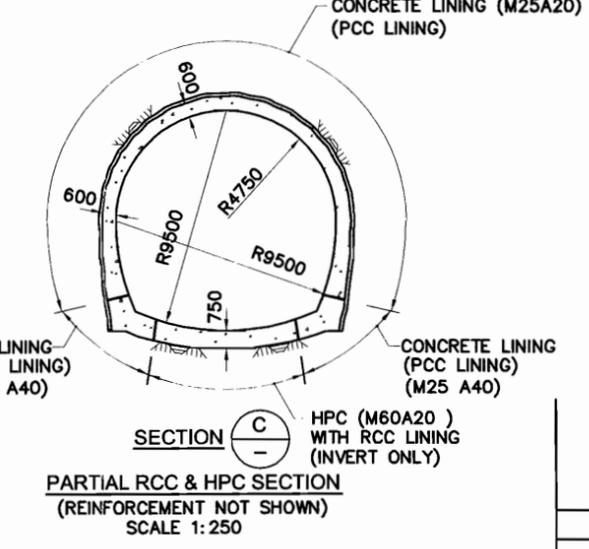
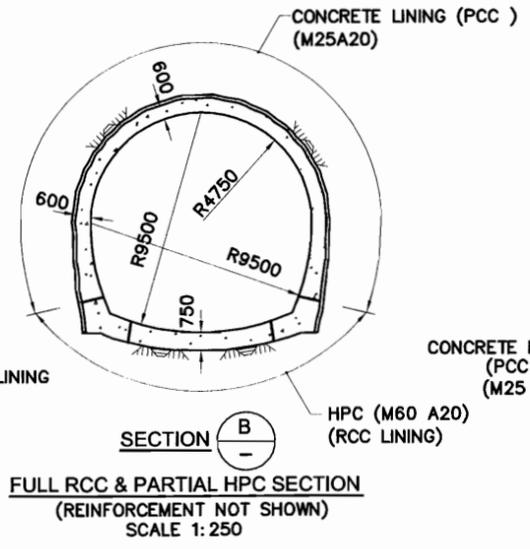
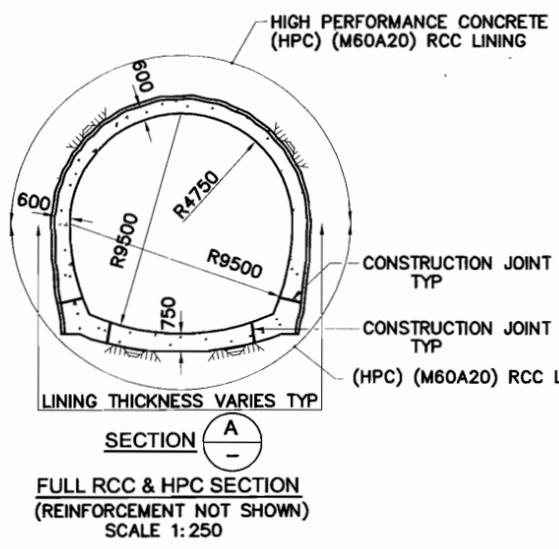
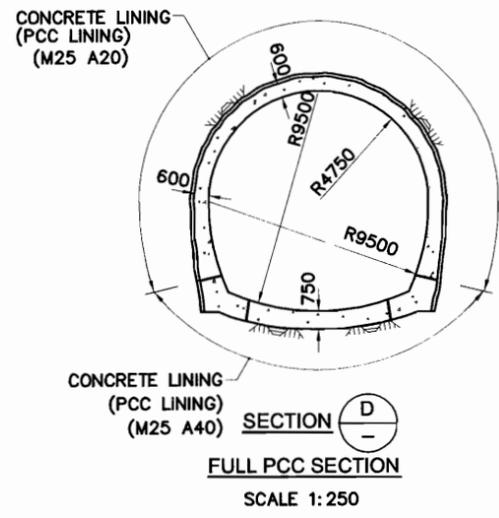
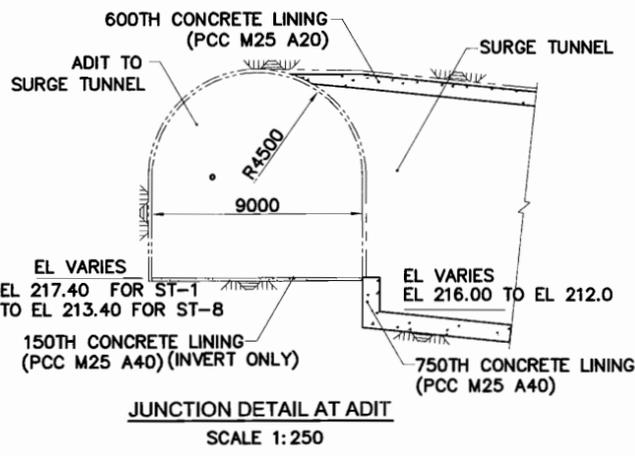


NOTES

- 1 ALL DIMENSIONS ARE IN MILLIMETRE AND ELEVATIONS IN METRE.
- 2 PCC CONCRETE LINING IN SURGE TUNNELS SHALL BE M25A40 IN INVERT AND M25A20 IN OVERT.
- 3 HIGH PERFORMANCE CONCRETE (HPC) LINING IN SURGE TUNNELS SHALL BE M60A20 AND LOCATION OF HPC LINING SHALL BE AS SHOWN IN DRAWINGS.
- 4 ALL CONSTRUCTION JOINTS PERPENDICULAR TO LENGTH OF TUNNEL CENTRE LINE SHALL BE AS DIRECTED BY THE ENGINEER-IN-CHARGE. CONSTRUCTION JOINTS PARALLEL TO THE LENGTH OF TUNNEL CENTRE LINE SHALL BE AS SHOWN IN THE DRAWING AND SHALL NOT BE CHANGED.
- 5 LOCATION OF RCC LINING SHALL BE AS SHOWN IN DRAWINGS .
- 6 FOR SURFACE FINISHES AND CONCRETE PLACEMENT REFER TS B.8 AND FOR FORM WORK REFER B. 9.
- 7 FOR REINFORCEMENT REFER SEPARATE DRAWINGS.
- 8 CONTACT GROUTING SHALL BE CARRIED OUT IN ENTIRE LENGTH OF THE SURGE TUNNELS. FOR CONTACT GROUTING REFER SEPARATE DRAWING & TECHNICAL SPECIFICATION.
- 9 FOR CONSOLIDATION GROUTING REFER SEPARATE DRAWING.
- 10 NO PRESSURE RELIEF HOLES SHALL BE PROVIDED IN SURGE TUNNELS .

REFERENCE DRAWINGS

NHSRL-3DC2-41-DD-338 TO 340
 NHSRL-3DC5-41-DD-518
 NHSRL-3DC5-41-DD-520



14.01.10	00	ISSUED FOR CONSTRUCTION.	BY:	CH. APP
DATE	NO.	REVISION OR ISSUES	BY.	CH. APP

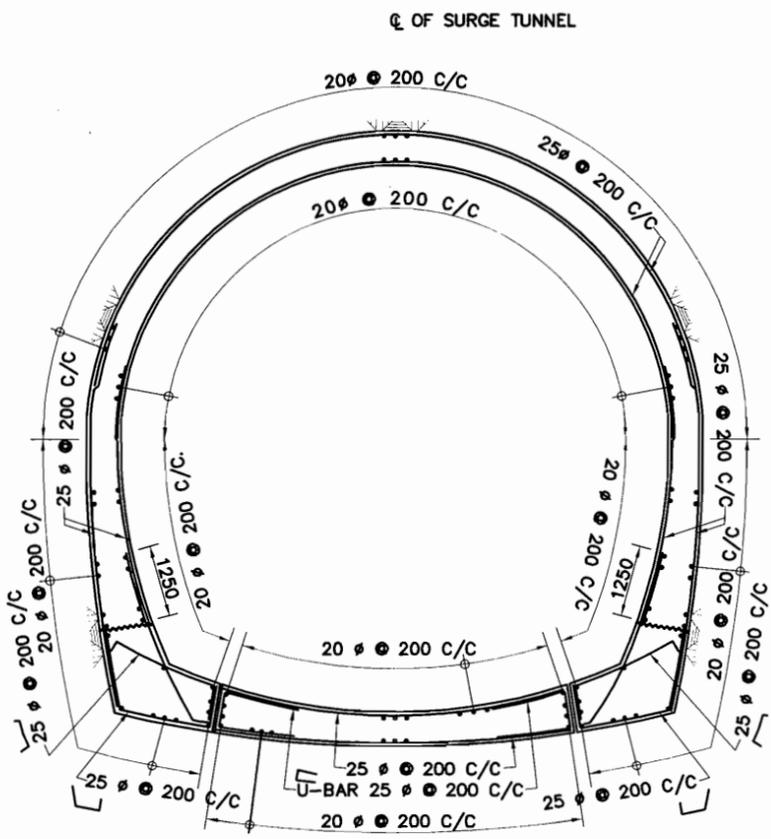
NHPCL
एन एच पी सी लिमिटेड
NHPCL Limited
(A Govt. of India Enterprise)

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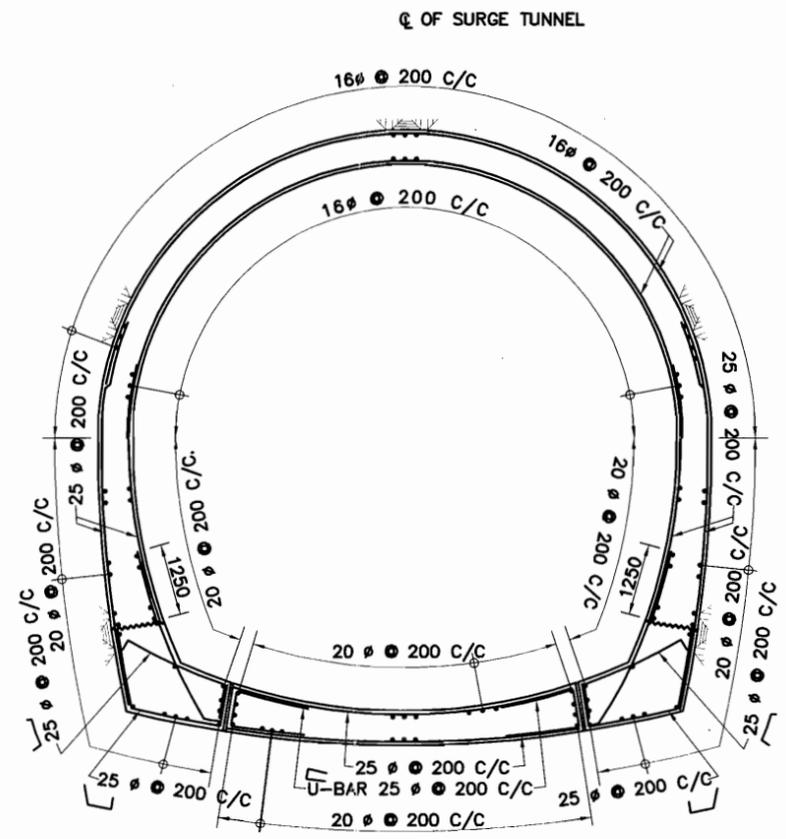
SURGE TUNNELS CONCRETE

DRAWN	SUBMITTED	RECOMMENDED	APPROVED
रविशर्मा RN SHARMA	राजेश K RAJESH K	सुनील SC JOSHI	अनुमोल A K JAIN
DATE	DRG. NO.	NHSRL	3DC5 41 DD 519 00
JAN. 2010	3008		

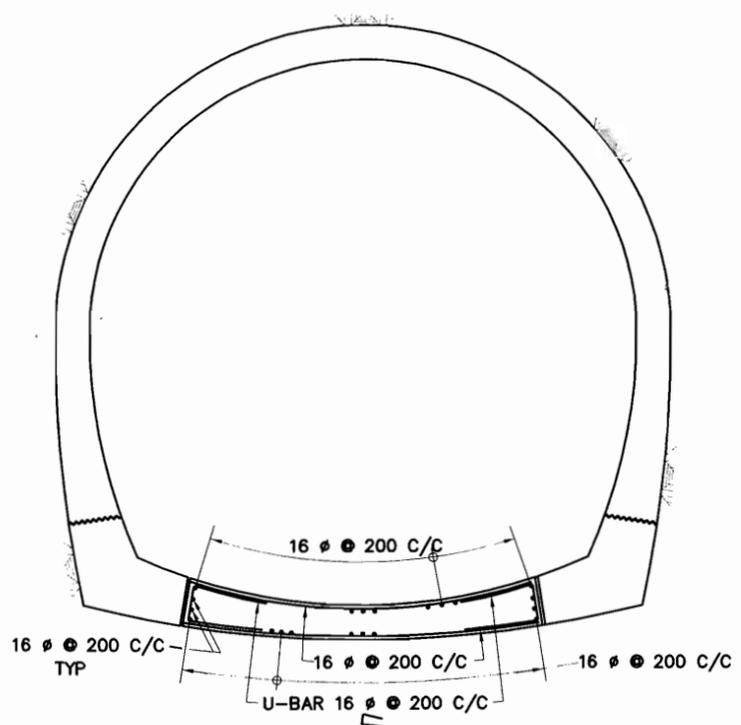
DRG. NO. NHSRL-3DC5-41-DD-519-00



TYPICAL REINFORCEMENT SECTION
(BEYOND SURGE SHAFT JUNCTION AREA & UPTO INVERT LEVEL EL175.0)



TYPICAL REINFORCEMENT SECTION
(FOR INVERT LEVEL EL 175.0 TO EL 195.0)



TYPICAL REINFORCEMENT SECTION
(FOR INVERT LEVEL EL 195.0 TO EL 201.0)

NOTES

- 1 ALL DIMENSIONS ARE IN MILLIMETRE AND ELEVATIONS IN METRE.
- 2 THE RCC LINING IS TO BE PROVIDED FOR THE TUNNEL LENGTH AS SHOWN IN DRAWING NO. NHSRL-3DC5-41-DD- 519.
- 3 UNLESS OTHERWISE SPECIFIED REINFORCEMENT SHALL H.Y.S.D. STEEL BARS GRADE Fe 500 CONFORMING TO IS 1786-1983.
- 4 UNLESS SPECIFIED MINIMUM CONCRETE COVER TO REINFORCEMENT SHALL BE 50 mm.
- 5 UNLESS STATED , THE STANDARD LAP LENGTH FOR REINFORCEMENT SHALL BE 50 TIMES THE DIA OF BARS AND SHALL BE STAGGERED .
- 6 THE HOOKS AND BENDS FOR REINFORCEMENT SHALL BE PROVIDED AS PER PROVISION IN IS 456-2000.
- 7 FOR SURGE SHAFT JUNCTION REINFORCEMENT REFER DRAWING NO-NHSRL- 3DC5-41-DD-531 TO 534.

REFERENCE DRAWINGS

NHSRL-3DC5-41-DD-519
NHSRL-3DC5-41-DD-531 TO 534



DRG. NO. NHSRL-3DC5-41-DD-520-00

14.01.10	00	ISSUED FOR CONSTRUCTION.			
DATE	NO.	REVISION OR ISSUES	BY	CH.	APP.
JAN 2009					

DRAWN R N SHARMA	SUBMITTED RAJESH K	RECOMMENDED S C JOSHI	APPROVED A K JAIN
DATE JAN 2009	DRG. NO. 329	NHSRL 3DC5 41 DD	520 00

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SUBANSIRI LOWER HYDROELECTRIC PROJECT

**SURGE TUNNELS
 LINING
 REINFORCEMENT-SECTIONS**

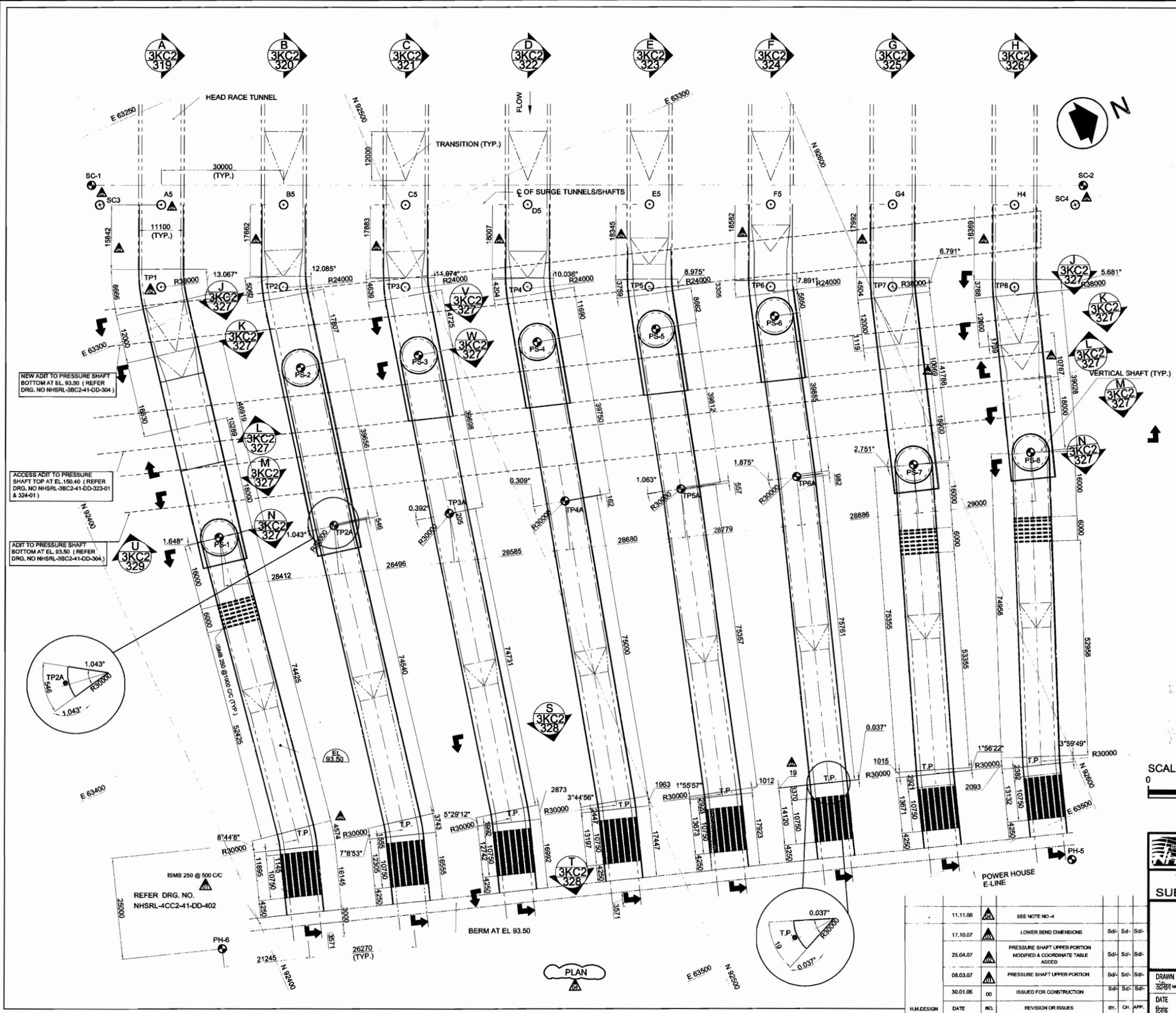
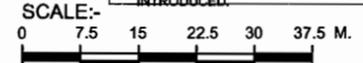
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SC2	92658.102	63358.782
SC3	92434.140	63266.964
SC4	92654.377	63362.335
A5	92447.909	63272.927
B5	92475.439	63284.848
C5	92502.968	63296.769
D5	92530.498	63308.691
E5	92558.028	63320.612
F5	92585.557	63332.533
G4	92613.087	63344.455
H4	92640.616	63356.376
TP1	92439.879	63291.456
TP2	92467.405	63303.385
TP3	92494.931	63315.314
TP4	92522.458	63327.243
TP5	92549.984	63339.173
TP6	92577.510	63351.102
TP7	92605.036	63363.031
TP8	92632.562	63374.961
PS-1	92428.497	63353.695
PS-2	92463.402	63323.334
PS-3	92491.280	63331.983
PS-4	92519.261	63340.666
PS-5	92547.351	63349.384
PS-6	92575.553	63358.140
PS-7	92592.424	63405.230
PS-8	92620.089	63413.927
PH-5	92589.593	63510.024
PH-6	92389.107	63446.996
TP2A	92455.600	63362.215
TP3A	92482.784	63370.761
TP4A	92510.053	63379.334
TP5A	92537.413	63387.935
TP6A	92564.868	63396.566

REFERENCE DRGS :

Sr. NO.	DESCRIPTION	DRAWING NO.
1	PRESSURE SHAFT - EXCAVATION SECTIONS (SUPERCEDED)	NHSRL-3KC2-41-DD-318 (SUPERCEDED)
2	PRESSURE SHAFT - EXCAVATION LONGITUDINAL SECTIONS THROUGH PS-1 TO PS-8 (SUPERCEDED)	NHSRL-3KC2-41-DD-319 TO 326 (SUPERCEDED)
3	PRESSURE SHAFT - EXCAVATION CROSS SECTIONS	NHSRL-3KC2-41-DD-327 TO 329
4	ADIT PRESSURE SHAFT - LAYOUT PLAN & SECTIONS	NHSRL-3KC2-41-DD-304
5	ACCESS ADIT NETWORK TO PRESSURE SHAFT TOP & HRT - SETTING OUT PLAN & SECTIONS	NHSRL-3KC2-41-DD-323 & 324
6	POWER HOUSE - SETTING OUT PLAN	NHSRL-4CC2-41-DD-401
7	POWER HOUSE - EXCAVATION PLAN	NHSRL-4CC2-41-DD-402

NOTES :

- ALL DIMENSIONS ARE IN MILLIMETRE AND LEVELS IN METRE.
- FOR COORDINATES OF CONTROL POINTS REFER DRG. NO. NHSRL-4CC2-41-DD-011.
- ALL EXCAVATION SHALL BE DONE AS PER T.S. 3.8. THE EXCAVATION SEQUENCE CLEARLY INDICATING THE LINE, LEVELS AND SEQUENCE NO. OF THE EXCAVATION METHODOLOGY SHALL BE APPROVED BY THE ENGINEER-IN-CHARGE.
- LOCATION OF PRESSURE SHAFT VERTICAL AND CURVATURE IN UPPER HORIZONTAL PRESSURE SHAFT IN 2,3,4,5,6 MODIFIED. ACCESS ADIT AT ELEVATION 93.5 M & HORIZONTAL BEND IN LOWER PRESSURE SHAFT INTRODUCED.





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NHPCL Limited
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SUBANSIRI LOWER HYDROELECTRIC PROJECT

PRESSURE SHAFTS
EXCAVATION (SHEET 1 OF 12)
PLAN

DRAWN Sd/- अमित मोहन शर्मा	SUBMITTED Sd/- हरिश्चंद्र शर्मा	RECOMMENDED Sd/- अनुराग स. जोशी	APPROVED Sd/- अनुमोदन स. मिश्रा
DATE JAN. 2006	DRG. NO. NHSRL 3KC2 41 DD 317	04	

11.11.08	SEE NOTE NO-4			
17.10.07	LOWER BEND DIMENSIONS	Sd/-	Sd/-	Sd/-
25.04.07	PRESSURE SHAFT UPPER PORTION MODIFIED & COORDINATE TABLE ADDED	Sd/-	Sd/-	Sd/-
08.03.07	PRESSURE SHAFT UPPER PORTION	Sd/-	Sd/-	Sd/-
30.01.06	ISSUED FOR CONSTRUCTION	Sd/-	Sd/-	Sd/-
H.M.DESIGN	DATE	NO.	REVISION OR ISSUES	BY, CH, APP.

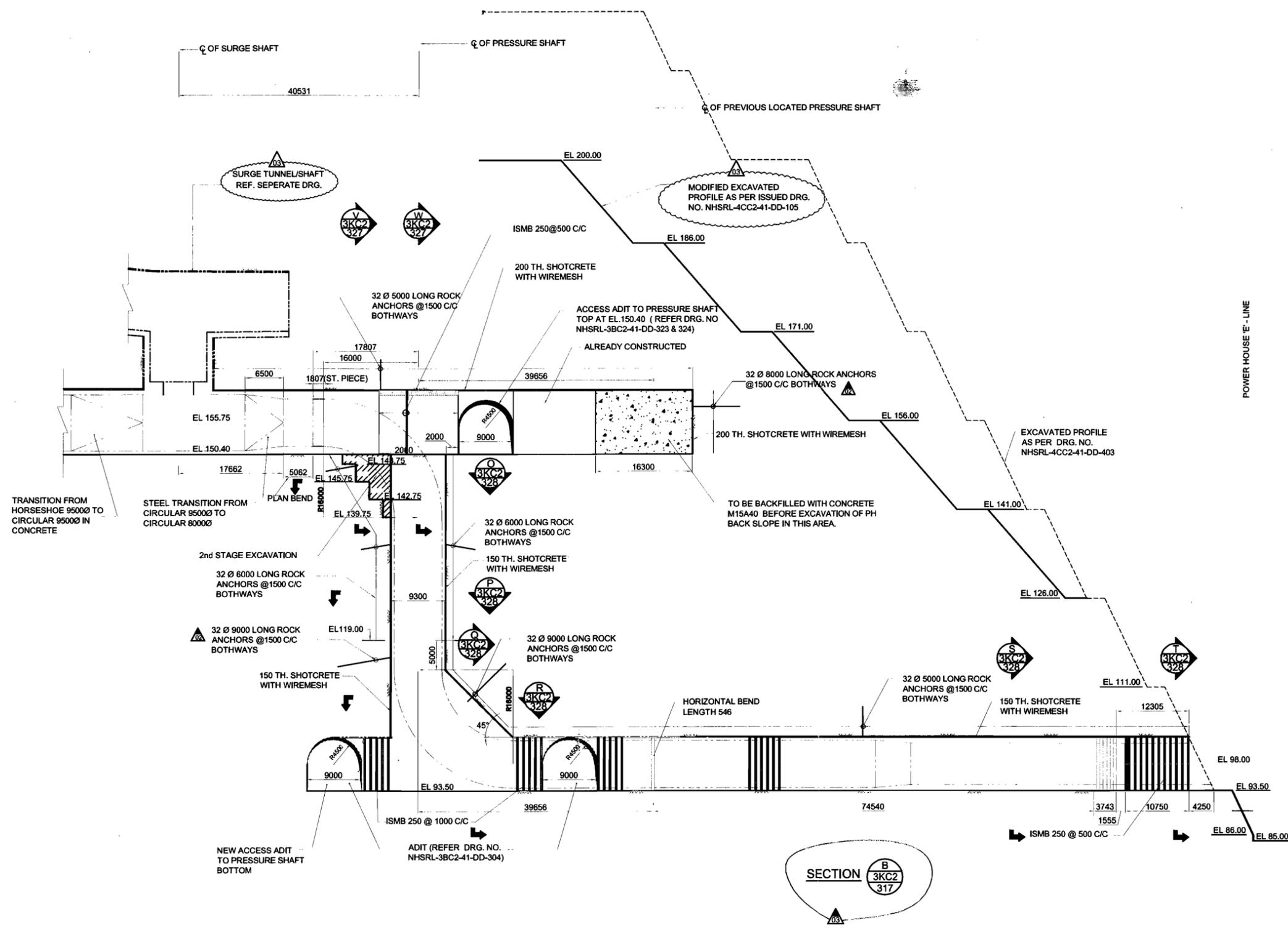
DRG. NO. NHSRL-3KC2-41-DD-317-04

REFERENCE DRGS :

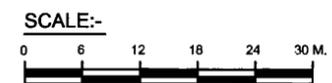
Sr. NO.	DESCRIPTION	DRAWING NO.
1	PRESURE SHAFT - EXCAVATION PLAN	NHSRL-3KC2-41-DD-317
2	PRESURE SHAFT - EXCAVATION LONGITUDINAL SECTIONS	NHSRL-3KC2-41-DD-320 TO 326
3	PRESURE SHAFT - EXCAVATION CROSS SECTIONS	NHSRL-3KC2-41-DD-327 TO 329
4	ADIT PRESSURE SHAFT - LAYOUT PLAN & SECTIONS	NHSRL-3BC2-41-DD-304
5	ACCESS ADIT NETWORK TO PRESSURE SHAFT TOP & HRT- LAYOUT PLAN & SECTIONS	NHSRL-3BC2-41-DD-323 & 324
6	POWER HOUSE - SETTING OUT PLAN	NHSRL-4CC2-41-DD-401
7	POWER HOUSE - EXCAVATION PLAN	NHSRL-4CC2-41-DD-402
8	POWER HOUSE - MODIFIED EXCAVATION PLAN	NHSRL-4CC2-41-DD-101
9	POWER HOUSE - DRG. NO.	NHSRL-4CC2-41-DD-101 TO 107

NOTES :

- ALL DIMENSIONS ARE IN MILLIMETRE AND LEVELS IN METRE.
- FOR COORDINATES OF CONTROL POINTS REFER DRG. NO. NHSRL-4CC2-41-DD-401.
- ALL EXCAVATION SHALL BE DONE AS PER T.S. 3.8. THE EXCAVATION SEQUENCE CLEARLY INDICATING THE LINE, LEVELS AND SEQUENCE NO. OF THE EXCAVATION METHODOLOGY SHALL BE APPROVED BY THE ENGINEER-IN-CHARGE.
- 50 mm THK. SHOTCRETE SHALL BE APPLIED IMMEDIATELY ON THE EXCAVATED SURFACE AFTER SCALING. SUSEQUENT SHOTCRETE / ROCK ANCHORS SHALL BE PROVIDED AFTER REMOVAL OF MUCK.
- THE EXCAVATED SURFACE SHALL BE SUPPORTED WITH SHOTCRETE WITH WIREMESH AND ROCK ANCHORS IN EACH ROUND BEFORE FURTHER EXCAVATION.
- SHEAR ZONE/FRACTURE ZONE, WHEN ENCOUNTERED DURING EXCAVATION, SHALL BE TAKEN CARE BY ADDITIONAL MEASURES I.E. CONSOLIDATION GROUTING, CLOSER SPACING OF ANCHORS/BOLTS, HIGHER THK OF SHOTCRETE, TWO OR MORE LAYERS OF WIREMESH AND STEEL RIBS. SUCH ZONES SHALL BE BROUGHT TO THE ATTENTION OF PROJECT GEOLOGY TEAM AND DESIGN GROUP AND SHALL REQUIRE CLOSER SUPERVISION.
- LOCATION OF VERTICAL SHAFT, CURVATURE & UPPER TRANSITION MODIFIED. ACCESS ADIT AT EL 93.5M & HORIZONTAL BEND IN LOWER PRESSURE SHAFT INTRODUCED. ALL TYPES OF BENDS IN UPPER HORIZONTAL PORTION IS FOR H.M. WORKS ONLY.



SECTION B
3KC2
317



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SUBANSIRI LOWER HYDROELECTRIC PROJECT

PRESSURE SHAFTS
EXCAVATION (SHEET 3 OF 12)
LONGITUDINAL SECTION THROUGH PRESSURE SHAFT-2

H.M.DESIGN	DATE	NO.	REVISION OR ISSUES	BY	CH.	APP.
	11.11.08	03	SEE NOTE NO-7			
	17.10.07	02	ROCK SUPPORT MODIFIED	Sd/-	Sd/-	Sd/-
	25.04.07	01	PRESSURE SHAFT UPPER PORTION MODIFIED	Sd/-	Sd/-	Sd/-
	08.03.07	00	ISSUED FOR CONSTRUCTION	Sd/-	Sd/-	Sd/-

DRAWN	Sd/-	SUBMITTED	Sd/-	RECOMMENDED	Sd/-	APPROVED	Sd/-
अश्विनी मोहन सिंह		हरिश्चंद्र		अनुशासिता C JOSHI		अनुमान	S.C. MITAL
DATE	MARCH 2007	DRG. NO.	NHSRL	3KC2	41	DD	320 03

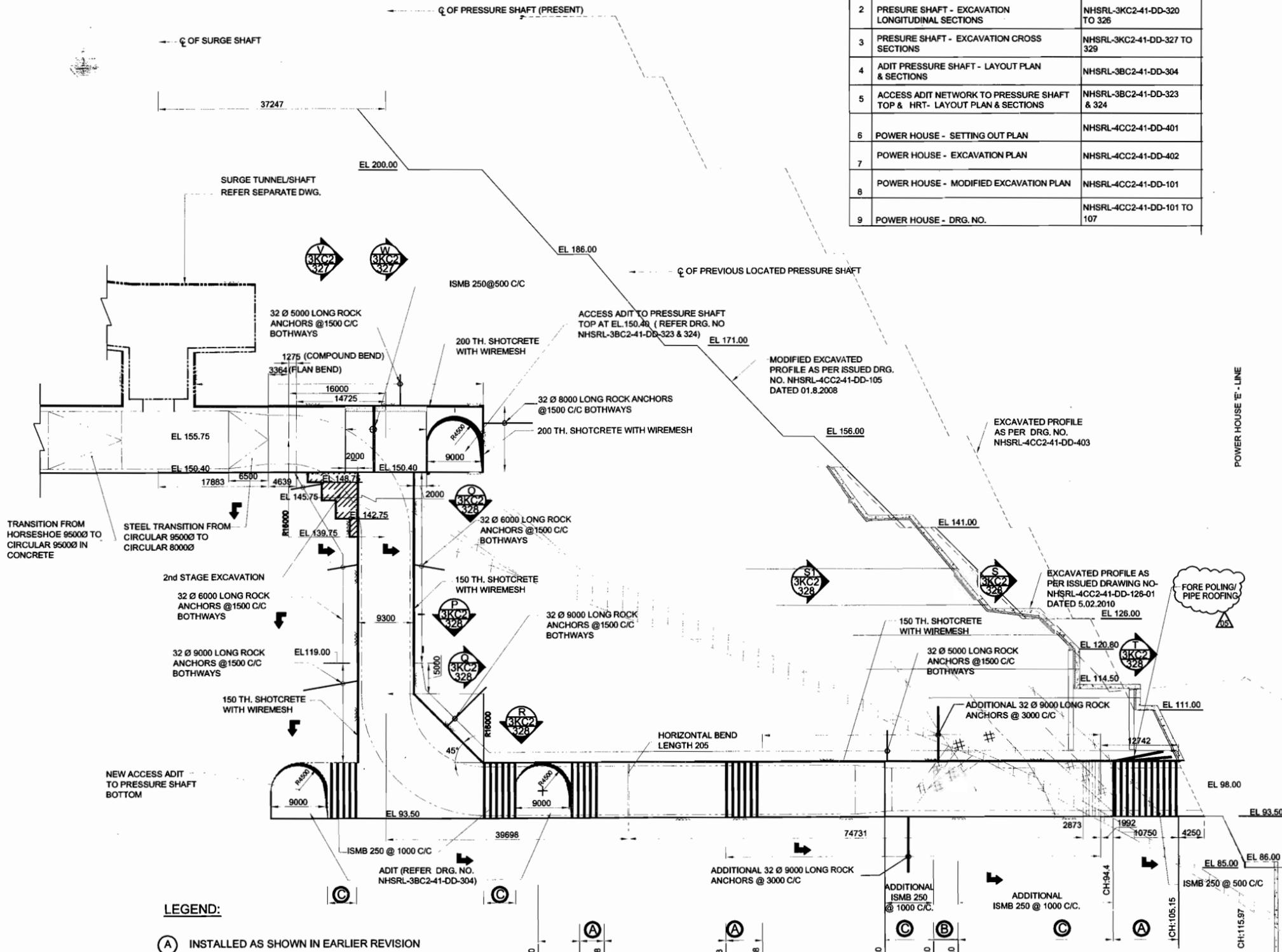
DRG. NO. NHSRL-3KC2-41-DD-320-03

REFERENCE DRGS :

Sr. NO.	DESCRIPTION	DRAWING NO.
1	PRESURE SHAFT - EXCAVATION PLAN	NHSRL-3KC2-41-DD-317
2	PRESURE SHAFT - EXCAVATION LONGITUDINAL SECTIONS	NHSRL-3KC2-41-DD-320 TO 326
3	PRESURE SHAFT - EXCAVATION CROSS SECTIONS	NHSRL-3KC2-41-DD-327 TO 329
4	ADIT PRESSURE SHAFT - LAYOUT PLAN & SECTIONS	NHSRL-3BC2-41-DD-304
5	ACCESS ADIT NETWORK TO PRESSURE SHAFT TOP & HRT- LAYOUT PLAN & SECTIONS	NHSRL-3BC2-41-DD-323 & 324
6	POWER HOUSE - SETTING OUT PLAN	NHSRL-4CC2-41-DD-401
7	POWER HOUSE - EXCAVATION PLAN	NHSRL-4CC2-41-DD-402
8	POWER HOUSE - MODIFIED EXCAVATION PLAN	NHSRL-4CC2-41-DD-101
9	POWER HOUSE - DRG. NO.	NHSRL-4CC2-41-DD-101 TO 107

NOTES

- ALL DIMENSIONS ARE IN MILLIMETRE AND LEVELS IN METRE.
- FOR COORDINATES OF CONTROL POINTS REFER DRG. NO. NHSRL-4CC2-41-DD-401.
- ALL EXCAVATION SHALL BE DONE AS PER T.S. 3.8. THE EXCAVATION SEQUENCE CLEARLY INDICATING THE LINE, LEVELS AND SEQUENCE NO. OF THE EXCAVATION METHODOLOGY SHALL BE APPROVED BY THE ENGINEER-IN-CHARGE.
- 50 mm THK. SHOTCRETE SHALL BE APPLIED IMMEDIATELY ON THE EXCAVATED SURFACE AFTER SCALING. SUSEQUENT SHOTCRETE / ROCK ANCHORS SHALL BE PROVIDED AFTER REMOVAL OF MUCK.
- THE EXCAVATED SURFACE SHALL BE SUPPORTED WITH SHOTCRETE WITH WIREMESH AND ROCK ANCHORS IN EACH ROUND BEFORE FURTHER EXCAVATION.
- SHEAR ZONE/FRACTURE ZONE, WHEN ENCOUNTERED DURING EXCAVATION, SHALL BE TAKEN CARE BY ADDITIONAL MEASURES I.E. CONSOLIDATION GROUTING, CLOSER SPACING OF ANCHORS/BOLTS, HIGHER THK OF SHOTCRETE, TWO OR MORE LAYERS OF WIREMESH AND STEEL RIBS. SUCH ZONES SHALL BE BROUGHT TO THE ATTENTION OF PROJECT GEOLOGY TEAM AND DESIGN GROUP AND SHALL REQUIRE CLOSER SUPERVISION.
- THE DRAWING WAS REVISED FOR ADDITIONAL ROCK SUPPORTS REQUIRED, BASED ON GEOLOGICAL DETAILS RECEIVED VIDE NOTE NO. NH/EG/102/08/140 DATED 06.-02-08 AND CROSS SECTIONS AND ROCK SUPPORT DETAILS RECEIVED FROM PROJECT BY E-MAIL ON 06-02-08.
- PATTERN CONSOLIDATION GROUTING SHALL BE CARRIED OUT IN UPPER, VERTICAL & LOWER PRESSURE SHAFT IN CLASS -IV ROCK MASS AS DETERMINED BY THE GEOLOGIST.
- IN SHEAR ZONES, CLASS-IV REACHES AND FROM CH: 94.4 TO 105.15, ADDITIONAL CONSOLIDATION GROUTING ALL AROUND THE EXCAVATED PROFILE OF PRESSURE SHAFT SHALL BE DONE.
- LOCATION OF VERTICAL SHAFT, CURVATURE & UPPER TRANSITION MODIFIED. ACCESS ADIT AT EL 93.5M & HORIZONTAL BEND IN LOWER PRESSURE SHAFT INTRODUCED. ALL TYPES OF BENDS IN UPPER HORIZONTAL PORTION IS FOR H.M. WORKS ONLY.
- THIS DRAWING IS BEING REVISED FOR ADDITIONAL ROCK SUPPORT SYSTEM REQUIRED IN LHPS BASED ON GEOLOGICAL DETAILS RECEIVED VIDE NH/EG/102A/19/73 DATED 15.01.2010 & NH/EG/102A/10/125 DATED 05.02.2010
- SLIDE MUCK INSIDE LHPS SHALL NOT BE REMOVED / DISTURBED UNTIL STEEL RIBS UP TO MUCK TOE ARE ERECTED AND SURFACE TREATMENT OF PH BACK SLOPE IS COMPLETED.
- TOE OF THE SLIDE MUCK INSIDE LHPS SHALL BE SUPPORTED WITH SUITABLE MEANS E.G.SAND BAGS ETC.
- GAP/OPENING AT THE CROWN OF THE LHPS BETWEEN ROCK & SLIDE MASS SHALL BE PLUGGED / FILLED WITH SAND BAGS / CONCRETE / FILL GROUT TO THE EXTENT POSSIBLE.
- FOREPOLING / PIPE ROOFING IN THE CROWN OF LHPS WITH HIGH TENSILE SEAMLESS PIPE CASING SHALL BE DONE AS PER SITE CONDITIONS.
- CONSOLIDATION GROUTING OF THE CROWN OF LHPS SHALL BE CARRIED OUT WITH OPC TO BE SUPPLEMENTED WITH MICRO- FINE CEMENT, IF REQUIRED SPECIALLY IN LOW COVER ZONE TO BE DETERMINED BY ENGINEER-IN-CHARGE.
- BEYOND RD 96 M TOWARDS D/S, STEEL RIBS SHALL BE INSTALLED AFTER CROWN IS SUPPORTED AND SURFACE TREATMENT OF PH BACK SLOPE IS COMPLETED.
- WORKS SHOWN IN THIS DRAWING FALL UNDER CLAUSE 10.1.2 OF DOP. AFTER OBTAINING NECESSARY APPROVALS BY THE PROJECT, THIS DRAWING BE DEEMED ISSUED FOR CONSTRUCTION.



LEGEND:

- (A) INSTALLED AS SHOWN IN EARLIER REVISION
- (B) INSTALLED AS PER SITE CONDITION
- (C) INSTALLED AS PER REV. 03

SECTION C 3KC2 317



DATE	NO.	REVISION OR ISSUES	BY	CH.	APP.
19.02.10	01	ADDITIONAL ROCK SUPPORT AND NOTE ADDED, SEE NOTE 18			
11.11.08	02	SEE NOTE NO-10	Sd/-	Sd/-	Sd/-
12.02.08	03	ADDITIONAL ROCK SUPPORT AND SECTION S1 ADDED	Sd/-	Sd/-	Sd/-
17.10.07	04	ROCK SUPPORT MODIFIED	Sd/-	Sd/-	Sd/-
25.04.07	05	PRESSURE SHAFT UPPER PORTION MODIFIED	Sd/-	Sd/-	Sd/-
06.03.07	00	ISSUED FOR CONSTRUCTION	Sd/-	Sd/-	Sd/-

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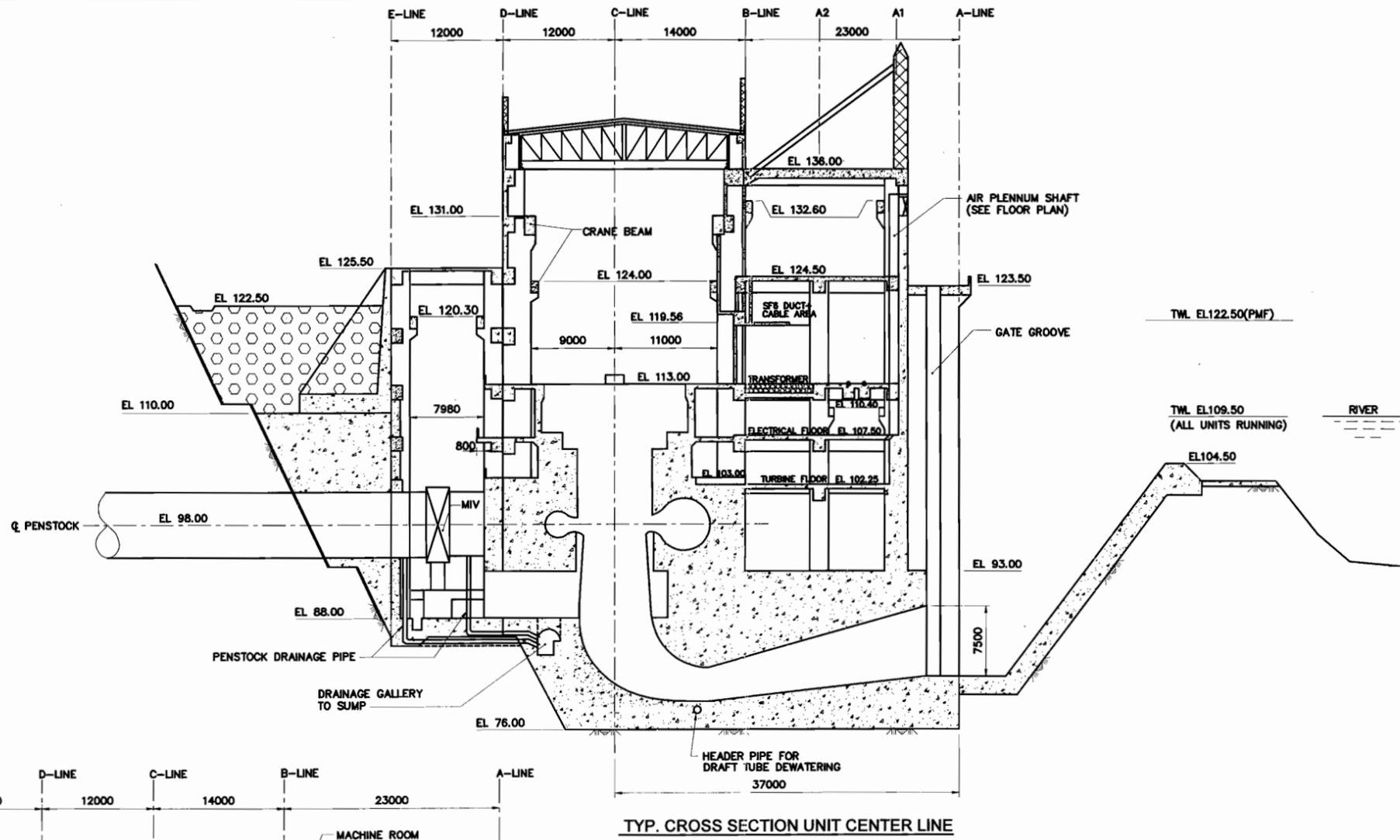
सुबनसिरी लोअर जलविद्युत परियोजना
SUBANSIRI LOWER HYDROELECTRIC PROJECT

**PRESSURE SHAFTS
EXCAVATION (SHEET 4 OF 12)**

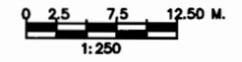
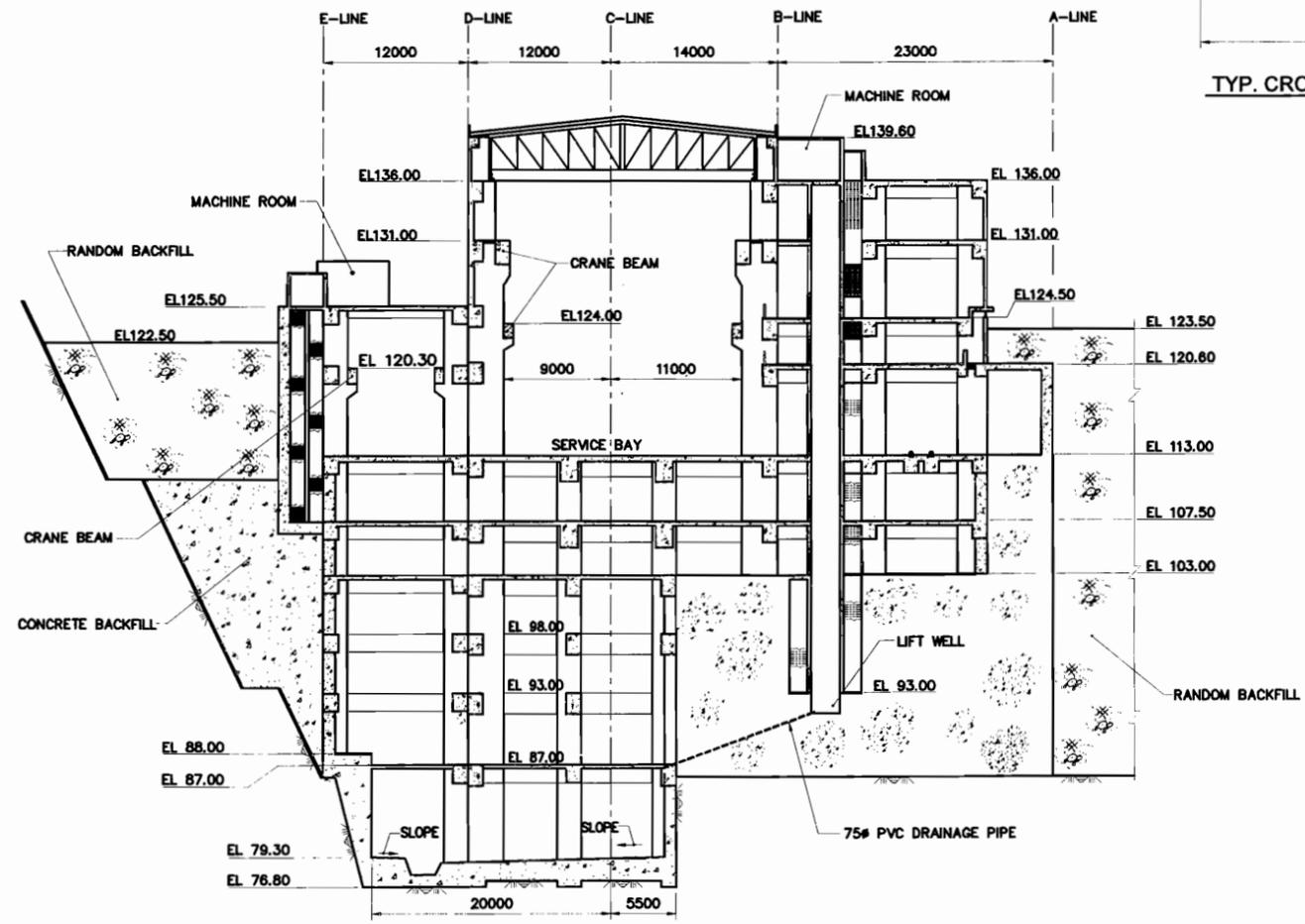
LONGITUDINAL SECTION THROUGH PRESSURE SHAFT-3

DRAWN Sd/- अशोक मोहन सिंह	SUBMITTED Sd/- प्रमोद	RECOMMENDED Sd/- अशोक C JOSHI	APPROVED Sd/- अशोक S.C. MITAL
DATE MARCH 2007	DRG. NO. NHSRL 3KC2 41 DD 321 05		

DRG. NO. NHSRL-3KC2-41-DD-321-05



NOTES
 1 ALL DIMENSIONS ARE IN MILLIMETRE AND ELEVATIONS IN METRE.



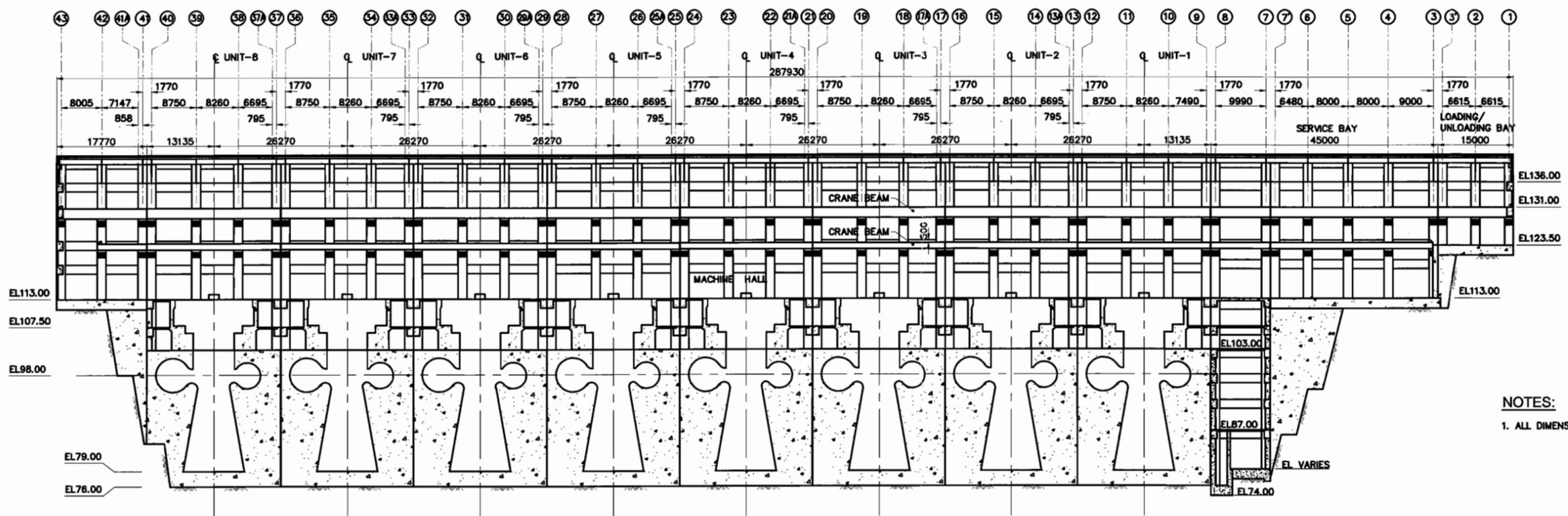
नैशनल हाइड्रोइलेक्ट्रिक पावर कारपोरेशन लि. NATIONAL HYDROELECTRIC POWER CORPORATION LTD.			
सुबनसिरी लोअर जलविद्युत परियोजना SUBANSIRI LOWER HYDROELECTRIC PROJECT			
POWER HOUSE GENERAL ARRANGEMENT CROSS-SECTIONS			
DRAWN रचित	SUBMITTED प्रस्तुत	RECOMMENDED अनुशंसित	APPROVED अनुमोदन
DATE दिनांक	OCT 2005	DRG. NO. रवेच नम्बरा	NHSRL-4CC2-41-GA-416

DATE	NO.	REVISION OR ISSUES	BY.	CH. APP
27.07.06	01	BRACKETS SIZE AND BEAM AT D-LINE EL 119.00 MODIFIED.		
Sd/-	02.02.06	00		ISSUED FOR CONSTRUCTION
E & M				

DRG. NO. NHSRL-4CC2-41-GA-416-01

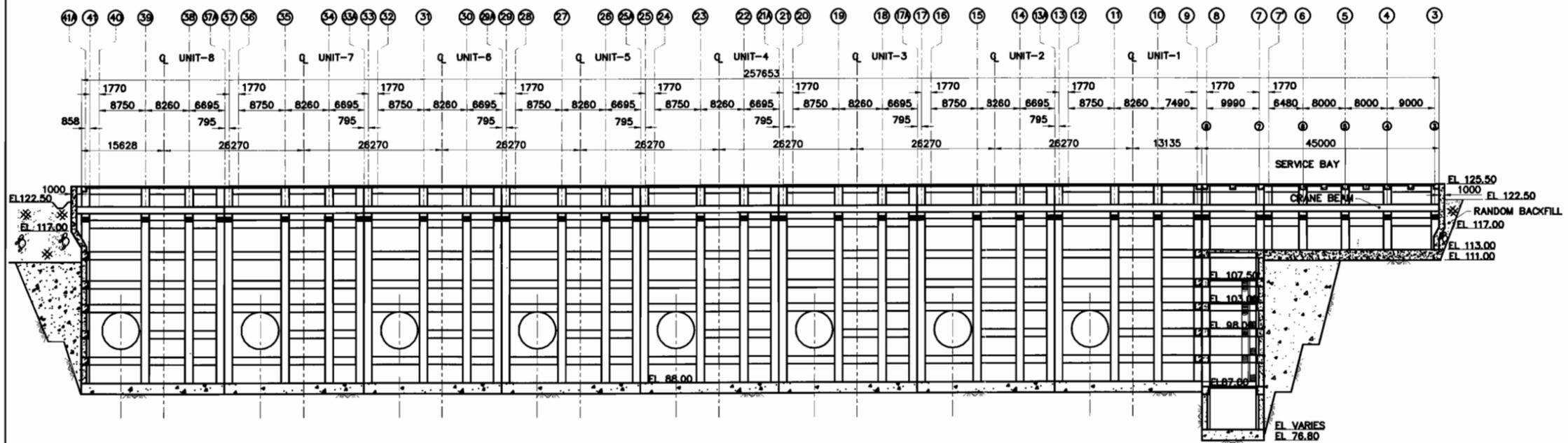
82

CROSS SECTION SERVICE BAY

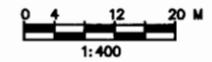


L-SECTION ALONG C-LINE OF POWER HOUSE

NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETRE AND ELEVATIONS IN METRE.

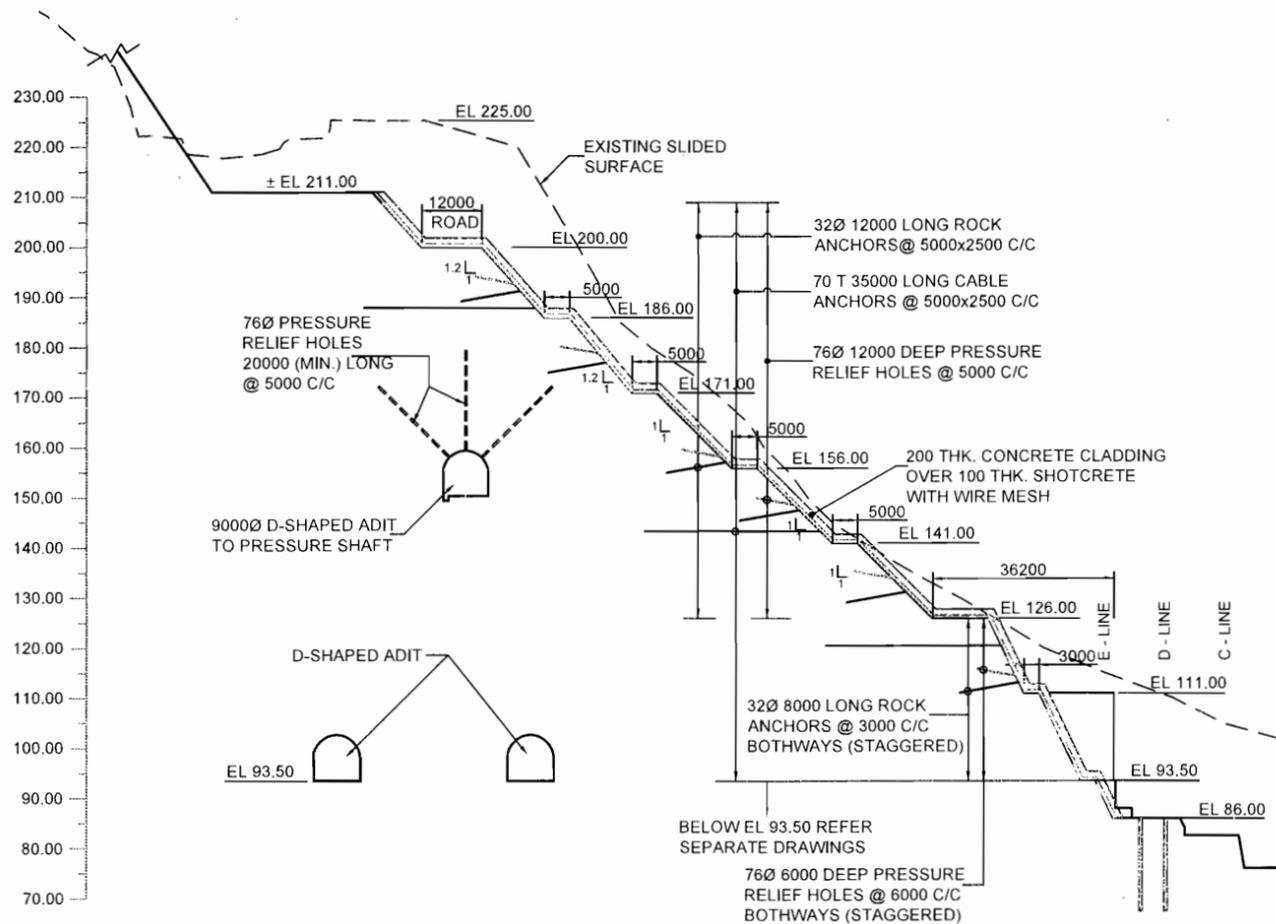


L-SECTION THROUGH MIV BLOCK

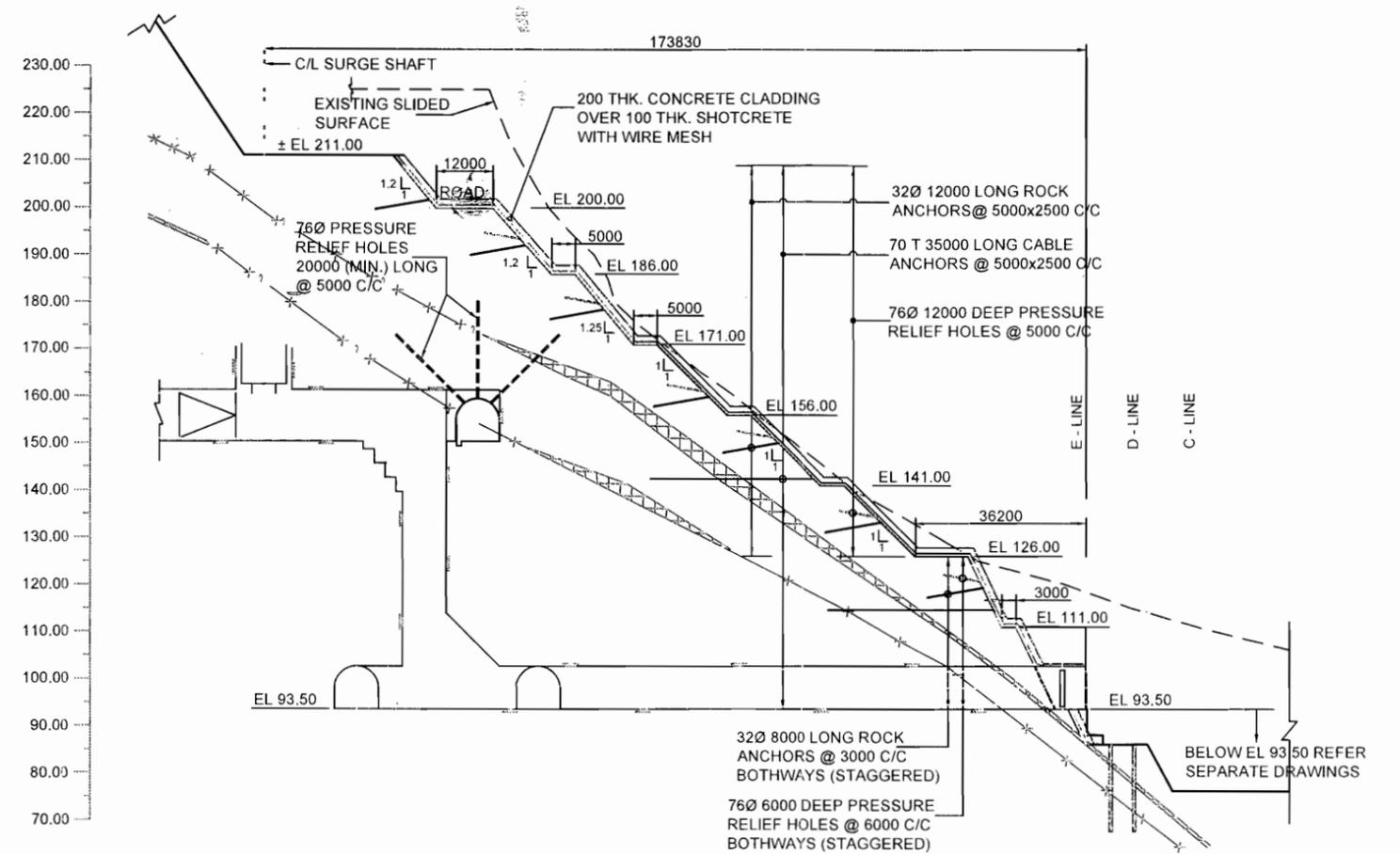


DRG. NO. NHSRL-4CC2-41-GA-417-01

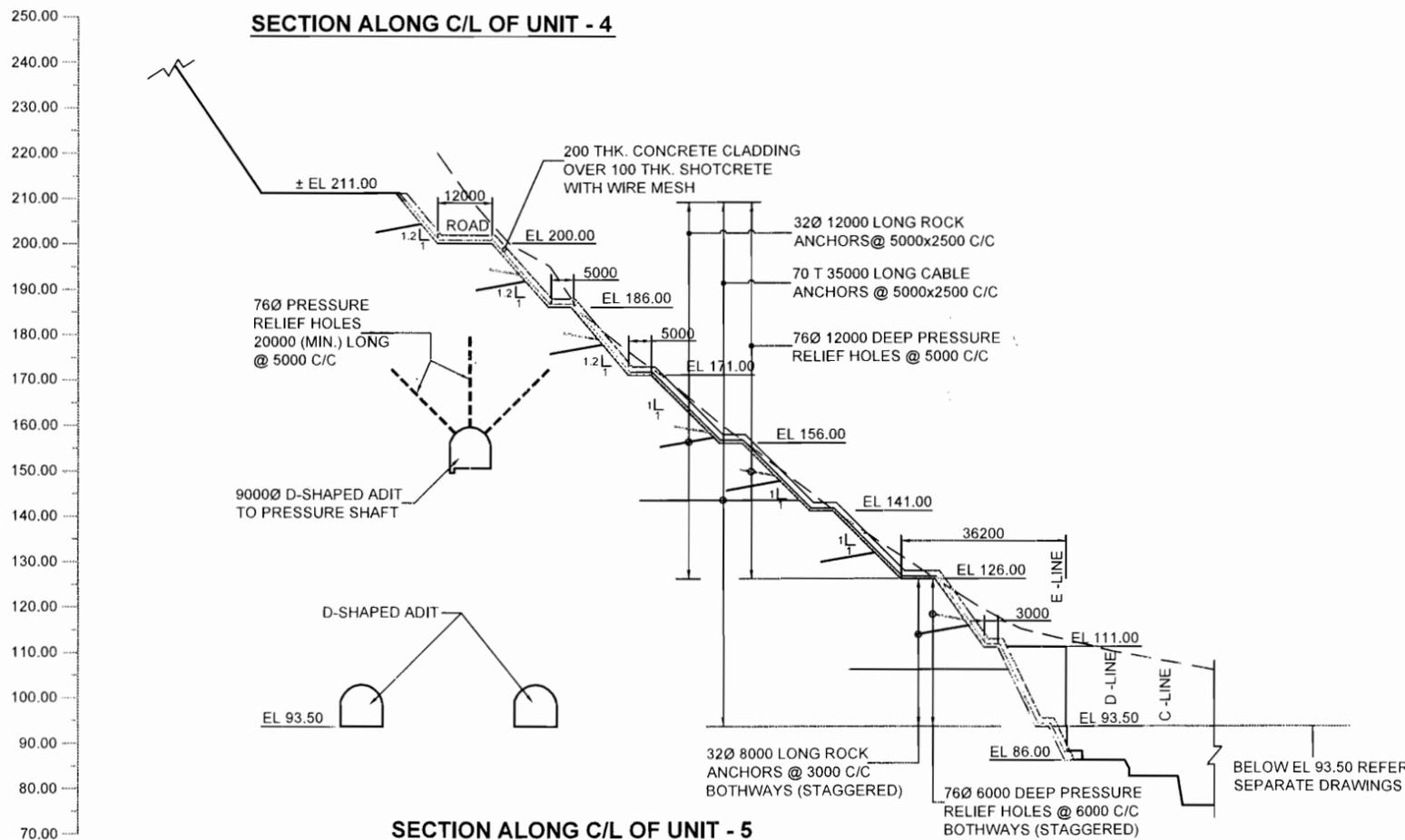
नेशनल हाइड्रोइलेक्ट्रिक पावर कारपोरेशन लि. NATIONAL HYDROELECTRIC POWER CORPORATION LTD.			
सुबनसिरी लोअर जलविद्युत परियोजना SUBANSIRI LOWER HYDROELECTRIC PROJECT			
POWER HOUSE GENERAL ARRANGEMENT LONGITUDINAL SECTIONS			
DRAWN रचित	SUBMITTED प्रस्तुत	RECOMMENDED अनुशंसित	APPROVED अनुमोदन
E & M	DATE दिनांक	NO. क्रमांक	REVISION OR ISSUES संशोधन व प्रश्न
	27.07.06	01	MIV COLUMNS LOCATION MODIFIED
	02.02.06	00	ISSUED FOR CONSTRUCTION
BY द्वारा	CH. विभाग	APP. अधिकारी	DATE दिनांक
			OCT 2005
DRG. NO. संकेत संख्या		NHSRL-4CC2-41-GA-417	
		01	



SECTION ALONG C/L OF UNIT - 4



SECTION ALONG C/L OF PS - 4



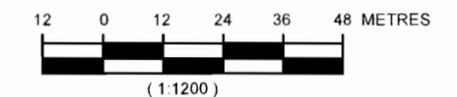
SECTION ALONG C/L OF UNIT - 5

NOTES :-

1. ALL DIMENSIONS ARE IN MILLIMETRE AND ELEVATIONS IN METRE.
2. FOR OTHER NOTES REFER DRAWING NO. NHSRL-4CC2-41-DD-112, 113 & 114.
3. SURGE SHAFT AND PRESSURE SHAFT SHOWN IN THIS DRAWING IS INDICATIVE.
4. BETWEEN UNIT-3 TO 5 THE PENSTOCK EXCAVATION SHALL BE SUPPORTED BEFORE EXCAVATION OF CUT SLOPE BELOW EL 126.00 OR REMOVAL OF MUCK.
5. THE 4000 RCC DOWELS HAVE BEEN SHOWN TENTATIVELY IN THIS DRAWING. LOCATION & SPACING SHALL BE REVIEWED BASED ON ACTUAL DISPOSITION OF SHEAR ZONE.

THIS DRAWING SUPERSEDES DRAWING NO. NHSRL-4CC2-41-DD-104

SCALE:-



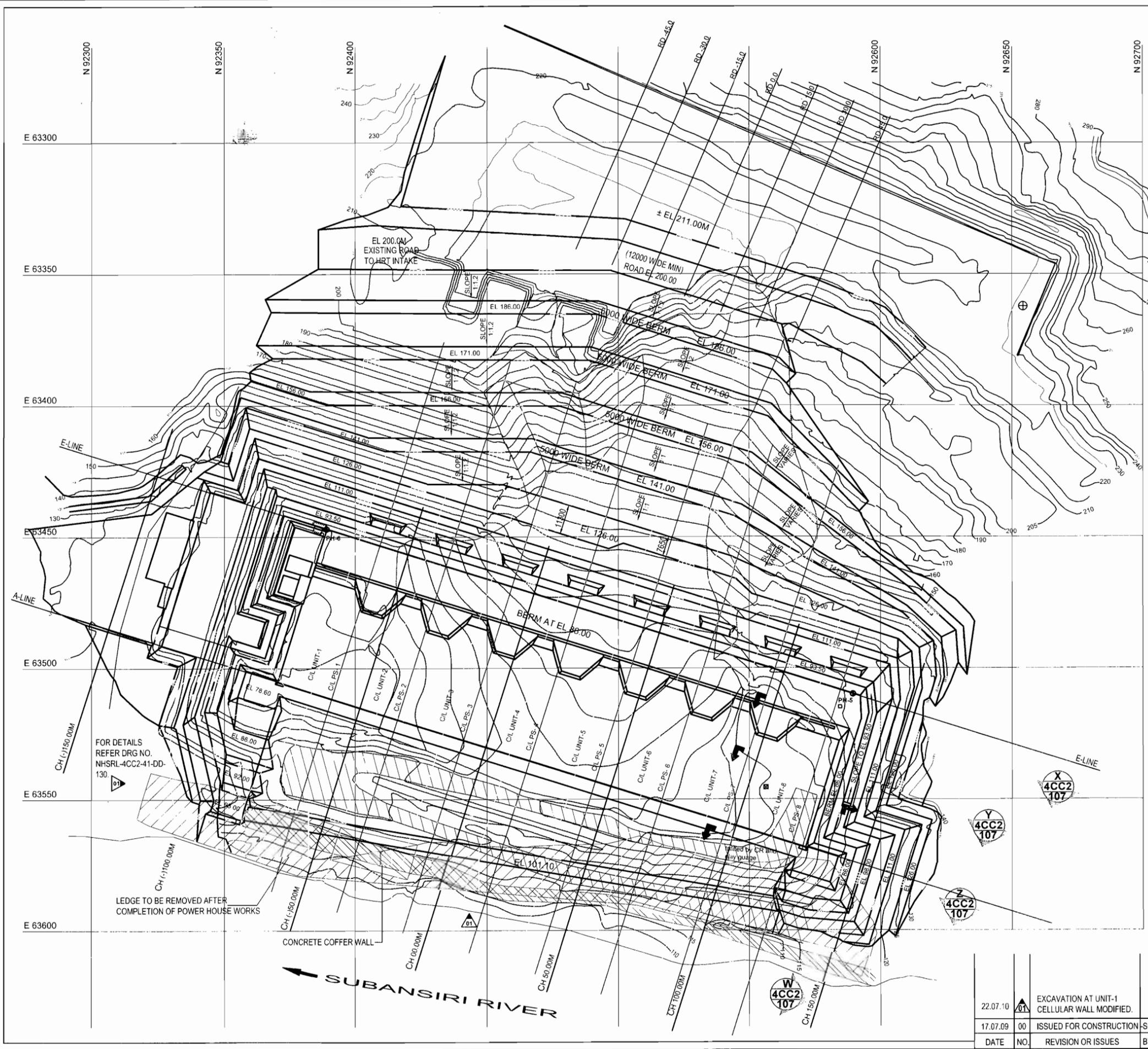
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SUBANSIRI LOWER HYDROELECTRIC PROJECT

**POWER HOUSE - HILL SLOPE
MODIFIED EXCAVATION
SECTIONS**

SHEET 3 OF 5

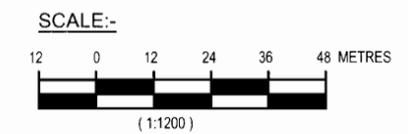
DATE	NO.	REVISION OR ISSUES	BY	CH.	APP.	DATE	DRG. NO.	NHSRL 4CC2 41 DD 115 00
17.07.09	00	ISSUED FOR CONSTRUCTION				JULY -2009	DRG. NO.	



NOTES

1. ALL DIMENSIONS ARE IN MILLIMETRE AND LEVELS IN METRE.
2. GROUND CONTOURS AND GRIDS HAVE BEEN TRACED FROM THE CONTOURS RECEIVED FROM THE SITE VIDE LETTER NO. NH/SLP/CC-II/W-767 DATED 09-09-2003 AND NOTE NO. NH/EG/102A/08/445 DT 15.04.08.
3. FOR COORDINATES OF CONTROL POINTS REFER DRG. NO. NHSRL-4CC2-41-DD-401.
4. ROCK EXCAVATION BY BLASTING SHALL BE STOPPED NOT LESS THAN 3M BEFORE FINAL LINE AND GRADE OF EXCAVATION. FURTHER EXCAVATION SHALL BE CARRIED OUT AS PER T.S. SEC B-2.
5. DEPTH OF THE ROCK EXCAVATION IN EACH CYCLE OF EXCAVATION SHALL BE 3M MAXIMUM. FURTHER EXCAVATION SHALL BE DONE ONLY AFTER THE SLOPE PROTECTION MEASURES i.e. SHOTCRETE AND ROCK ANCHORS HAVE BEEN PROVIDED.
6. THE FINAL 200 MM OF EXCAVATION WHERE SHOTCRETE / CONCRETE IS TO BE PLACED, SHALL BE EXCAVATED MANUALLY TO AVOID DISTURBANCE TO THE BOTTOM AND UNDULATIONS.
7. 50MM THICK SHOTCRETE SHALL BE APPLIED IMMEDIATELY ON THE EXCAVATED SURFACE. SUBSEQUENT SHOTCRETE AND ROCK ANCHORS SHALL BE PROVIDED AFTER REMOVAL OF MUCK.
8. PRESSURE RELIEF HOLES SHALL BE PROVIDED AS PER T.S. B-7.
9. CONTRACTOR SHALL MAKE ALL ARRANGEMENTS OF SURFACE DRAINAGE FOR THE PROTECTION OF EXCAVATED SLOPES AND POWER HOUSE PIT AS PER T.S.
10. FOR SURFACE DRAINAGE CATCH DRAIN IN PH & S.S AREA REFER DRAWING NO. NHSRL-4CC2-41-DD-405. THE SURFACE DRAINAGE SHALL BE DIVERTED AWAY FROM THE EXCAVATED SLOPES.
11. ADDITIONAL CATCH DRAINS AS PER SITE REQUIREMENT SHALL BE PLANNED WITH THE APPROVAL OF ENGINEER-IN-CHARGE. ALL DRAINS SHALL BE MAINTAINED / CLEANED REGULARLY.
12. HAUL ROAD SHALL BE PLANNED AND CONSTRUCTED WITH MINIMUM DISTURBANCE TO THE INDICATED BERMS AND SIDE SLOPES.
13. INSTRUMENTS LIKE SURVEY TARGET, MPBX ETC SHALL HAVE TO BE INSTALLED DURING CONSTRUCTION FOR MONITORING THE CUT SLOPES. REFER SEPARATE DRAWING FOR SAME.
14. TO MONITOR THE SLOPE MOVEMENT, THE READINGS OF THE INSTRUMENTS SHALL BE REGULARLY OBSERVED DURING CONSTRUCTION AND DATA BE ANALYSED AND SUBMITTED TO THE ENGINEER-IN-CHARGE.
15. FOR EARTHMAT DETAILS REFER SEPARATE DRAWING.
16. FOR EXCAVATION DETAILS OF SURGE CHAMBER AND PRESSURE SHAFTS REFER RELEVANT DRAWINGS.
17. THIS DRAWING SHOWS MODIFIED EXCAVATION & ROCK SUPPORT AFTER SLIDE (JAN. 2008) IN POWER HOUSE AREA.
18. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH EARLIER EXCAVATION DRAWING NO. NHSRL-4CC2-41-DD-402 TO 404.
19. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH EXCAVATION DRAWING NO. NHSRL-4CC2-41-DD-113 TO 117 & 107.
20. CHAINAGES & RD'S INDICATED IN THIS DRAWING ARE AS MARKED AT SITE FOR POWER HOUSE & SURGE SHAFT RESPECTIVELY.
21. SHEAR ZONE SHOWN IN THESE DRAWINGS IS AS RECEIVED FROM GEOTECH DIVISION VIDE NOTE NO. NH/EG/102A/2008/649DT:30.05.08
22. THESE DRAWINGS GIVE GUIDELINES FOR MINIMUM ROCK SUPPORT TO BE INSTALLED IN PH CUT SLOPE. ADDITIONAL SUPPORT IF REQUIRED AS PER GEOLOGICAL REQUIREMENT SHALL BE INSTALLED WITH THE APPROVAL OF ENGINEER-IN-CHARGE.
23. FOR EXCAVATION DETAILS AT CELLULAR WALL (UNIT-1) AND DOWN STREAM WEIR REFER DRG NO. NHSRL-4CC2-41-DD-130, 131 & 132.

THIS DRAWING SUPERSEDES DRAWING NO. NHSRL-4CC2-41-DD-101



एन एच पी सी लिमिटेड
 (भारत सरकार का उद्यम)
NHPC Limited
 (A GOVT. OF INDIA ENTERPRISE)

सुबनसिरी लोअर जलविद्युत परियोजना
SUBANSIRI LOWER HYDROELECTRIC PROJECT

POWER HOUSE - HILL SLOPE
MODIFIED EXCAVATION
PLAN

22.07.10	01	EXCAVATION AT UNIT-1 CELLULAR WALL MODIFIED.	SD	SD	SD
17.07.09	00	ISSUED FOR CONSTRUCTION	SD	SD	SD
DATE	NO.	REVISION OR ISSUES	BY	CH	APP

DRAWN	SUBMITTED	RECOMMENDED	APPROVED
वर्तिका	प्रस्तुत	अनुमोदित	अनुमोदन
DATE	DRG. NO.	NHSRL 4CC2 41 DD 112 01	
दिनांक	उद्भव संख्या		

Government of India
Central Water Commission
Hydel Civil Designs (NW&S) Directorate

6th Floor, Sewa Bhawan
R K Puram
New Delhi-110066

Sub: Subansiri Lower HEP (2000MW) in Arunachal Pradesh – Memorandum of Changes.

Ref: i) CEA Letter No. 2/NHPC/26/CEA/2001-PAC/1759-62 dated 01.08.2017.
ii) CWC U.O No. 26/33/2015-HCD(NW&S)/2660-61 dated 04.08.2017
iii) NHPC letter no. NH/PD/IP/SLP(RCE/2052 dated 10.08.2017

Please refer letter under reference iii vide which head loss calculation alongwith requisite details for Lower Subansiri HEP was submitted to this office for vetting. The same has been examined in this office.

As per the details submitted by Project Authority, head loss in longest water conductor system may be taken as 5.102 m and in shortest water conductor system it may be taken as 4.41 m.

S K Das
18/8/2017

S K Das
Director

Director(PAC), 3rd Floor, CEA, Sewa Bhawan, R.K.Puram, New Delhi
CWC U.O.No. 26/33/2015-HCD (NW&S)/ 2748-49 dt. 18.08.2017

Copy to:

✓ Chief Engineer (Plg.), NHPC, NHPC Office Complex, Sector-33, Faridabad,
Haryana, PIN-121003.



एनएचपीसी लिमिटेड
(भारत सरकार का उद्यम)

NHPC Limited
(A Government of India Enterprise)

संदर्भ सं./Ref. No. NH/PD/IP/SLP (RCE)/ 2052

फोन/Phone : _____
दिनांक/Date : 10.08.2017

**Shri Sudista Kumar Das (Director),
Hydel Civil Designs (NW&S) Directorate,
6th floor, Central Water Commission,
Sewa Bhawan, R. K. Puram,
New Delhi – 110066**

Sub: Subansiri Lower HE Project: - Regarding Head loss Calculation based on Memorandum of changes from DPR.

**Ref: 1. NHPC letter no NH/PD/IP/SLP-RCE/206 dated 02.02.2015.
2. CWC letter No. 26/33/2015-HCD (NW &S)/ 2660-61 dated 04.08.2017**

Sir,

Please refer to your letter dated 04.08.2017 on the subject cited above. Reply to observation is enclosed herewith as Annexure-A alongwith requisite documents and drawings.

It is therefore requested to kindly convey the requisite clearance as desired by CEA for SLP H.E project at the earliest.

Thanking you,

Yours faithfully,

Encl: As above.


**(H. Bulchandani)
Chief Engineer (Plg.)**

Copy to:

1. Director (PAC), 3rd floor, Central Electricity Authority, Sewa Bhawan, R. K. Puram, New Delhi – 110066.

Point No.	Observation	Reply
i	Head loss calculation after approval of memorandum of changes.	Head loss calculation for the approved changes is enclosed as Annexure-I (Already submitted).
ii	Modification approved in DPR for any changes in discharge, head and water conductor system.	There is no change in design discharge, gross head. The change in water conductor submitted vide above reference and has been approved by HCD vide letter no CWC U.O. No. 26/33/2015-HCD (NW&S)/1119-20 dated 03.08.2016. Comparative salient feature w.r.t DPR TEC & Present is enclosed as Annexure-II (Already submitted).
iii	L-section Drawings showing whole length and components of water conductor system including intake, gate shafts, HRT, Pressure shafts, draft tube and tail race channel.	Drawings showing the L-section of whole length and components of water conductor system are as follows (a) L-section of water conductor system is enclosed as drawing no. NHSRL-3CT6-41-GA-007 (b) Pressure shafts excavation L-section through pressure shaft-2 : NHSRL-3KC2-41-DD-320-00. (c) Power House General arrangement cross section : NHSRL-4CC2-41-GA-416-01.
iv	Drawings showing all dimensions of water conductor system from intake to tail race channel including all transitions, bends, bend angles etc.	The drawings showing dimensions of water conductor system from intake to tail race channel including all transitions, bends, bend angles are enclosed as follows:- 1. Intake and head race tunnel setting out plan NHSRL-3CT6-GA-006-00 2. Intake & HRT-1 setting out L-section : NHSRL-3CT6-41-GA-007-00 3. Pressure shafts excavation plan:- NHSRL-3KC2-41-DD-317-04 4. Pressure shafts excavation L-section through pressure shaft-2 : NHSRL-3KC2-41-DD-320-00. 5. Power House General arrangement cross section : NHSRL-4CC2-41-GA-416-01. 6. Power-House draft tube profile: NHSRL-4CC2-41-DD-505-01 7. Power-House draft tube concrete details sections:- NHSRL-4CC2-41-DD-522-01

Subansiri Lower H.E. Project (2000 MW)

Head loss in water conductor system

Data							
Discharge Q per tunnel =	1 Unit	for max length		All 8 units			
		322.40	cumeecs	2579.20	cumeecs		
Description	HRT	Pressure Shaft		Penstock	Draft tube / TRC/ Weir		Total WCS Length
		215					
Length, L=	1164	30	121	64	35		1414.00
Depth, D=	9.5	9.5	8	7			
Shape	Horse shoe	Horse shoe	Circle	Circle			
No. of Conduits	8	8	8	8			
Area of c/s, A=	74.844	74.844	50.240	38.465			
Perimeter, P=	31.037	31.070	25.120	21.991			
Hydraulic Radius, R=A/P	2.411	2.409	2.000	1.749			
Velocity, V=Q/A	4.308	4.308	6.417	8.382			
g=	9.81	9.81	9.81	9.81	9.81		
Calculation of Various Losses							
Sl. No/Description	HRT	Pressure Shaft		Penstock	Draft tube / TRC/ Weir		
1. Trashrack loss							
No. of bays	2.000						
Clear span of each bay	7.500						
Sill level	157.250						
MDDL	181.000						
Height of trash Rack	23.750						
slant ht of trash rack	20.600						
Gross area of trash rake	356.250						
Ratio of net area / gross area (assuming 100 mm clear distance between 60 mm flat)=100/160	0.625						
Net area of rakes	222.656						
For max. head loss 50% choking of trash rack is recommended (As per clause 4.2 of IS 4880-III, Pg.11)							
Clogging ratio (assumed)	0.500						
vel. through rakes gross	1.448						
Net vel. through rakes v = Q/(0.5an)	2.896						
$K_t = 1.45 - 0.45 \cdot a_n / a_t - (a_n / a_t)^2$							
Head loss coeff. K_t	0.778						
Head loss $h_f = K_t \cdot v^2 / 2g$	0.333						0.333
2. Entry loss							
Loss coefficient for Square Bell Mouth entrance (As per table 1 of IS 4880-III, Pg.12)							
$K_{en} =$	0.16						
Velocity, V=Q/A	4.31						
Head Loss							
$h_f = K_{en} \cdot v^2 / 2g$	0.1513						0.151
3. Intake Gate Loss (Rectangular)							
				Draft Tube Gate loss			
B (m)	7.3						
H (m)	9.5						
Total Area (m ²)	69.35				129.375		
No. of Gates	2						
V=Q/A (m/sec)	2.324				2.492		
k_g	0.1				0.1		
$H_f = K_g \cdot v^2 / 2g$	0.055				0.032		0.087
4. Friction loss							
Loss due to friction, based on Manning's formula					Draft tube part 1 (steel)	Draft tube part 2 (Conc)	TRC
Roughness coefficient, n= USBR small dam P-471	0.014	0.014	0.012	0.012	0.012	0.014	0.014
Length L	1164.000	30.000	121.000	64.000	17.140	21.000	24.100
Area A	74.844	74.844	50.240	38.465	60.710	119.337	3446.624
Perimeter P	31.037	31.070	25.120	21.991	35.330	51.590	242.960
hyd Radius R	2.411	2.409	2.000	1.749	1.718	2.313	14.186
Velocity V	4.308	4.308	6.417	8.382	5.310	2.702	0.748
Head Loss							
$h_f = L \cdot v^2 \cdot n^2 / R^{4/3}$	1.309	0.034	0.285	0.307	0.0338	0.0098	0.0001
							1.979

5 Transition loss	7.3m (w) x9.5m (h) expansion	9.5 m HS to 9.5 m Circ contraction	9.5cir to 8 m cir contraction	8 m cir to 7 m cir contraction	Draft tube part 1 expansion	Draft tube part 2 expansion	Draft tube part 3 expansion	part
Q (m ³ /sec)	322.40	322.40	322.40	322.40	322.40	322.40		322.40
B (m)	7.30	9.50	9.50	8.00				
H (m)	9.50	9.50	9.50	8.00				
Total Area A ₁ (m ²)	69.350	74.844	70.846	50.240	48.136	73.276		76.548
V ₁ =Q/A (m/sec)	4.649	4.308	4.551	6.417	6.698	4.400		4.212
D (m)	9.50	9.50	8.00	7.00				
Area A ₂ (m ²)	74.844	70.846	50.240	38.465	73.276	76.548		162.127
V ₂ =Q/A (m/sec)	4.308	4.551	6.417	8.382	4.400	4.212		1.989
K _{ex, con}	0.100	0.100	0.100	0.100	0.100	0.100		0.100
H _r =K _{ex} (V ₁ -V ₂) ² /2g for expansion IS 11625								
H _r =K _{con} (V ₁ ² /2g - V ₂ ² /2g) for contraction IS 11625	0.001	0.011	0.104	0.148	0.0269	0.0002		0.0252
6 Bend Loss	< 45° Horz. Bend		90° vertical bends	< 45° Horz. Bend	vertical bends			0.316
No. of Bends	4		2	1	3			
Defl. Angle 1	42		90	10	9			
R1	25		16	30	8.486			
D1	9.5		8	7	10.820			
area					60.720			
Velocity					5.310			
Defl. Angle 2	39				12			
R2	25				6.037			
D2	9.5				15.810			
area					77.190			
Velocity					4.177			
Defl. Angle 3	46				8			
R3	25				6.037			
D3	9.5				19.390			
area					77.170			
Velocity					4.178			
Defl. Angle 4	13							
R4	38							
D4	9.5							
R1/D1	2.632		2.000	4.29	0.784			
(R ₁ -J IS 11625)								
R2/D2	2.632				0.382			
R3/D3	2.632				0.311			
R4/D4	4							
K _b =	0.08		0.14	0.02	0.025			
Head Loss								
h _r = K _b .v ² /2g	0.3026		0.5877	0.0716	0.0804			1.042
7 Valve loss								
Loss coefficient for valves, as per IS 2951-2 Table-1								
For 1 Mpa pressure K _v =	0	0		0.14				
No valve	No valve	No valve						
Head Loss								
h _r = K _v .v ² /2g	0	0		0.501				0.501
8 Loss at Weir(Exit loss from WCS to river)								
water level in the River corresponding to the rating curve at 800 m d/s of Dam Axis (from DPR)								
Water level H2	109.00 m							
TWL corresponding to all unit running	109.50 m							(To pass a discharge of 2579.20cumecs for all units running)
Considering the velocity head to be same as Tail pool and river								the difference in total head between Tail Pool and River is
Exist loss to river	0.50 m							
Head Losses	2.151	0.045	0.977	1.028	0.708			0.500
Total head losses in water conductor system =				4.909 m				4.909

Subansiri Lower H.E. Project (2000 MW)

Head loss in water conductor system

Data									
Discharge Q per tunnel =		1 Unit	for min length		All 8 units	2579.20 cumecs			
Description		HRT	Pressure Shaft		Penstock	Draft tube / TRC / Weir	Total WCS Length		
			192						
Length, L=		608	28	106	58	35	835.00		
Depth, D=		9.5	9.5	8	7				
Shape		Horse shoe	Horse shoe	Circle	Circle				
No. of Conduits		8	8	8	8				
Area of c/s, A=		74.844	74.844	50.240	38.465				
Perimeter, P=		31.037	31.070	25.120	21.991				
Hydraulic Radius, R=A/P		2.411	2.409	2.000	1.749				
Velocity, V=Q/A		4.308	4.308	6.417	8.382				
q=		9.81	9.81	9.81	9.81	9.81			
Calculation of Various Losses									
Sl. No	Description	HRT	Pressure Shaft		Penstock	Draft tube / TRC / Weir			
1	Trashrack loss								
	No. of bays	2.000							
	Clear span of each bay	7.500							
	Sill level	157.250							
	MDDL	181.000							
	Height of trash Rack	23.750							
	slant ht of trash rack	20.600							
	Gross area of trash rake	356.250							
	ratio of net area / gross area (assuming 100 mm clear distance between 60 mm flat) = $\frac{100}{160}$	0.625							
	Net area of rakes	222.656							
	For max. head loss 50% choking of trash rack is recommended (As per clause 4.2 of IS 4880-III, Pg.11)								
	Clogging ratio (assumed)	0.500							
	vel. through rakes gross	1.448							
	Net vel. through rakes $v = \frac{Q}{(0.5an)}$	2.896							
	$K_t = 1.45 - .45 \cdot \frac{a_n}{a_t} (\frac{a_n}{a_t})^2$								
	Head loss coeff.	0.778							
	Head loss	0.333					0.333		
2	Entry loss								
	Loss coefficient for Square Bell Mouth entrance (As per table 1 of IS 4880-III, Pg.12)								
	$K_{en} =$	0.16							
	Velocity, V=Q/A	4.31							
	Head Loss								
	$h_f = K_{en} \cdot v^2 / 2g$	0.1513					0.151		
3	Intake Gate Loss (Rectangular)					Draft Tube Gate loss			
	B (m)	7.3							
	H (m)	9.5							
	Total Area (m2)	69.350				129.375			
	No. of Gates	2							
	V=Q/A (m/sec)	2.324				2.492			
	$K_g =$	0.1				0.1			
	$H_f = K_g \cdot V^2 / 2g$	0.055				0.032	0.087		
4	Friction loss								
	Loss due to friction, based on Manning's formula		concrete	concrete	steel	steel	Draft tube part 1 (steel)	Draft tube part 2 (Conc)	TRC
	Roughness coefficient, n=		0.014	0.014	0.012	0.012	0.012	0.014	0.014
	USBR small dam P-471								
	Length L	608.000	28.000	106.000	58.000	17.140	21.000	24.100	
	Area A	74.844	74.844	50.240	38.465	60.710	119.337	3446.624	
	Perimeter P	31.037	31.070	25.120	21.991	35.330	51.590	242.960	
	hyd Radius R	2.411	2.409	2.000	1.749	1.718	2.313	14.186	
	Velocity V	4.308	4.308	6.417	8.382	5.310	7.702	0.748	
	Head Loss								
	$h_f = L \cdot v^2 \cdot n^2 / R^{1/3}$	0.684	0.032	0.249	0.278	0.0338	0.00982	0.0001	1.287

5 Transition loss	7.3m (w) x9.5m (h)	9.5 m HS to 9.5 m Circ	9.5cir to 8 m cir	8 m cir to 7 m cir	Draft tube part 1	Draft tube part 2	Draft tube part 3
	expansion	contraction	contraction	contraction	expansion	expansion	expansion
Q (m ³ /sec)	322.40	322.40	322.40	322.40	322.40	322.40	322.40
B (m)	7.30	9.50	9.50	8.00			
H (m)	9.50	9.50	9.50	8.00			
Total Area A ₁ (m ²)	69.350	74.844	70.846	50.240	48.136	73.276	76.548
V ₁ =Q/A (m/sec)	4.649	4.308	4.551	6.417	6.698	4.400	4.212
D (m)	9.50	9.50	8.00	7.00			
Area A ₂ (m ²)	74.844	70.846	50.240	38.465	73.276	76.548	162.127
V ₂ =Q/A (m/sec)	4.308	4.551	6.417	8.382	4.400	4.212	1.989
K _{ex, con}	0.100	0.100	0.100	0.100	0.10	0.10	0.10
H _r =K _{ex} (V ₁ -V ₂) ² /2g for expansion IS 11625							
H _r =K _{con} (V ₁ ² /2g - V ₂ ² /2g) for contraction IS 11625	0.001	0.011	0.104	0.148	0.0269	0.00018	0.0252
							0.316
6 Bend Loss	< 45° Horz. Bend		90° vertical bends	< 45° Horz. Bend	vertical bends		
No. of Bends	4		2	1	3		
Defl. Angle 1	42		90	10	9		
R1	25		16	30	8.486		
D1	9.5		8	7	10.82		
area					60.72		
Velocity					5.310		
Defl. Angle 2	39				12		
R2	25				6.037		
D2	9.5				15.81		
area					77.19		
Velocity					4.177		
Defl. Angle 3	46				8		
R3	25				6.037		
D3	9.5				19.39		
area					77.17		
Velocity					4.178		
Defl. Angle 4	13						
R4	38						
D4	9.5						
R1/D1	2.632		2.000	4.29	0.784		
(Fig. 3 IS 11625)							
R2/D2	2.632				0.382		
R3/D3	2.632				0.311		
R4/D4	4						
K _b =	0.08		0.14	0.02	0.025		
Head Loss							
h _r = K _b .v ² /2g	0.3026		0.5877	0.0716	0.0804		1.042
7 Valve loss							
Loss coefficient for valves, as per IS 2951-2 Table-1							
For 1 Mpa pressure K _v =	0	0		0.14			
No valve	No valve	No valve					
Head Loss							
h _r = K _v .v ² /2g	0	0		0.501			0.50
8 Loss at Weir(Exit loss from WCS to river)							
water level in the River corresponding to the rating curve at 800 m d/s of Dam Axis (from DPR)							
Water level H2	109.00 m						
TWL corresponding to all unit running	109.50 m						(To pass a discharge of 2579.20cumecs for all units running)
Considering the velocity head to be same as Tail pool and river							the difference in total head between Tail Pool and River is
Exit loss to river	0.50 m						
							0.500
Head Losses	1.526	0.043	0.941	0.999	0.708		
Total head losses in water conductor system =				4.2175 m			4.2175

SUBANSIRI LOWER H.E.PROJECT

DESCRIPTION OF WATER CONDUCTOR SYSTEM FOR HEAD LOSS CALCULATION FOR LONGEST WCS HRT-1

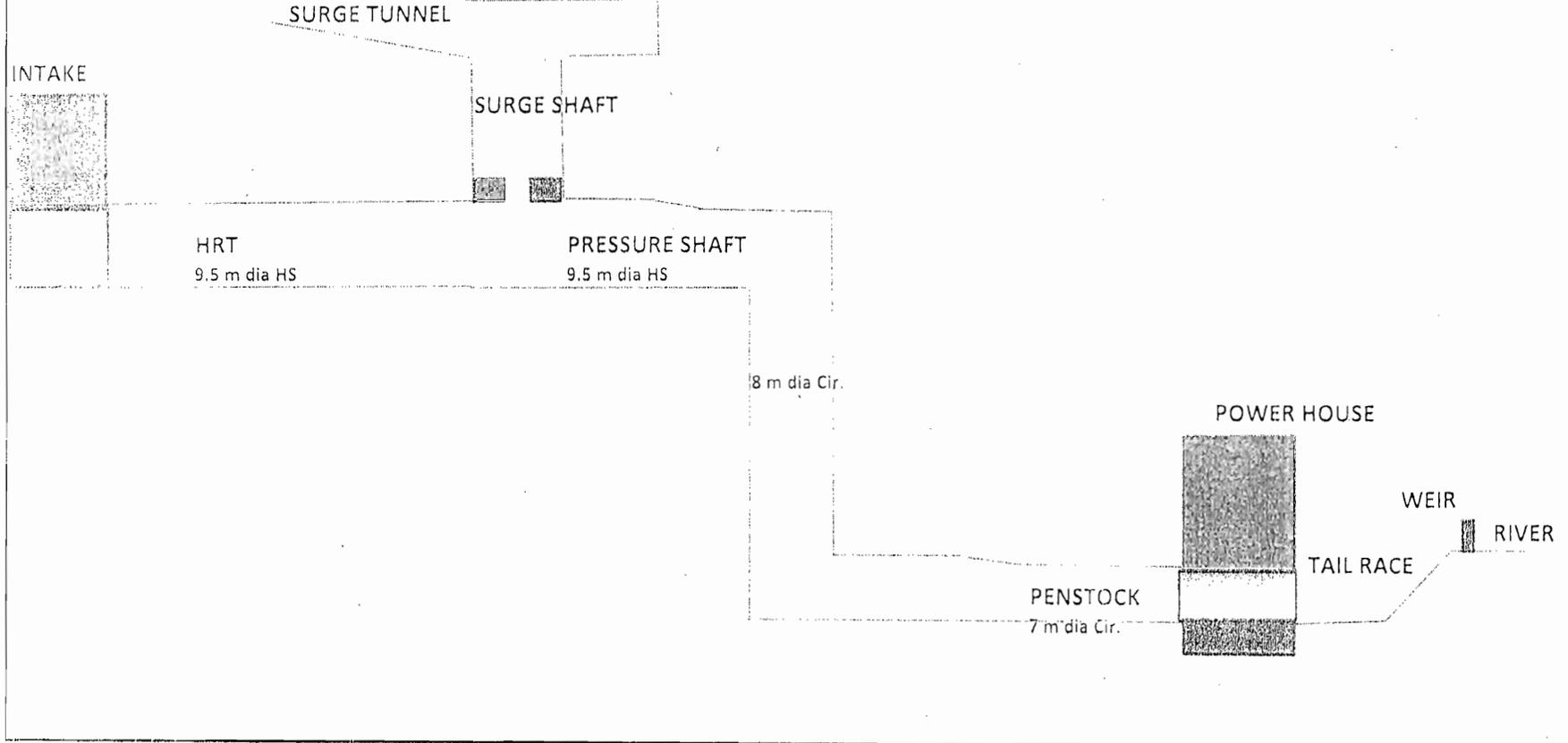
	DESCRIPTION	HEAD RACE TUNNEL (HRT) meter	PRESSURE SHAFT (PS)			TAIL RACE TUNNEL (TRT)/ TAIL RACE CHANNEL (TRC) (meter)	TOTAL LENGTH OF LONGEST WATER CONDUCTOR SYSTEM (meter)
			(meter)				
DPR STAGE	SIZE (M) NOS LENGTH(M)	9.5 M DIA HORSE SHOE SHAPE 8 390	9.5 M DIA CIRCULAR 8			9.5 M DIA HORSE SHOE SHAPE 8 780	1286.25
			68.25 Vertical	48 Horizontal	116.25		
AT PRESENT	SIZE (M) NOS LENGTH(M)	9.5 M DIA HORSE SHOE SHAPE 8 1164	9.5m DIA CIRCULAR 8 30	8m DIA CIRCULAR 8 121	7 m DIA CIRCULAR 8 64	206(W) X 35(L) 1 35	1414

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SUBANSIRI LOWER H.E. PROJECT

SCHEMATIC DIAGRAM OF WATER CONDUCTOR SYSTEM



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SUBANSIRI LOWER H.E PROJECT

Comparitive : Salient Features

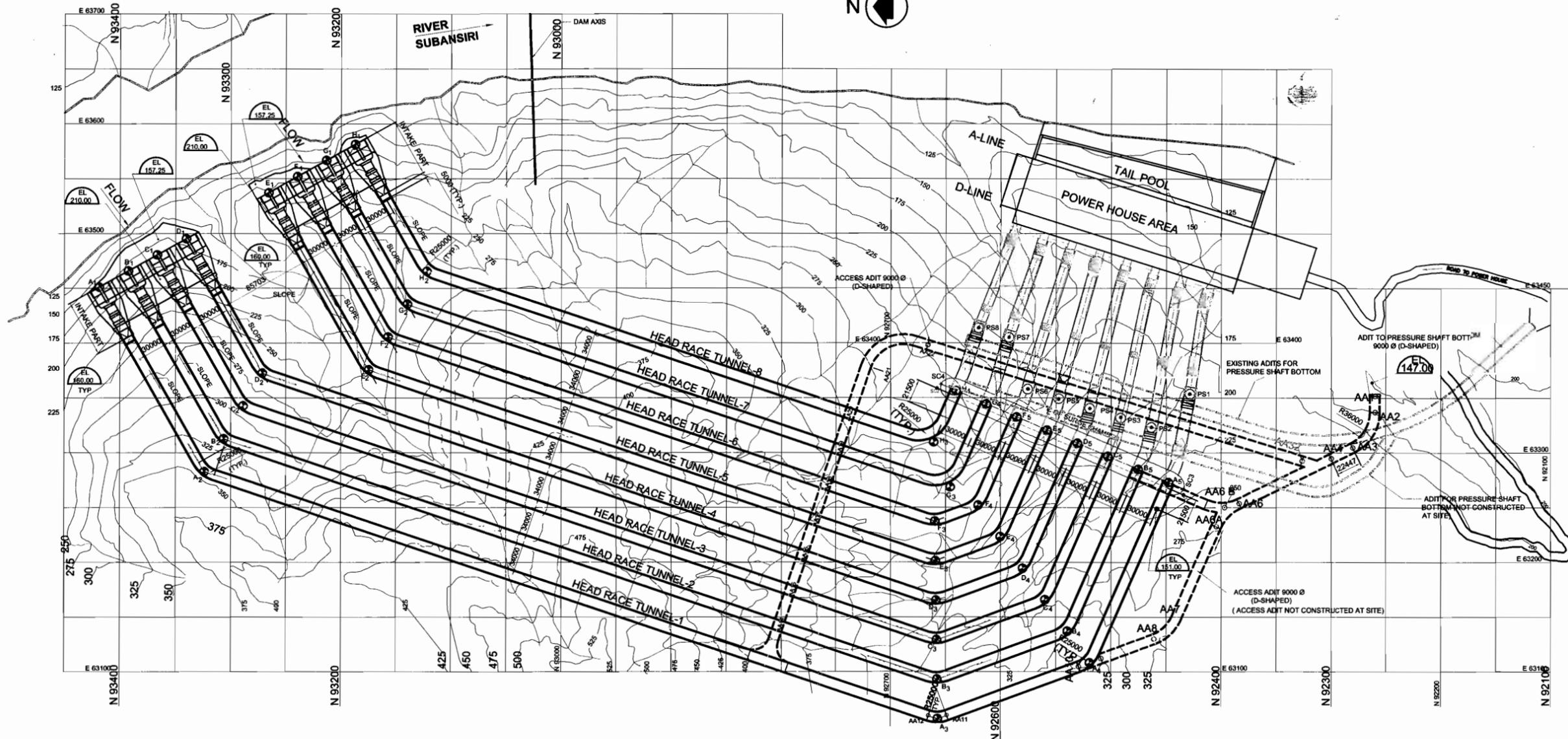
		DPR TEC STAGE	PRESENT	Observations
1	RESERVOIR			
	MAXIMUM WATER LEVEL(MWL)	EL 208.25 M	EL 208.25 M	No change in technical parameters
	FULL RESERVOIR LEVEL (FRL)	EL 205.0 M	EL 205.0 M	
	MINIMUM RESERVOIR LEVEL (MRL)	EL 190.0 M	EL 190.0 M	
	MINIMUM DRAW DOWN LEVEL (MDDL)	EL 181 M	EL 181 M	
	GROSS STORAGE AT EL 205.0, 190.0&181.0 M	1365 / 923 / 720 M CUM	1365 / 923 / 720 M CUM	
	AREA UNDER SUBMERGENCE AT FRL	33.50 SQ. KM.	33.50 SQ. KM.	
2	DIVERSION TUNNEL			
	NUMBER	5	5	Minor change in length as per site conditions i.e. topographical and geological conditions
	SIZE	9.5 M DIAMETER	9.5 M DIAMETER	
	SHAPE	HORSESHOE	HORSESHOE	
	LENGTH	From 485 M to 640 M (Total 3.4 km)	From 493 M to 693 M (Total 4 Km)	
	DIVERSION CAPACITY	4,550 M ³ /s	4,550 M ³ /s	
3	DAM			
	TYPE	CONCRETE GRAVITY DAM	CONCRETE GRAVITY DAM	• No change in technical parameters for
	TOP ELEVATION OF DAM	EL 210.0 M	EL 210.0 M	
	HEIGHT OF DAM ABOVE RIVER BED LEVEL	116 M	116 M	
	HEIGHT OF DAM ABOVE DEEPEST FOUNDATION LEVEL	133 M	125 M	•At the time of the overburden excavation of the Dam foundation, the rock was found at higher elevations.
4	SPILLWAY			
	DESIGN FLOOD	37500 CUMECS	37500 CUMECS	<ul style="list-style-type: none"> Gate opening modified 11.5 m (W) x 14 m (H), Crest level lowered by 5 m (now El.145 m) after hydraulic model studies by CWC. Base width increased by 100m as per recommendations of DDRP.
	TYPE	ORIFICE TYPE	ORIFICE TYPE	
	CREST ELEVATION	EL 150 M	EL 145 M	
	NUMBER & SIZE OF SPILLWAY OPENING	9 NOS; 11.5 M X 14.7 M	9 NOS; 11.5 M X 14.0 M	
	ENERGY DISSIPATION	SKI-JUMP WITH PLUNGE POOL	SKI-JUMP WITH PREFORMED PLUNGE POOL	
	Cut-off Wall		<ul style="list-style-type: none"> U/S cut-off wall under overflow & all NOF blocks. D/S cut-off wall in central spillway portion. 	In DPR there was U/S cut-off wall beneath overflow & part NOF.

SUBANSIRI LOWER H.E PROJECT				
Comparitive : Salient Features				
5	INTAKE			
	INVERT LEVEL	EL 160	EL 160	No change in technical parameters for intake
	NUMBER & SIZE OF GATE OPENING	8 NOS; 7.3 M X 9.5 M	8; 7.3 M X 9.5 M	
6	HEAD RACE TUNNEL			
	NUMBER	8	8	Length changed in view of provision of surface power house in tender stage / Present w.r.t. underground in DPR stage
	SIZE & SHAPE	9.5 M DIA. HORSE SHOE	9.5 M DIA. HORSE SHOE	
	LENGTH	From 225 M to 390 M	From 608 M to 1168 M. Total Length = 7.2 Km	
	DESIGN DISCHARGE	322.4 CUMECS	322.4 CUMECS	
7	SURGE CHAMBER			
(a)	U/S SURGE CHAMBER			
	NUMBER OF COMPARTMENT	NA	8 Nos. Surge Tunnels	Modified surge arrangement of 8 Nos. surge tunnels of dia 9.5m horse shoe shaped was provided after slope failure near Power House.
	COMPARTMENT SIZE	No provision due to underground power house. During tender underground power house changed to surface power house hence surge chamber was provided. Number of compartment 8 of size 26 m x 16 m x 62 m	<ul style="list-style-type: none"> • 9.5 M Dia. • Horse Shoe Tunnel • Total length 3545m. • Length varying from 400m to 485m 	
	D/S SURGE CHAMBER CUM DRAFT TUBE GATE CAVERN		D/S surge chamber was provisioned in DPR stage when there was Underground Power house due to longer length of TRT. The same was not required when the power house changed from underground to surface.	
(b)	SIZE	15 M X 62.5 M X 249 M (COMPARTMENTED INTO 8 NUMBERS)		
8	PRESSURE SHAFT			
	NUMBER	8	8	Size of PS modified as per excavation methodology during tender stage. PS-2, PS-3, PS-4, PS-5 PS-6 was shifted towards hill by about 40m for the lateral cover requirement.
	SHAPE	CIRCULAR, STEEL LINED	CIRCULAR/ HORSESHOE	
	DIAMETER	8 M	9.5/ 8/ 7 M	
	LENGTH	Vertical 68.25 M + 48 M horizontal	192 M TO 215 M (Vertical portion part 48 M) (Steel lined portion of 155M)	

SUBANSIRI LOW HEAD H.E PROJECT

Comparitive : Salient Features

9	POWER HOUSE			
	TYPE	UNDERGROUND	SURFACE	Powerhouse was conceptualised from underground in DPR to surface during tender stage/Present.
	INSTALLED CAPACITY	2,000 MW	2,000 MW	No change in technical parameters
	NUMBER OF UNITS	8	8	
	POWER HOUSE CAVERN	24 M X 62.4 M X 337 M	288 M X 61 M X 64 M	
	TRANSFORMER CUM MIV CAVERN	15 M X 42.0 M X 327 M		
	TYPE OF TURBINE	FRANCIS	FRANCIS	
	GROSS HEAD	91 M	91 M	
	BUS DUCT GALLERY	6 X 6 M x 30 M		
	DIAMETER OF MIV	7 M		
	DRAFT TUBE OPENING	12 M X 10 M including intermediate piers of 2.0 m width	3Nos X 5.75 M x 7.5 M for each unit	
	DESIGN ENERGY	7421.59MU	7421.59MU	
11	TAILRACE TUNNEL/CHANNEL	Tunnel	Channel	
	SHAPE	HORSE SHOE SHAPED		Due to change of PH from UG to Surface TRT was eliminated and TRC was provided
	LENGTH	From 450 M to 780 M	35 M	
	DIA	9.5 M		
	WIDTH		206 M	
12	SWITCHYARD			
	SIZE & LOCATION	100 M X 300 M AT EL 190 M	Pothcad yard between A to B line at EL.136.00m	
13	ACCESS TUNNELS			
	SIZE	8 M D - SHAPED	9.0 M D - SHAPED	Access tunnel arrangement got modified as per change in power house type & site requirements.
	TOTAL LENGTH	2422 M	2197 M for HRT,PS top and bottom .	
	SIZE	5 M X 7.5 M D - SHAPED	9.0m , D-Shaped	
	TOTAL LENGTH	343 M	1568 m for Surge Tunnel	
	SIZE	9 M X 10 M D - SHAPED		
	TOTAL LENGTH	300 M		



NOTES

1. ALL DIMENSIONS ARE IN MILLIMETRE, GRID VALUES, COORDINATES AND ELEVATIONS IN METRE.
2. FOR BALANCE WORKS OF HRT INTAKE STRUCTURE & HRT, PLEASE REFER INFORMATION FOR BIDDERS AND OTHER TENDER DOCUMENTS.
3. INSPECTION, MONITORING OF ROCK SURFACE AND MAINTENANCE OF DRAINS AND INSTRUMENTS IN TUNNELS, SHAFTS AND ADITS AND CARE THERE OF, SHALL BE CARRIED OUT BY CONTRACTOR WITH PRIOR INFORMATION AND APPROVAL OF ENGINEER-IN-CHARGE.

**TENDER DRAWING
NOT FOR CONSTRUCTION**



H.R.T. LENGTH IN (M) UPTO Q OF SURGE SHAFT	
H.R.T. - 1	1168.420
H.R.T. - 2	1092.439
H.R.T. - 3	1016.458
H.R.T. - 4	940.476
H.R.T. - 5	843.139
H.R.T. - 6	767.159
H.R.T. - 7	691.708
H.R.T. - 8	608.227

COORDINATES		
POINTS	NORTHING	EASTING
A ₁	93418.622	63451.202
A ₂	93324.012	63282.830
A ₃	92657.224	63056.978
A ₄	92519.274	63108.256
A ₅	92447.909	63272.927
B ₁	93392.468	63465.899
B ₂	93306.424	63312.770
B ₃	92657.753	63093.054
B ₄	92539.510	63137.007
B ₅	92475.439	63284.848
C ₁	93366.314	63480.595
C ₂	93288.836	63342.710
C ₃	92658.281	63129.131
C ₄	92559.746	63165.758
C ₅	92502.968	63296.769

COORDINATES		
POINTS	NORTHING	EASTING
D ₁	93340.160	63495.291
D ₂	93271.247	63372.650
D ₃	92658.810	63165.207
D ₄	92579.982	63194.509
D ₅	92530.498	63308.691
E ₁	93265.445	63537.274
E ₂	93174.746	63375.861
E ₃	92659.338	63201.284
E ₄	92600.218	63223.260
E ₅	92558.028	63320.612
F ₁	93239.291	63551.970
F ₂	93157.157	63405.801
F ₃	92659.866	63237.360
F ₄	92620.454	63252.011
F ₅	92585.557	63332.533

COORDINATES		
POINTS	NORTHING	EASTING
G ₁	93213.137	63566.666
G ₂	93139.569	63435.741
G ₃	92645.981	63268.554
G ₄	92613.087	63344.455
H ₁	93186.983	63581.362
H ₂	93121.981	63465.681
H ₃	92660.926	63309.514
H ₄	92640.616	63356.376

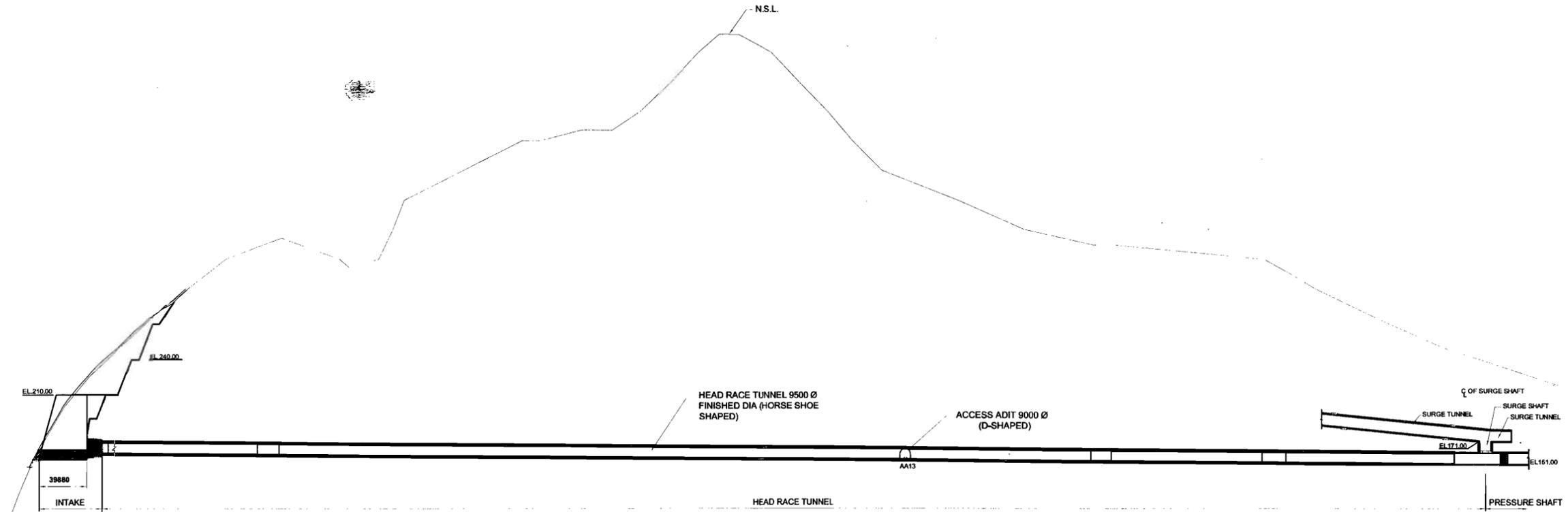
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एन सी ई आर सी २०२१
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SUBANSIRI LOWER HYDROELECTRIC PROJECT

INTAKE AND HEADRACE TUNNELS
SETTING OUT
PLAN

DATE	NO.	REVISION OR ISSUES	BY: CH. APP.
06.06.15	00	ISSUED FOR TENDER	
DATE	DRG. NO.	DRG. NO.	APPROVED
JUNE, 2015	NHSRL-3CT6-41-GA-006	00	

DRG. NO. NHSRL-3CT6-41-GA-006-00



H.R.T. INVERT LEVEL (m.)	160.00	160.00																151.00
PARTIAL LENGTH (mm)	-52630	5000	125917	18307				144294	17062	127636	20149	142516	26297					
CUMULATIVE LENGTH (mm)	-52630	5000	130917	149224				690466	834760	851822		979458	999607	1142123	1168420			
SLOPE	0%							126.347 H: 1 V										0%
CURVE DATA				R = 25000					R = 25000			R = 25000						

L-SECTION THROUGH HRT-1

NOTES

- 1 ALL DIMENSIONS ARE IN MILLIMETRE, GRID VALUES, COORDINATES AND ELEVATIONS IN METRE.
- 2 FOR BALANCE WORKS OF HRT INTAKE STRUCTURES, HRTS, SURGE TUNNELS AND SURGE SHAFTS, PLEASE REFER INFORMATION FOR BIDDER AND OTHER TENDER DOCUMENTS.
- 3 INSPECTION, MONITORING OF ROCK SURFACE AND MAINTENANCE OF DRAINS AND INSTRUMENTS IN TUNNELS, SHAFTS AND ADITS AND CARE THERE OF, SHALL BE CARRIED OUT BY CONTRACTOR WITH PRIOR INFORMATION AND APPROVAL OF ENGINEER-IN-CHARGE.

TENDER DRAWING
NOT FOR CONSTRUCTION

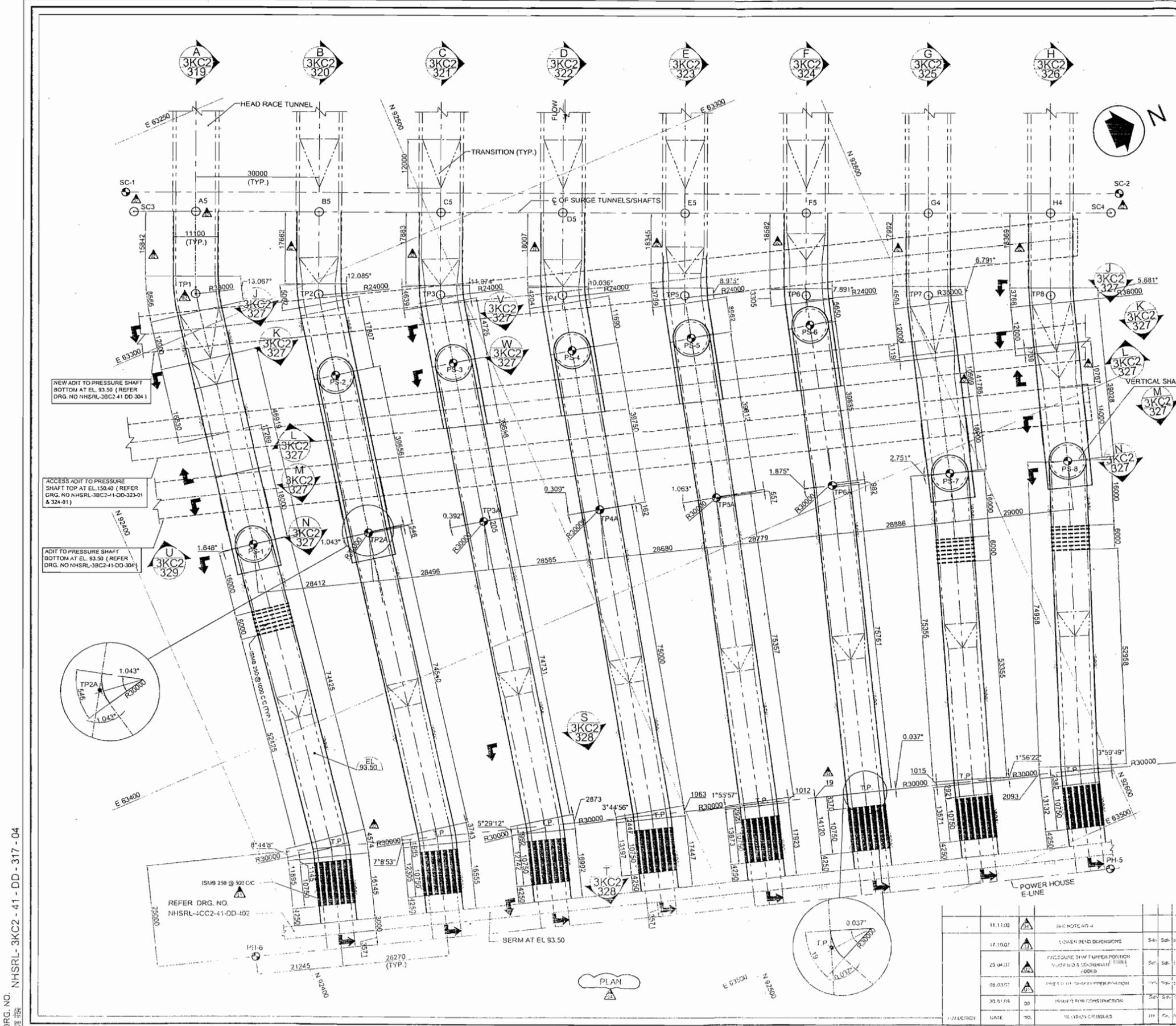
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SUBANSIRI LOWER HYDROELECTRIC PROJECT

**INTAKE & HEADRACE TUNNEL-1
SETTING OUT
LONGITUDINAL SECTION**

08.06.15	00	ISSUED FOR TENDER																	
DATE	NO.	REVISION OR ISSUES	BY.	CH.	APP.	DATE	DRG. NO.	NHSRL-3CT6-41-GA-007		00									



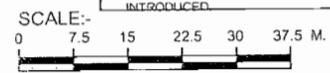
COORDINATES		
POINTS	NORTHING	EASTING
SC1	92434.218	63261.766
SC2	92658.102	63358.782
SC3	92434.140	63266.964
SC4	92654.377	63362.335
A5	92447.909	63272.927
B5	92475.439	63284.848
C5	92502.968	63296.769
D5	92530.498	63308.691
E5	92558.028	63320.612
F5	92585.557	63332.533
G4	92613.087	63344.455
H4	92640.616	63356.376
TP1	92439.879	63291.456
TP2	92467.405	63303.385
TP3	92494.931	63315.314
TP4	92522.458	63327.243
TP5	92549.984	63339.173
TP6	92577.510	63351.102
TP7	92605.036	63363.031
TP8	92632.562	63374.961
PS-1	92428.497	63353.695
PS-2	92483.402	63323.334
PS-3	92491.280	63331.983
PS-4	92519.261	63340.666
PS-5	92547.351	63349.384
PS-6	92575.553	63358.140
PS-7	92592.424	63405.230
PS-8	92620.089	63413.927
PH-5	92589.593	63510.024
PH-6	92389.107	63446.996
TP2A	92455.600	63362.215
TP3A	92482.784	63370.761
TP4A	92510.053	63379.334
TP5A	92537.413	63387.935
TP6A	92564.868	63396.566

REFERENCE DRGS :

Sr. No.	DESCRIPTION	DRAWING NO.
1	PRESSURE SHAFT - EXCAVATION SECTIONS	NHSRL-3KC2-41-DD-318 (SUPERCEDED)
2	PRESSURE SHAFT - EXCAVATION LONGITUDINAL SECTIONS THROUGH PS-1 TO PS-8	NHSRL-3KC2-41-DD-319 TO 326 (SUPERCEDED)
3	PRESSURE SHAFT - EXCAVATION CROSS SECTIONS	NHSRL-3KC2-41-DD-327 TO 329
4	ADIT PRESSURE SHAFT - LAYOUT PLAN & SECTIONS	NHSRL-3BC2-41-DD-304
5	ACCESS ADIT NETWORK TO PRESSURE SHAFT TOP & HWT. SETTING OUT PLAN & SECTIONS	NHSRL-3BC2-41-DD-323 & 324
6	POWER HOUSE - SETTING OUT PLAN	NHSRL-4CC2-41-DD-401
7	POWER HOUSE - EXCAVATION PLAN	NHSRL-4CC2-41-DD-402

NOTES :

- ALL DIMENSIONS ARE IN MILLIMETRE AND LEVELS IN METRE.
- FOR COORDINATES OF CONTROL POINTS REFER DRG. NO. NHSRL-4CC2-41-DD-401.
- ALL EXCAVATION SHALL BE DONE AS PER T.S. 3.8. THE EXCAVATION SEQUENCE CLEARLY INDICATING THE LINE, LEVELS AND SEQUENCE NO. OF THE EXCAVATION METHODOLOGY SHALL BE APPROVED BY THE ENGINEER-IN-CHARGE.
- LOCATION OF PRESSURE SHAFT VERTICAL AND CURVATURE IN UPPER HORIZONTAL PRESSURE SHAFT IN 2.3,4,5,6 MODIFIED. ACCESS ADIT AT ELEVATION 93.5 M & HORIZONTAL BEND IN LOWER PRESSURE SHAFT INTRODUCED.



DRG. NO. NHSRL-3KC2-41-DD-317-04

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SUBANSIRI LOWER HYDROELECTRIC PROJECT

PRESSURE SHAFTS
EXCAVATION (SHEET 1 OF 12)
PLAN

DRAWN BY	DESIGNED BY	RECOMMENDED BY	APPROVED BY
DATE	DRG. NO.	NHSRL-3KC2-41-DD-317-04	

JAN. 2006

REFERENCE DRGS :

Sr. NO.	DESCRIPTION	DRAWING NO.
1	PRESURE SHAFT - EXCAVATION PLAN	NHSRL-3KC2-41-DD-317
2	PRESURE SHAFT - EXCAVATION LONGITUDINAL SECTIONS	NHSRL-3KC2-41-DD-320 TO 326
3	PRESURE SHAFT - EXCAVATION CROSS SECTIONS	NHSRL-3KC2-41-DD-327 TO 329
4	ADIT PRESSURE SHAFT - LAYOUT PLAN & SECTIONS	NHSRL-3BC2-41-DD-304
5	ACCESS ADIT NETWORK TO PRESSURE SHAFT TOP & HRT - LAYOUT PLAN & SECTIONS	NHSRL-3BC2-41-DD-323 & 324
6	POWER HOUSE - SETTING OUT PLAN	NHSRL-4CC2-41-DD-401
7	POWER HOUSE - EXCAVATION PLAN	NHSRL-4CC2-41-DD-402
8	POWER HOUSE - MODIFIED EXCAVATION PLAN	NHSRL-4CC2-41-DD-101
9	POWER HOUSE - DRG. NO.	NHSRL-4CC2-41-DD-101 TO 107

NOTES :

- ALL DIMENSIONS ARE IN MILLIMETRE AND LEVELS IN METRE.
- FOR COORDINATES OF CONTROL POINTS REFER DRG. NO. NHSRL-4CC2-41-DD-401.
- ALL EXCAVATION SHALL BE DONE AS PER T.S. 3.8. THE EXCAVATION SEQUENCE CLEARLY INDICATING THE LINE, LEVELS AND SEQUENCE NO. OF THE EXCAVATION METHODOLOGY SHALL BE APPROVED BY THE ENGINEER-IN-CHARGE.
- 50 mm THK. SHOTCRETE SHALL BE APPLIED IMMEDIATELY ON THE EXCAVATED SURFACE AFTER SCALING. SUSEQUENT SHOTCRETE / ROCK ANCHORS SHALL BE PROVIDED AFTER REMOVAL OF MUCK.
- THE EXCAVATED SURFACE SHALL BE SUPPORTED WITH SHOTCRETE WITH WIREMESH AND ROCK ANCHORS IN EACH ROUND BEFORE FURTHER EXCAVATION.
- SHEAR ZONE/FRACTURE ZONE, WHEN ENCOUNTERED DURING EXCAVATION, SHALL BE TAKEN CARE BY ADDITIONAL MEASURES I.E. CONSOLIDATION GROUTING, CLOSER SPACING OF ANCHORS/BOLTS, HIGHER THK OF SHOTCRETE, TWO OR MORE LAYERS OF WIREMESH AND STEEL RIBS. SUCH ZONES SHALL BE BROUGHT TO THE ATTENTION OF PROJECT GEOLOGY TEAM AND DESIGN GROUP AND SHALL REQUIRE CLOSER SUPERVISION.
- LOCATION OF VERTICAL SHAFT, CURVATURE & UPPER TRANSITION MODIFIED. ACCESS ADIT AT EL 93.5M & HORIZONTAL BEND IN LOWER PRESSURE SHAFT INTRODUCED. ALL TYPES OF BENDS IN UPPER HORIZONTAL PORTION IS FOR H.M. WORKS ONLY.

SCALE:-



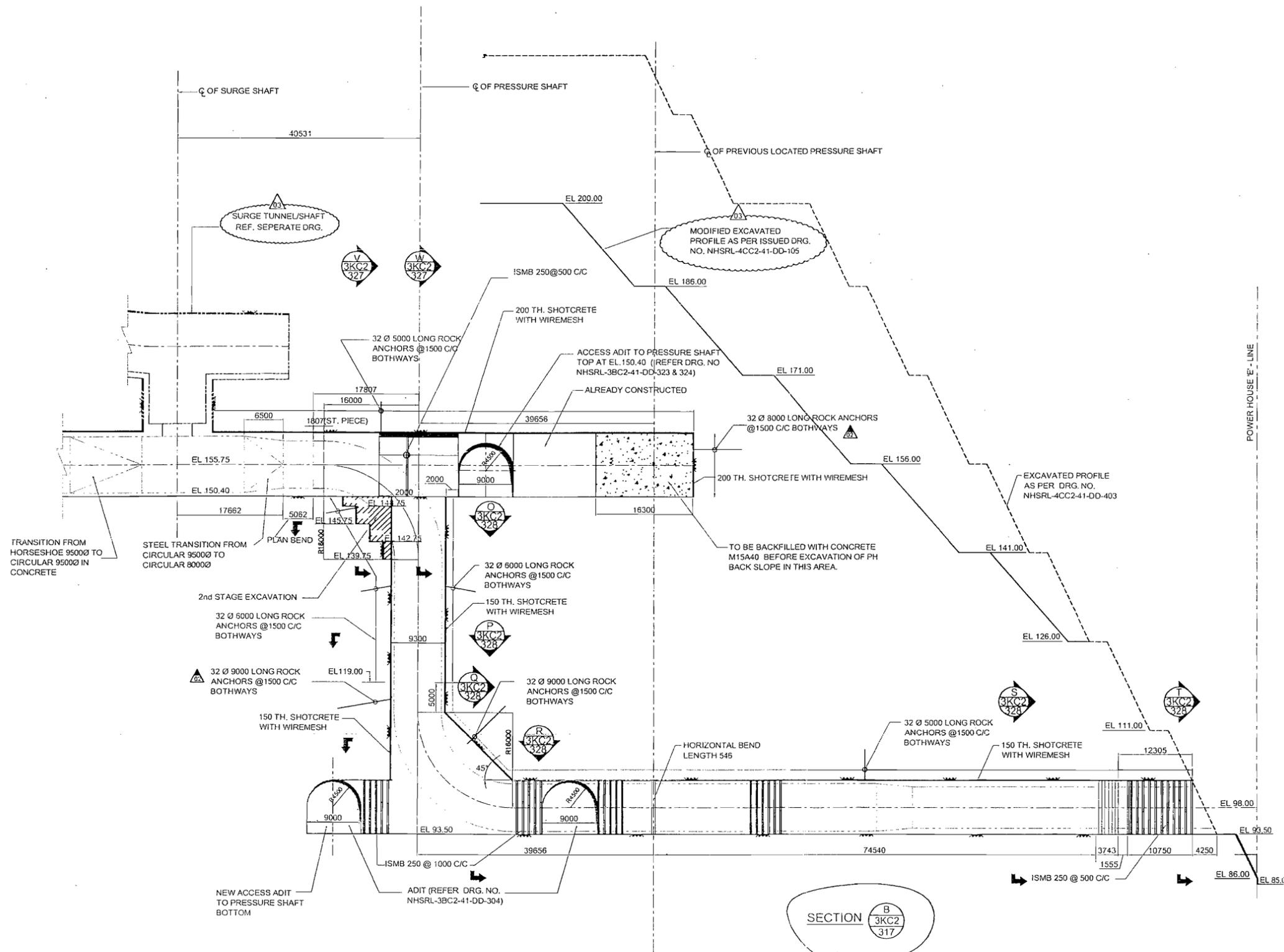
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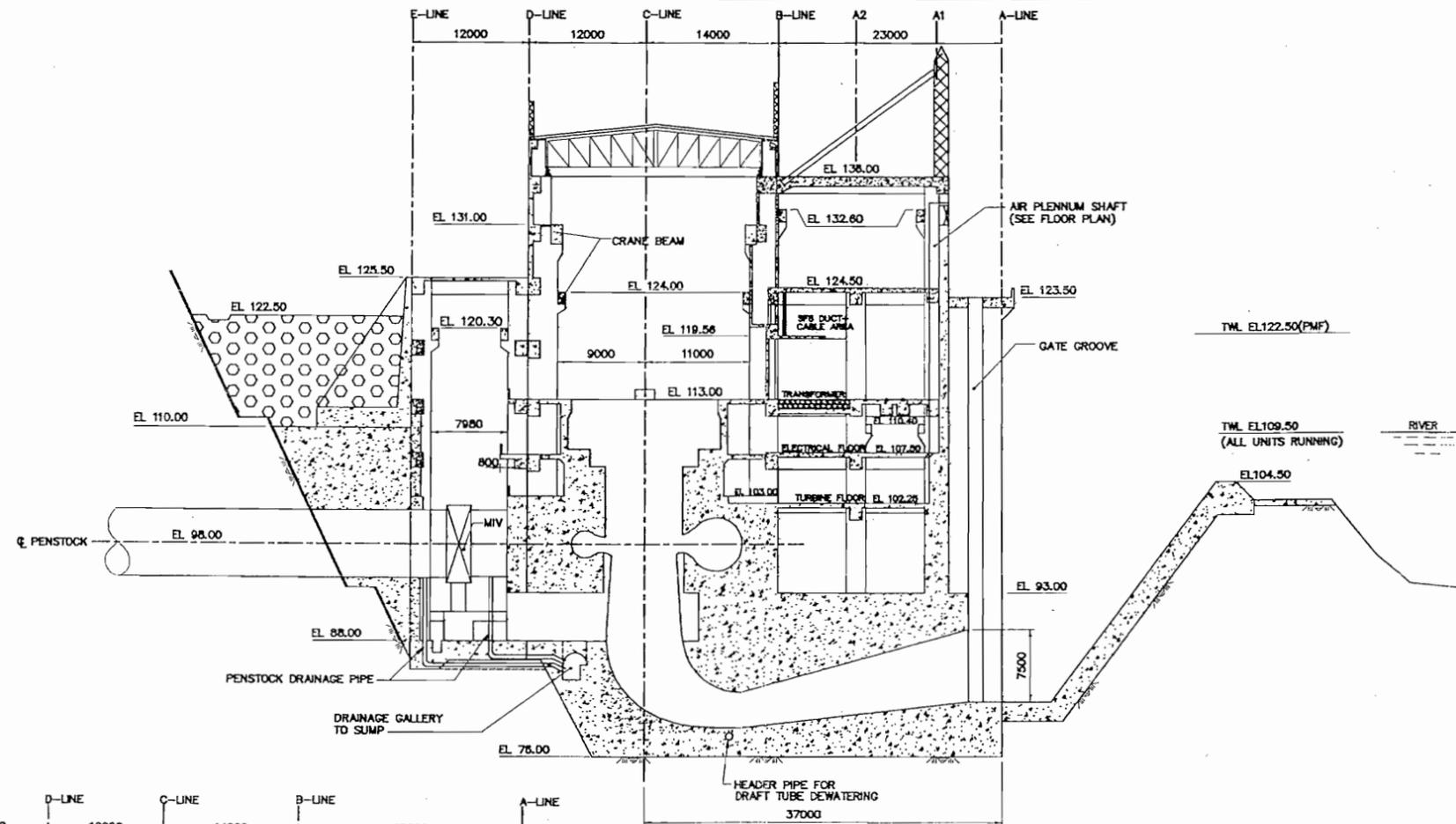
PRESSURE SHAFTS
EXCAVATION (SHEET 3 OF 12)
LONGITUDINAL SECTION THROUGH PRESSURE SHAFT-2

DRAWN	SUBMITTED	RECOMMENDED	APPROVED
श्रीमती मोहनश्री	प्रमोद	अनुराजिस C JOSHI	अनुमोलिन S.C. MITAL
DATE	DRG. NO.	APPROVED	
MARCH 2007	NHSRL 3KC2 41 DD 320 03		

H.M. DESIGN	DATE	NO.	REVISION OR ISSUES	BY	CHK	APP
	11.11.06	03	SEE NOTE NO-7			
	17.10.07	02	ROCK SUPPORT MODIFIED	SUB	SUB	SUB
	25.04.07	01	PRESSURE SHAFT UPPER PORTION MODIFIED	SUB	SUB	SUB
	08.03.07	00	ISSUED FOR CONSTRUCTION	SUB	SUB	SUB

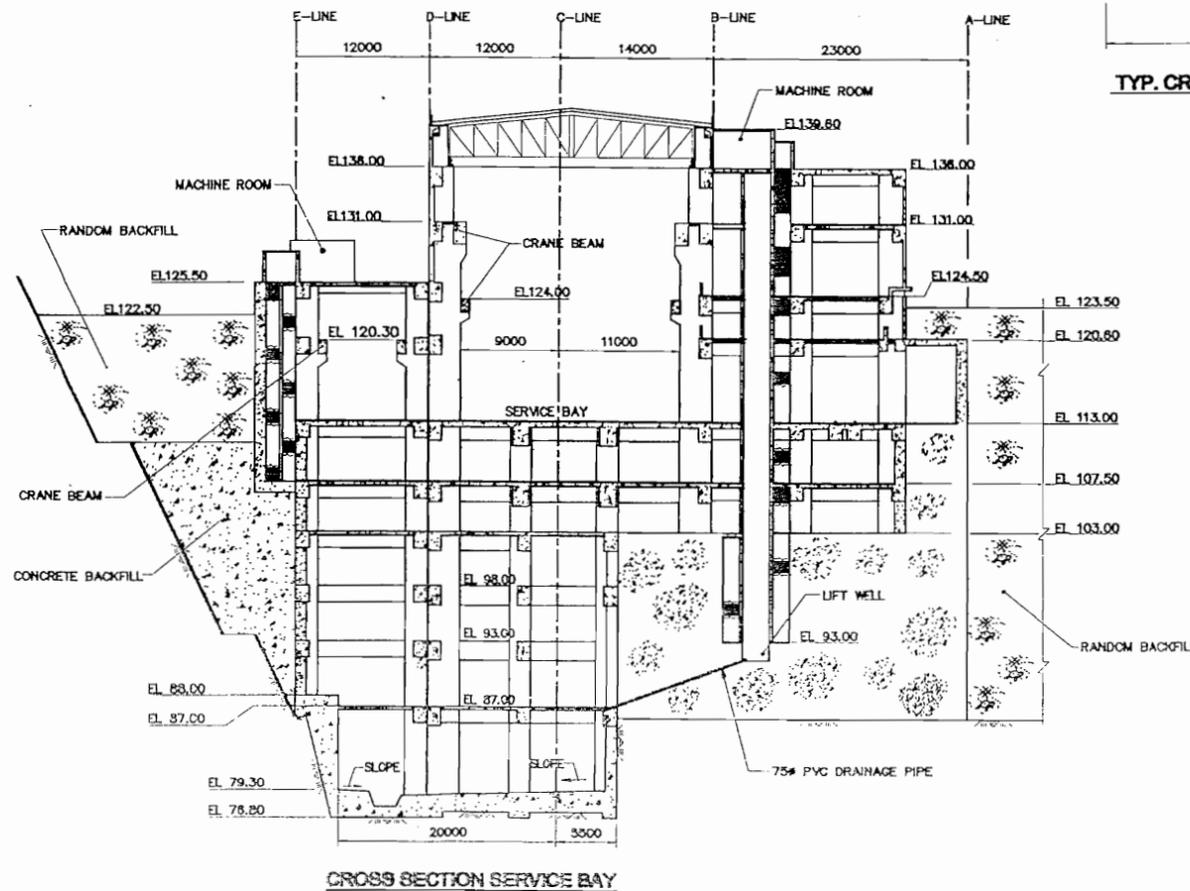


DRG. NO. NHSRL-3KC2-41-DD-320-03

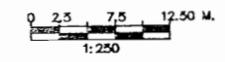


TYP. CROSS SECTION UNIT CENTER LINE

NOTES
1 ALL DIMENSIONS ARE IN MILLIMETRE AND ELEVATIONS IN METRE.



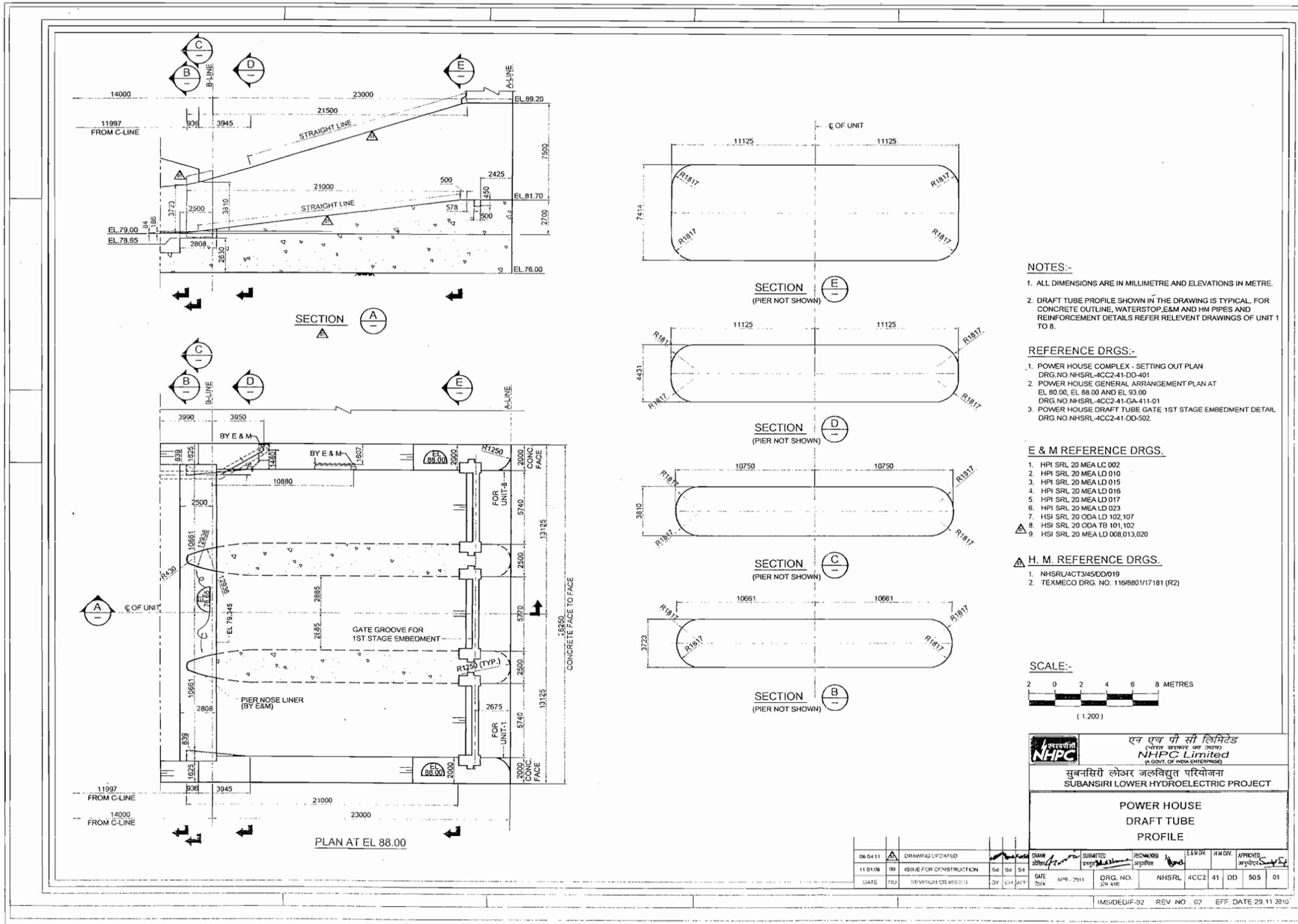
CROSS SECTION SERVICE BAY



नेशनल हाइड्रोइलेक्ट्रिक पावर कारपोरेशन लि. NATIONAL HYDROELECTRIC POWER CORPORATION LTD.	
सुबानसिरी लोअर जलविद्युत परियोजना SUBANSIRI LOWER HYDROELECTRIC PROJECT	
POWER HOUSE GENERAL ARRANGEMENT CROSS-SECTIONS	
27.07.06 01 BRACKETS SIZE AND BEAM AT D-LINE EL 119.00 MODIFIED.	02.02.06 00 ISSUED FOR CONSTRUCTION
Sd/- U.K. GAIK	Sd/- B. BISHAS
Sd/- S.C. JOSHI	Sd/- Y.K. CHALBEY
DATE OCT 2005	DRG. NO. NHSRL-4CC2-41-GA-418
BY CH. APP.	01

DRG. NO. NHSRL-4CC2-41-GA-418-01

DATE	NO.	REVISION OR ISSUES	BY	CH. APP.



NOTES:-

1. ALL DIMENSIONS ARE IN MILLIMETRE AND ELEVATIONS IN METRE.
2. DRAFT TUBE PROFILE SHOWN IN THE DRAWING IS TYPICAL. FOR CONCRETE OUTLINE, WATERSTOP, E&M AND HM PIPES AND REINFORCEMENT DETAILS REFER RELEVANT DRAWINGS OF UNIT 1 TO 8.

REFERENCE DRGS:-

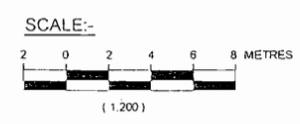
1. POWER HOUSE COMPLEX - SETTING OUT PLAN DRG. NO. NHSRL-4CC2-41-DD-401
2. POWER HOUSE GENERAL ARRANGEMENT PLAN AT EL. 80.00, EL. 88.00 AND EL. 93.00 DRG. NO. NHSRL-4CC2-41-GA-411-01
3. POWER HOUSE DRAFT TUBE GATE 1ST STAGE EMBEDMENT DETAIL DRG. NO. NHSRL-4CC2-41-DD-502

E & M REFERENCE DRGS.

1. HPI SRL 20 MEA LC 002
2. HPI SRL 20 MEA LD 010
3. HPI SRL 20 MEA LD 015
4. HPI SRL 20 MEA LD 016
5. HPI SRL 20 MEA LD 017
6. HPI SRL 20 MEA LD 023
7. HSI SRL 20 ODA LD 102, 107
8. HSI SRL 20 ODA TB 101, 102
9. HSI SRL 20 MEA LD 008, 013, 020

H. M. REFERENCE DRGS.

1. NHSRL/ACT/345/00/019
2. TEXMECO DRG. NO. 116/880/1/17181 (R2)



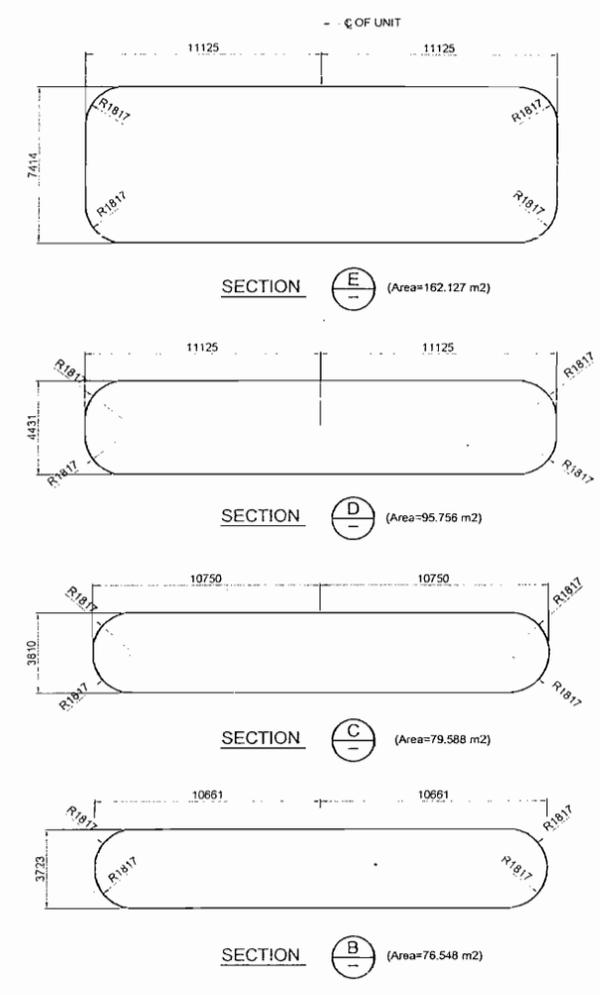
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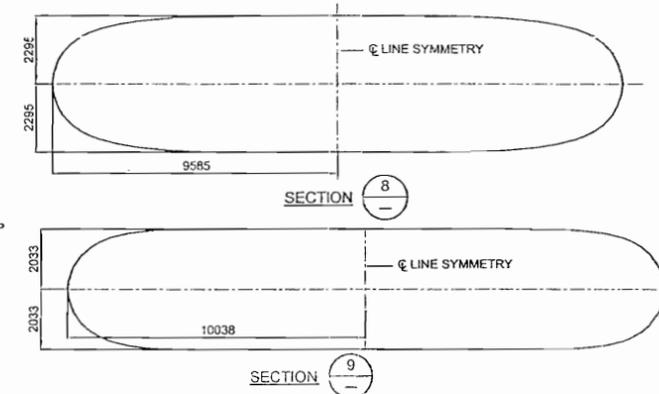
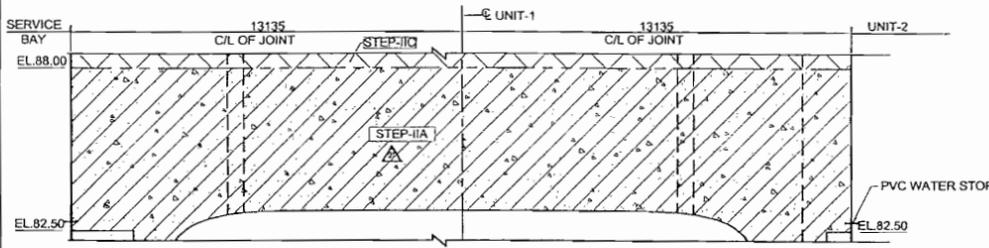
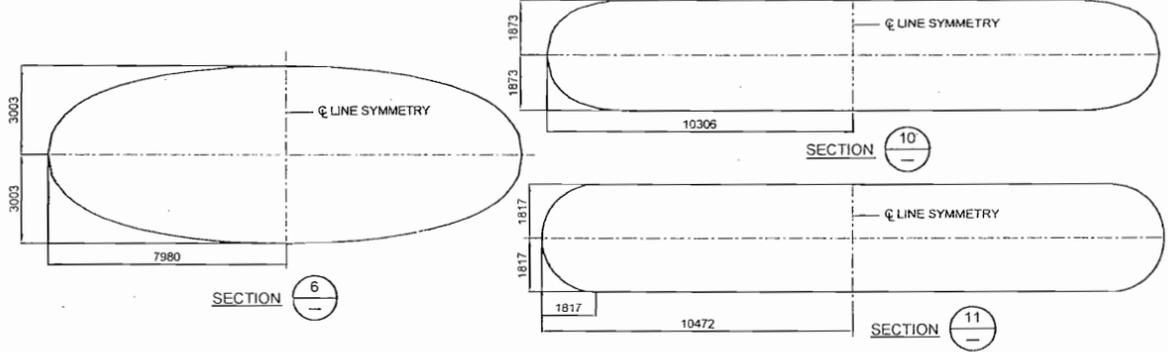
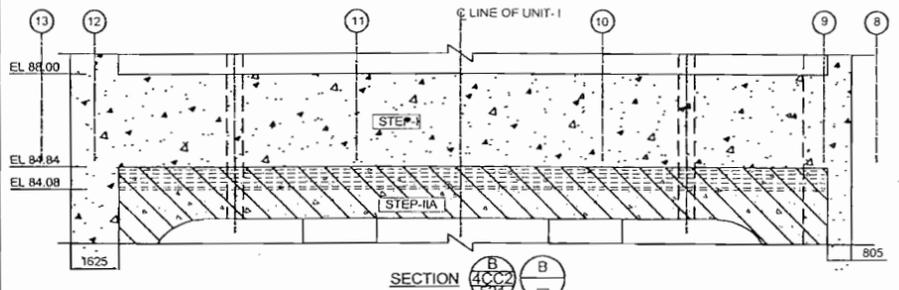
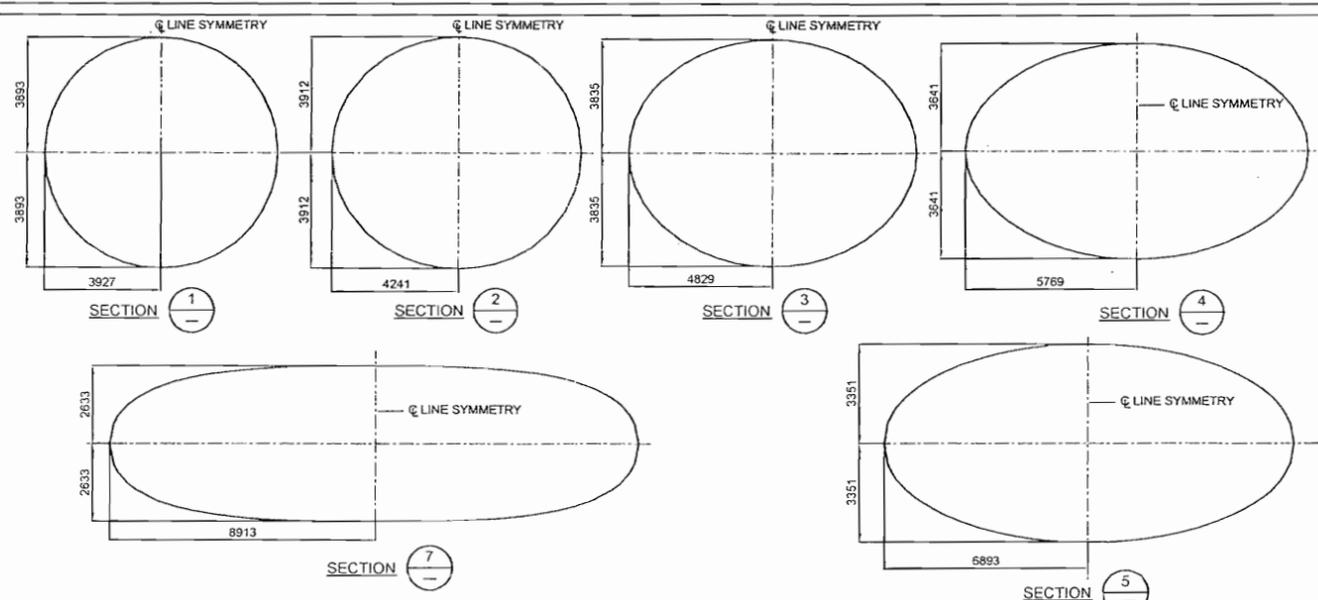
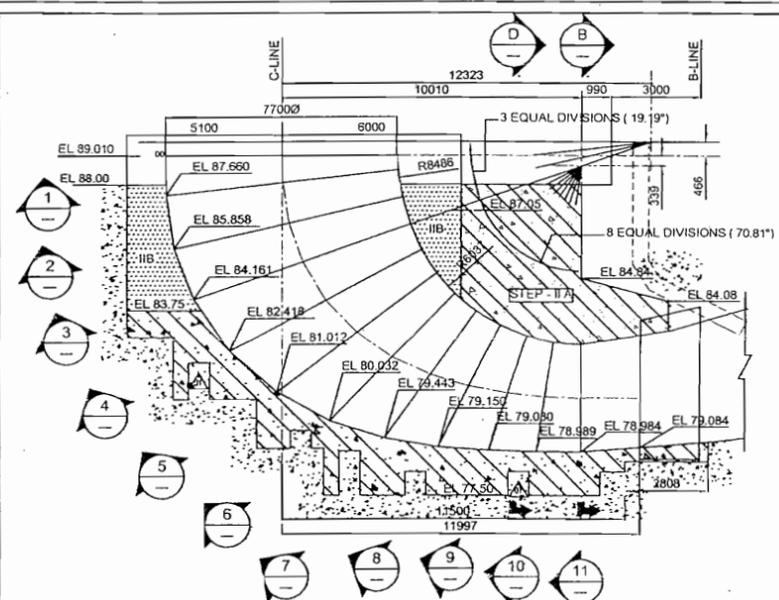
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SUBANSIRI LOWER HYDROELECTRIC PROJECT

**POWER HOUSE
 DRAFT TUBE
 PROFILE**

06/04/11	Δ	DRAWING UPDATED										
11/01/08	00	ISSUE FOR CONSTRUCTION	SA	SA	SA							
DATE	REV	REVISION OR DESCRIPTION	BY	CHK	APP	DATE	DRG. NO.	NHSRL	4CC2	41	DD	505_01

HMS/DEG/IF-02 REV NO. 02 EFF. DATE 29.11.2010





NOTES:-
 1. ALL DIMENSIONS ARE IN MILLIMETRE AND LEVELS IN METRE
 2. FOR OTHER NOTES REFER DRG. NO. NHSRL-4CC2-41-DD-521

SCALE:-
 1.5 0 1.5 3.0 4.5 6 METRES
 (1:150)

NHPC Limited
 (A GOVT. OF INDIA ENTERPRISE)

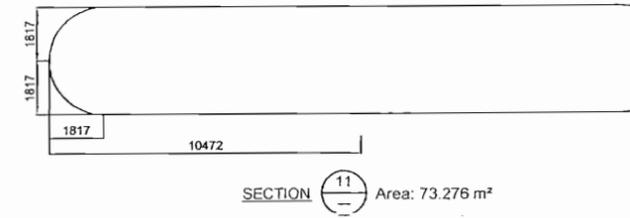
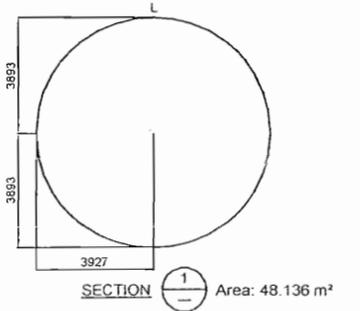
सुबनसिरी लोअर जलविद्युत परियोजना
SUBANSIRI LOWER HYDROELECTRIC PROJECT

POWER HOUSE - UNIT-1(B TO D - LINE)
STEP - II CONCRETE - DRAFT TUBE
CONCRETE DETAILS-SECTIONS

SHEET 2 OF 2

27.04.10	DRG. NO. UPDATED & SECTION - D ADDED	Sd.	DRG.	SUBMITTED	RECOMMENDED	APPROVED
08.03.10	ISSUE FOR CONSTRUCTION	Sd.	Sd.	Sd.	Sd.	Sd.
DATE	NO	BY	CHK	APP	DATE	DRG. NO.
					APR - 2010	NHSRL 4CC2 41 DD 522 01

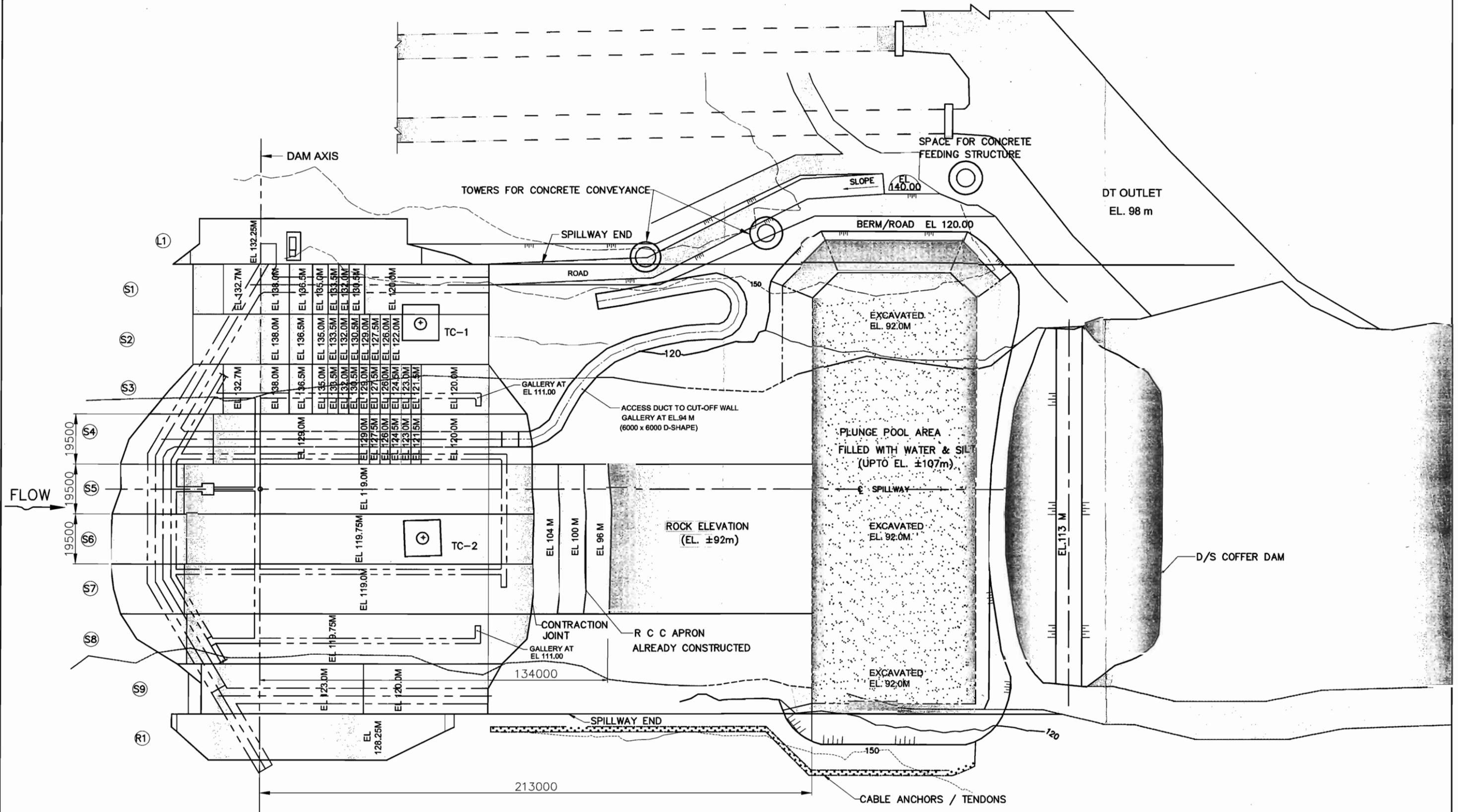
IMS/DED/F-02 REV. NO. 00 EFF DATE 16.06.2010



DDRP DRAWINGS

SUBANSIRI LOWER HYDROELECTRIC PROJECT CONCRETE DAM & ASSOCIATED STRUCTURES

DAM DESIGN REVIEW PANEL

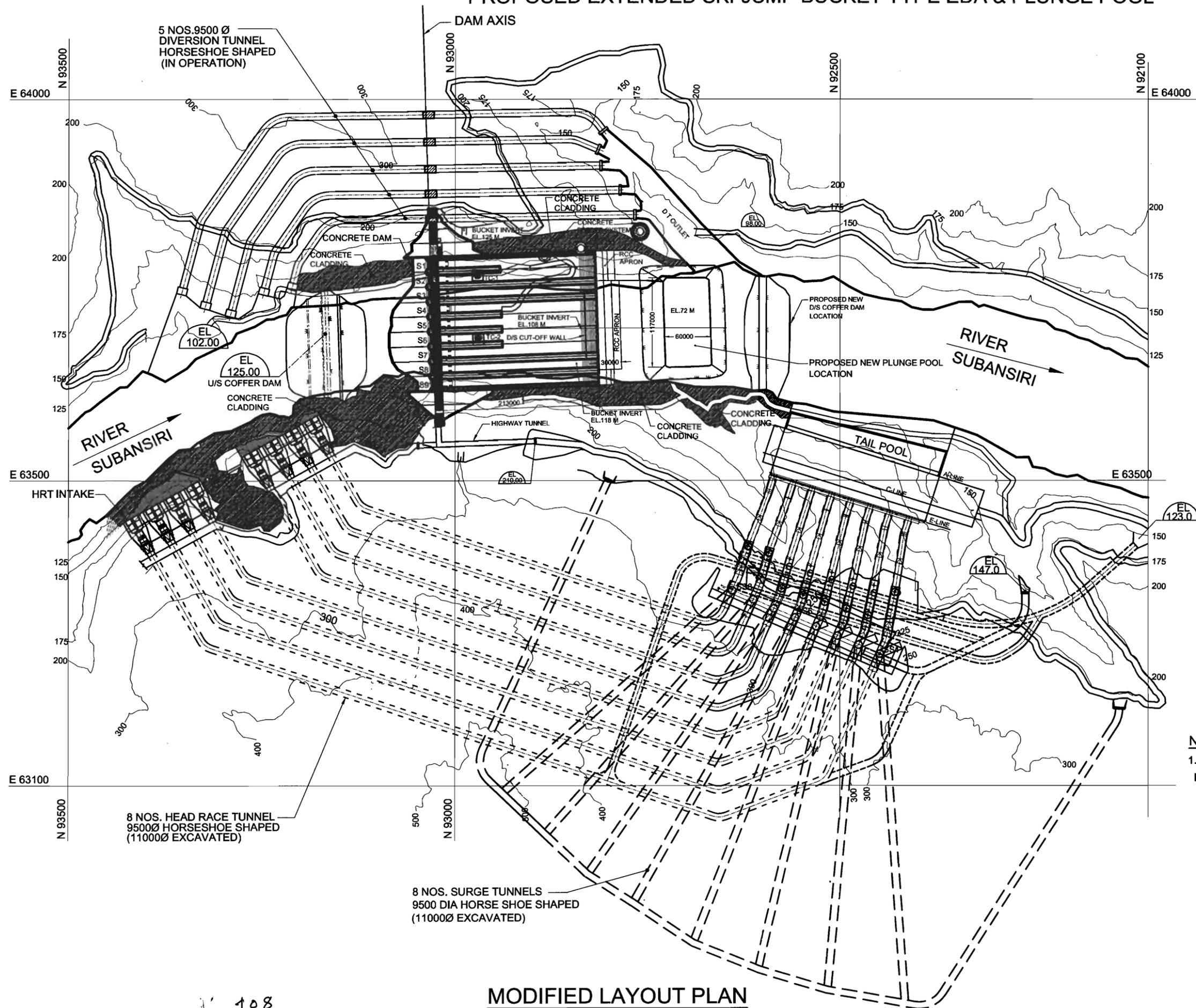


PLAN SHOWING CONCRETING STATUS

FIG. 2

SUBANSIRI LOWER HYDROELECTRIC PROJECT

PROPOSED EXTENDED SKI-JUMP BUCKET TYPE EDA & PLUNGE POOL

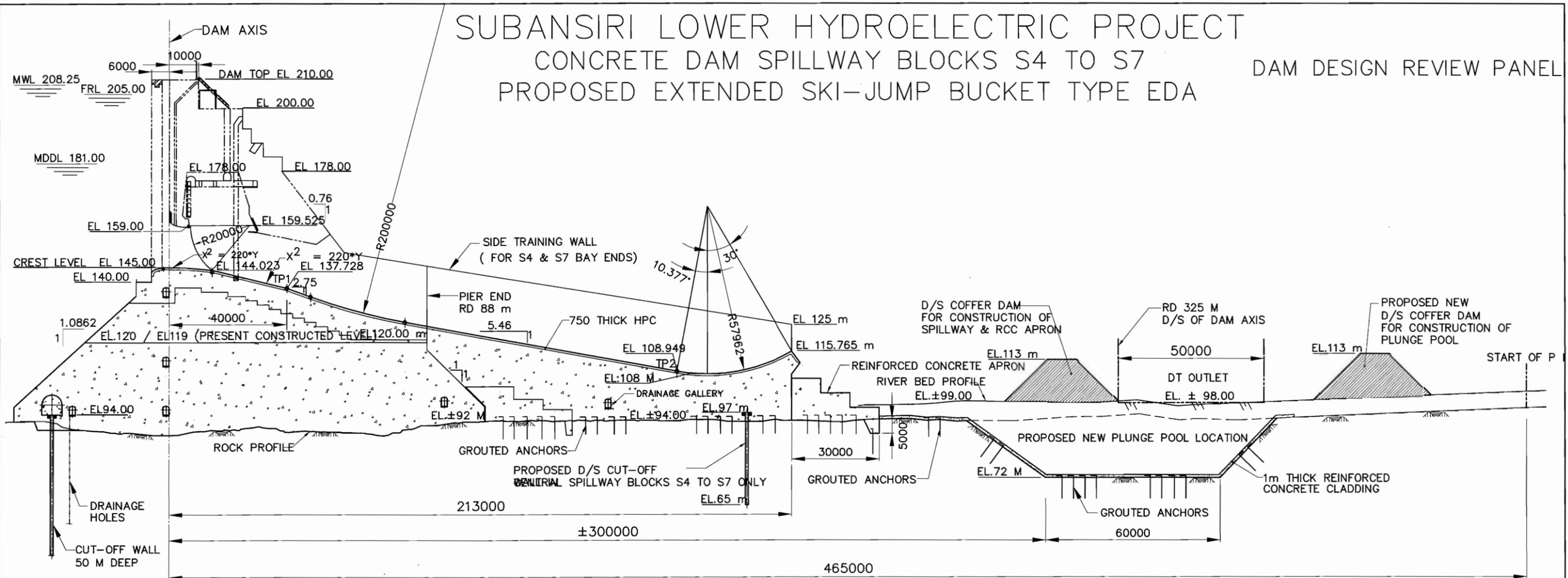


NOTE-
1. ALL DIMENSIONS ARE IN MILLIMETRE, GRID VALUES AND ELEVATIONS IN METRE.

MODIFIED LAYOUT PLAN

SUBANSIRI LOWER HYDROELECTRIC PROJECT
 CONCRETE DAM SPILLWAY BLOCKS S4 TO S7
 PROPOSED EXTENDED SKI-JUMP BUCKET TYPE EDA

DAM DESIGN REVIEW PANEL



TYPICAL PROFILE FOR S4,S5,S6 & S7 BLOCKS

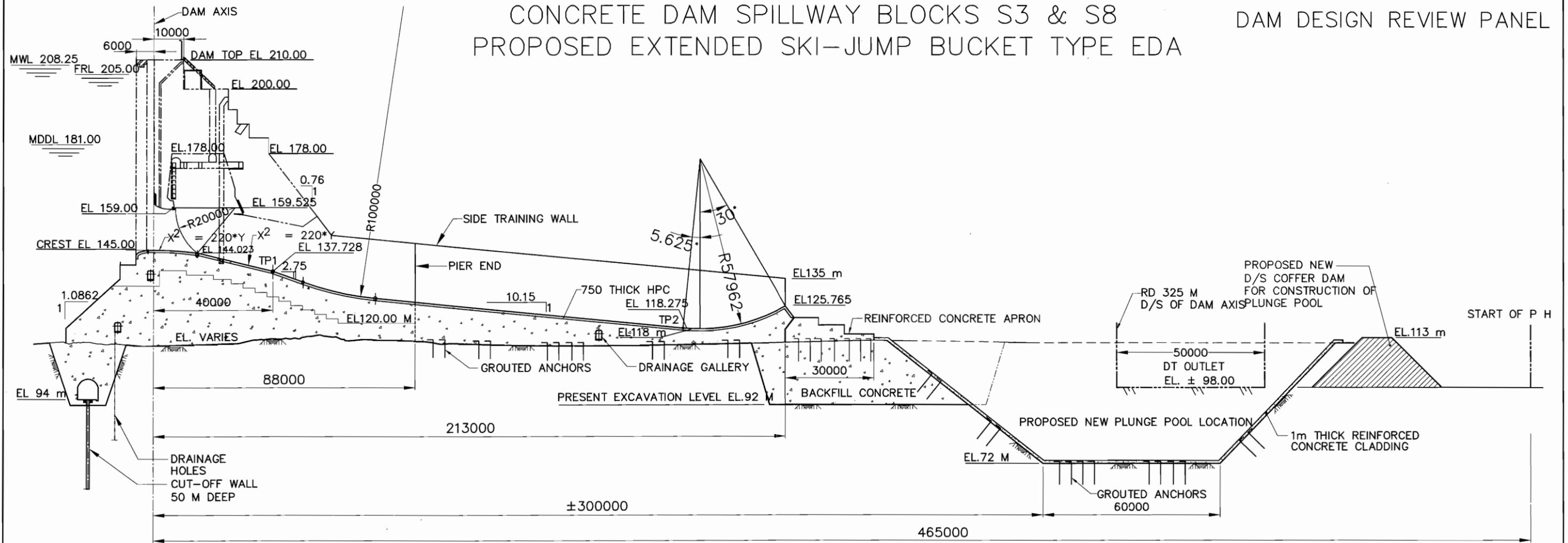
NOTE :

- 1.The above spillway glacis profile & aeration arrangement shall be firmed up by CWPRS,Pune by hydraulic model studies.
- 2.Location & dimension of Plunge pool shall be confirmed by CWPRS,Pune by hydraulic model studies.

FIG. 4

SUBANSIRI LOWER HYDROELECTRIC PROJECT
 CONCRETE DAM SPILLWAY BLOCKS S3 & S8
 PROPOSED EXTENDED SKI-JUMP BUCKET TYPE EDA

DAM DESIGN REVIEW PANEL



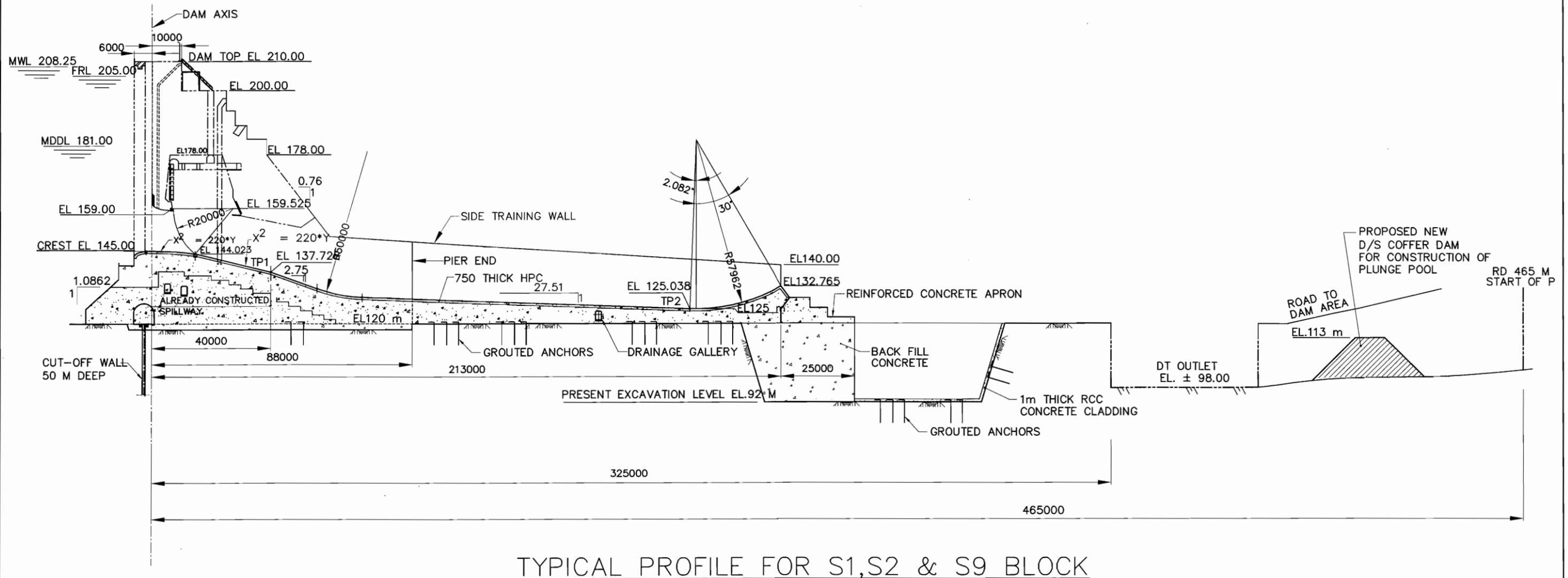
TYPICAL PROFILE FOR S3 & S8 BLOCK

NOTE :

- 1.The above spillway glacis profile & aeration arrangement shall be firmed up by CWPRS,Pune by hydraulic model studies.
- 2.Location & dimension of Plunge pool shall be confirmed by CWPRS,Pune by hydraulic model studies.

FIG. 5

SUBANSIRI LOWER HYDROELECTRIC PROJECT DAM DESIGN REVIEW PANEL
 CONCRETE DAM SPILLWAY BLOCKS S1,S2&S9
 PROPOSED EXTENDED SKI-JUMP BUCKET TYPE EDA



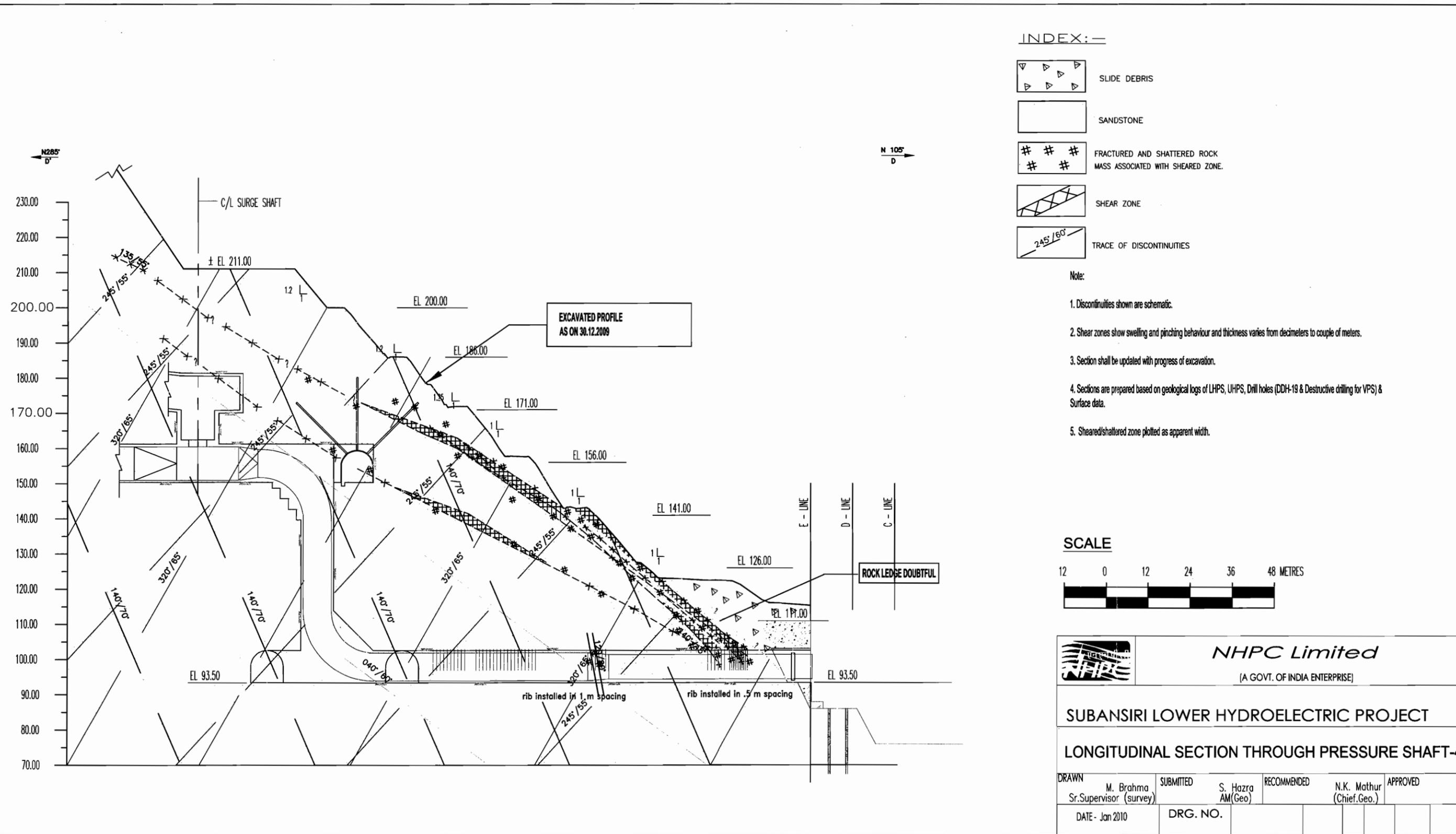
TYPICAL PROFILE FOR S1,S2 & S9 BLOCK

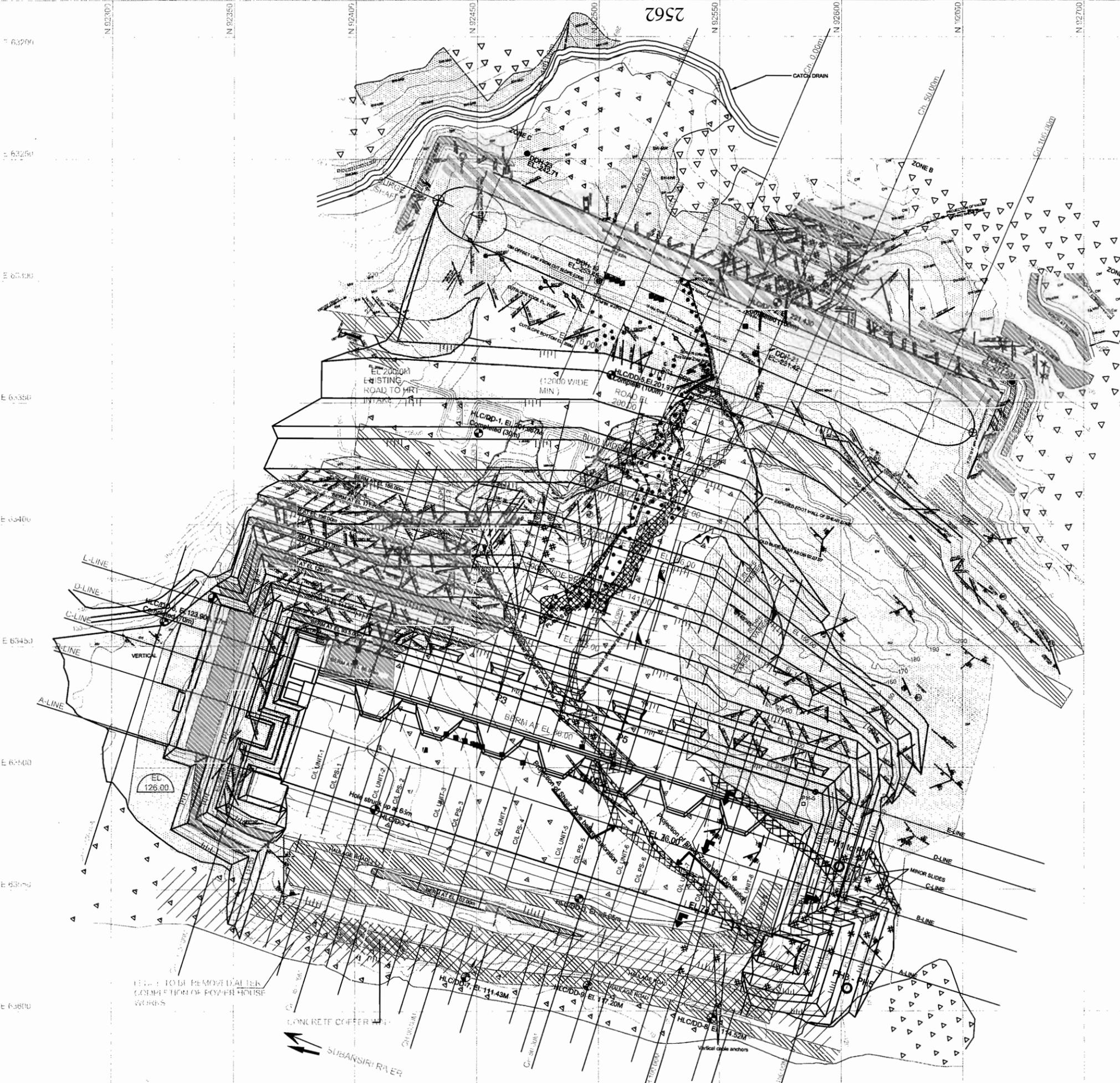
NOTE :

1.The above spillway glaxis profile & aeration arrangement shall be firmed up by CWPRS,Pune by hydraulic model studies.

FIG. 6

UPDATED GEOLOGICAL PLAN AND SECTIONS
OF POWER HOUSE AREA





- INDEX:**
- SLIDE DEBRIS
 - EXCAVATED MUCK
 - SLOPE WASH MATERIAL
 - COMPLETELY WEATHERED ROCK
 - MODERATELY TO HIGHLY WEATHERED ROCK
 - SLIGHTLY TO MODERATELY WEATHERED ROCK
 - SANDSTONE (UNWEATHERED)
 - FRACTURED & WEATHERED ROCK MASS WITH ISLAND OF GOOD ROCK
 - SHEAR ZONE
 - SHEAR SEAM < 50CM
 - SHEAR SEAM < 10CM
 - SLIDE BOUNDARY
 - S1 PLANE DEFINING SLOPE GEOMETRY
 - S4 PLANE DEFINING SLOPE GEOMETRY
 - RANDOM PLANE DEFINING SLOPE GEOMETRY
 - TRACE OF DISCONTINUITY WITH DIP DIRECTION & DIP AMOUNT
 - ATTITUDE OF DISCONTINUITIES
 - OPEN JOINTS
 - CRACKS IN SHOTCRETE
 - BENCH
 - MPBX / LOAD CELL / SURVEY TARGET
 - COMPLETED PLT
 - COMPLETED DST
 - DRILL HOLE (Completed)
 - DRILL HOLE (VERTICAL)
 - INCLINED DRILL HOLE (App. 70°)
 - UNDISTURBED SAMPLE COLLECTION

GEOTECHNICAL CHARACTERISTIC OF JOINTS BASED ON LOG

Joint No.	Orientation	Spacing	Persistence	Roughness	Aperture/Filling
S-1	140°-165° 70°-75°	Moderately to widely spaced (5-200cm)	Medium to High (5-12m)	Rough planar (Block-in-block)	Tight to partly open (1.5cm) occasional clay
S-2	210°-240° 40°-50°	Very widely spaced (>200cm)	Low to Medium	Rough planar (Block-in-block)	Tight to partly open (1.5cm) Fe stain with occasional clay
S-3	310°-330° 60°-75°	Moderately to widely spaced (5-200cm)	Low to Medium (2-9m)	Rough planar	Tight to partly open (1.5cm) Fe stain with occasional clay
S-4	225°-240° 60°-70°	Widely spaced (150-200cm)	Medium (3-7m)	Rough planar	Tight to partly open (1.5cm) Fe stain with occasional clay

Note: There are two major shear zone (valley dipping and hill dipping) in the area. Disposition of valley dipping shear zones at different levels has been shown as per excavation / projection on cut slope

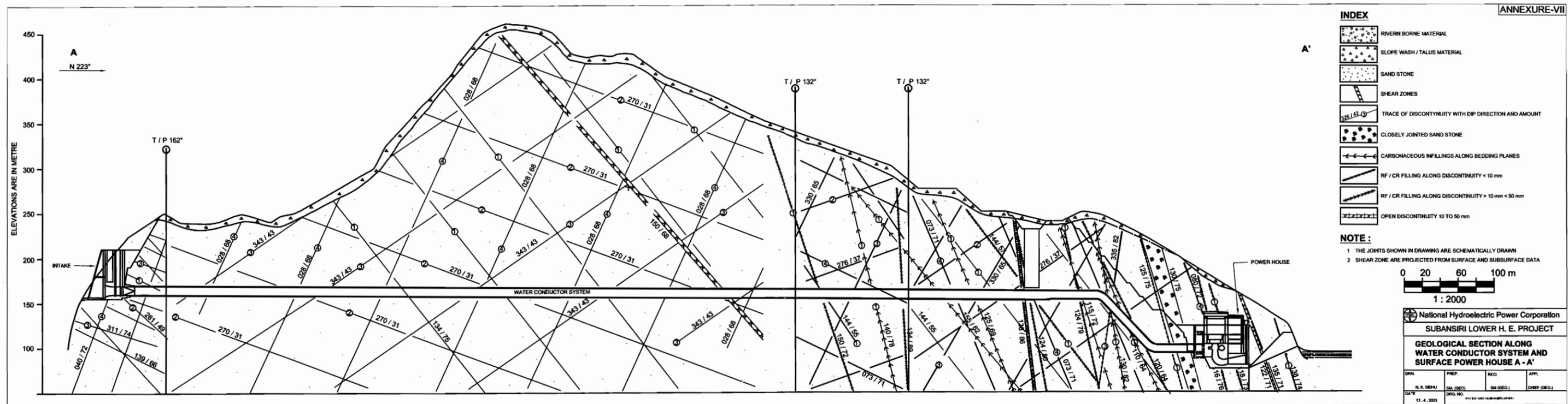


NHPC एन एच पी सी लिमिटेड
NHPC Limited
(A GOVT. OF INDIA ENTERPRISE)

SUBANSIRI LOWER HYDROELECTRIC PROJECT

UPDATED GEOLOGICAL PLAN OF POWER HOUSE AND SURGE CHAMBER AREA

DATE	20.06.2009	DRG. NO.	DRG. NO./NHSLP/GEOP/H04
SCALE	AS SHOWN	APPROVED	AS SHOWN



117

SUBANSIRI LOWER H E PROJECT

HM DPR DRAWINGS			
S.No.	DESCRIPTION	DRAWING NO.	REFERENCE
1	GENERAL ARRANGEMENT SPILLWAY RADIAL GATE	NHSB-2DA2-45-GA-02	Submitted by NHPC vide letter dated 14.07.2016 (referred in Gates Dte,CWC letter dated 29.08.2016)
2	PRESSURE SHAFT PLAN AND SECTIONS	NHSB-2KA2-45-GA-03	

LIST OF ISSUED CONSTRUCTION DRAWINGS

HM DRAWINGS			
1	SPILLWAY RADIAL GATE,BULKHEAD GATE AND GANTRY CRANE GENERAL ARRANGEMENT	NHSRL-2DT3-45-GA-001-01	Submitted by NHPC vide its letter dated 25.08.17 (referred in CWC letter no 27/04/2009/GD(NW& S)/244-245 dated 31.08.17)
	SCHEMATIC ARRANGEMENT OF ROPE DRUM HOIST OF DRAFT TUBE GATE		
2	PRESSURE SHAFT LINER GA FOR PS 1	NHSRL-3KC3-45-GA-001-02	Submitted by NHPC vide its letter dated 06.10.2015 (referred in CWC letter no 26/33/2015-HCD (NW&S)/1119-20 dated 03.08.16)
3	PRESSURE SHAFT LINER GA & DETAIL FOR LANE PS 2	NHSRL-3KC3-45-GA-002-03	
4	PRESSURE SHAFT LINER GA & DETAIL OF PENSTOCK FOR PS 3	NHSRL-3KC3-45-GA-003-03	
5	PRESSURE SHAFT LINER GA & DETAIL OF PENSTOCK FOR PS 4	NHSRL-3KC3-45-GA-004-03	
6	PRESSURE SHAFT LINER GA & DETAIL OF PENSTOCK FOR PS 5	NHSRL-3KC3-45-GA-005-03	
7	PRESSURE SHAFT LINER GA & DETAIL OF PENSTOCK FOR PS 6	NHSRL-3KC3-45-GA-006-03	
8	PRESSURE SHAFT LINER GENERAL ARRANGEMENT FOR PS 7	NHSRL-3KC3-45-GA-007-02	
9	PRESSURE SHAFT LINER GENERAL ARRANGEMENT FOR PS 8	NHSRL-3KC3-45-GA-008-02	

शुक्रवार, 27/04/2016 (कारक (न.प.म.व.)) / 2016
 भारत सरकार / Government of India
 केन्द्रीय जल आयोग / Central Water Commission
 गेट डिजाइन (न.प.म.व. व.) निदेशालय / Gates Design (NW&S) Directorate

सक्रिय-7, प्रथम तल, परिषदी बंगला-2
 रा. कृ. पुरम, नई दिल्ली-110066

दिनांक: 27/04/2016

To,
 Director-PAC Directorate,
 Central Electricity Authority,
 3rd Floor, Sewa Bhavan,
 R K Puram, New Delhi-110066

Sub : Subansiri Lower HEP Project(2000MW) In Arunachal Pradesh-Memorandum on design Changes In Hydro-Mechanical Components(with reference to DPR).

Ref : (i) Letter No. 27/4/09/GD(NW&S)/203-205 dated 26/4/2016
 (ii) Letter No. NH/PD/IP/SLP-RCE/101/1601 dated 14.07.16.

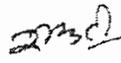
In reply to this office observations vide letter under reference (i) regarding "Memorandum on design changes for HM components of Subansiri Lower HEP", NHPC has submitted the compliance vide letter under reference (ii).

Project authorities stated that they have made the provision of 3 numbers of Gantry to handle the 3 draft tube gates simultaneously to isolate at least one generating unit to cater any emergent eventuality.

Compliance has been examined. Here, it is mentioned that the size of the Gantry crane shall be such that the smooth operation of three Gantry cranes simultaneously is ensured.

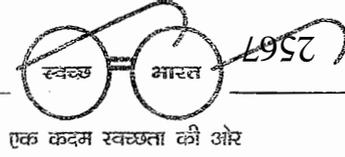
No further comment is being offered except the above suggestions as far as this directorate is concerned.

This issue with the approval of Chief Engineer, Designs (NW&S).


 (राहुल कुमार सिंह)
 (Rahul Kumar Singh)
 निदेशक /Director

Copy to:

- The Chief Engineer (Plg), NHPC Ltd, NHPC Office Complex, Sector-33, Faridabad, Haryana-121003
- Director-PA(N), CWC, Sewa Bhavan, R K Puram, New Delhi-110066



एन एच पी सी लिमिटेड
(भारत सरकार का उद्यम)

NHPC Limited

(A Government of India Enterprise)

फोन/Phone : _____

दिनांक/Date : 14.07.16

संदर्भ सं./Ref. No. NH/PD/IP/SLP-RCE/101/1601
Director,

Gates Design (NW & S) Directorate,
Central Water Commission,
Wing - 7, 1st Floor, West Block- 2,
R.K. Puram, New Delhi – 110066

**Sub: Subansiri Lower Hydro Electric Project (2000MW) in Arunachal Pradesh –
Memorandum of changes**

Sir,

This has reference to CWC's letter No. 27/4/09/ Gate (NW&S) / 203 dtd.26.04.2016 vide which CWC has raised the observation regarding Gate design (NW & S) CWC on Memorandum on Design changes in Hydro Mechanical components.

In this regard, the point wise clarification on the observations of Gate design (NW&S) directorate on Design changes in Hydro Mechanical components (with reference to DPR) is enclosed as **Annexure-A**. Further as desired by Gate design (NW&S) directorate, a copy of Memorandum of changes from DPR of Subansiri Lower HE project already submitted to CEA/CWC is enclosed as **Annexure-B**.

It is requested for perusal of same & convey the requisite clearances on the proposed memorandum of changes.

Thanking you,

Encl: As above

Yours faithfully,

(B.P.Rao) 14/7

Chief Engineer (Plg.)

Copy to:

1. **Director (PAC)**, PAC Directorate, 3rd floor, Central Electricity Authority, Sewa Bhawan, R.K. Puram, New Delhi – 110066– for information please.

NOO:

1. **Chief Engineer (HM)**, Design & Engineering Division, C.O- for information please.

पंजीकृत कार्यालय : एन एच पी सी ऑफिस कॉम्प्लेक्स, सैक्टर-33, फरीदाबाद – 121003, हरियाणा

Regd. Office : NHPC Office Complex, Sector-33, Faridabad - 121 003, Haryana

CIN : L40101HR1975GOI032564; Website : www.nhpcindia.com; E-mail :

webmaster@nhpc.nic.in; Fax : 0129-2277941; EPABX No. : 0129-2588110/2588500

Sub: Subansiri Lower H.E. Project (2000 MW) in Arunachal Pradesh- Memorandum on Design changes in Hydro-Mechanical components with reference to DPR.

Ref: CWC letter No. 27/4/09/फाटक (उ.प. एवं द.)/203- dated 26.04.2016.

Refer to above cited CWC (Gates Design (NW&S) Directorate) letter dated 26.04.2016 regarding Memorandum on Design Changes in Hydro-Mechanical components with reference to DPR.

The related design & detailed engineering of Hydro-Mechanical components were done on the basis of design philosophy/ criteria adopted at DPR stage. However, during later stage there were changes in civil structures and layout/ arrangement in the Power house, HRT and Surge Shaft etc. which entailed changes in Design of some Hydro mechanical components i.e. Diversion Tunnel Gates, Spillway Radial Gates, Spillway Bulkhead Gates and Draft Tube Gates. The Memorandum of Changes from DPR was accordingly submitted to CEA/CWC vide NHPC letters dated 05.11.2013 & 22.11.2013 for obtaining concurrence on technical changes required for updating of RCE to current price level.

The clarifications regarding observations raised vide aforesaid CWC letter are as follows.

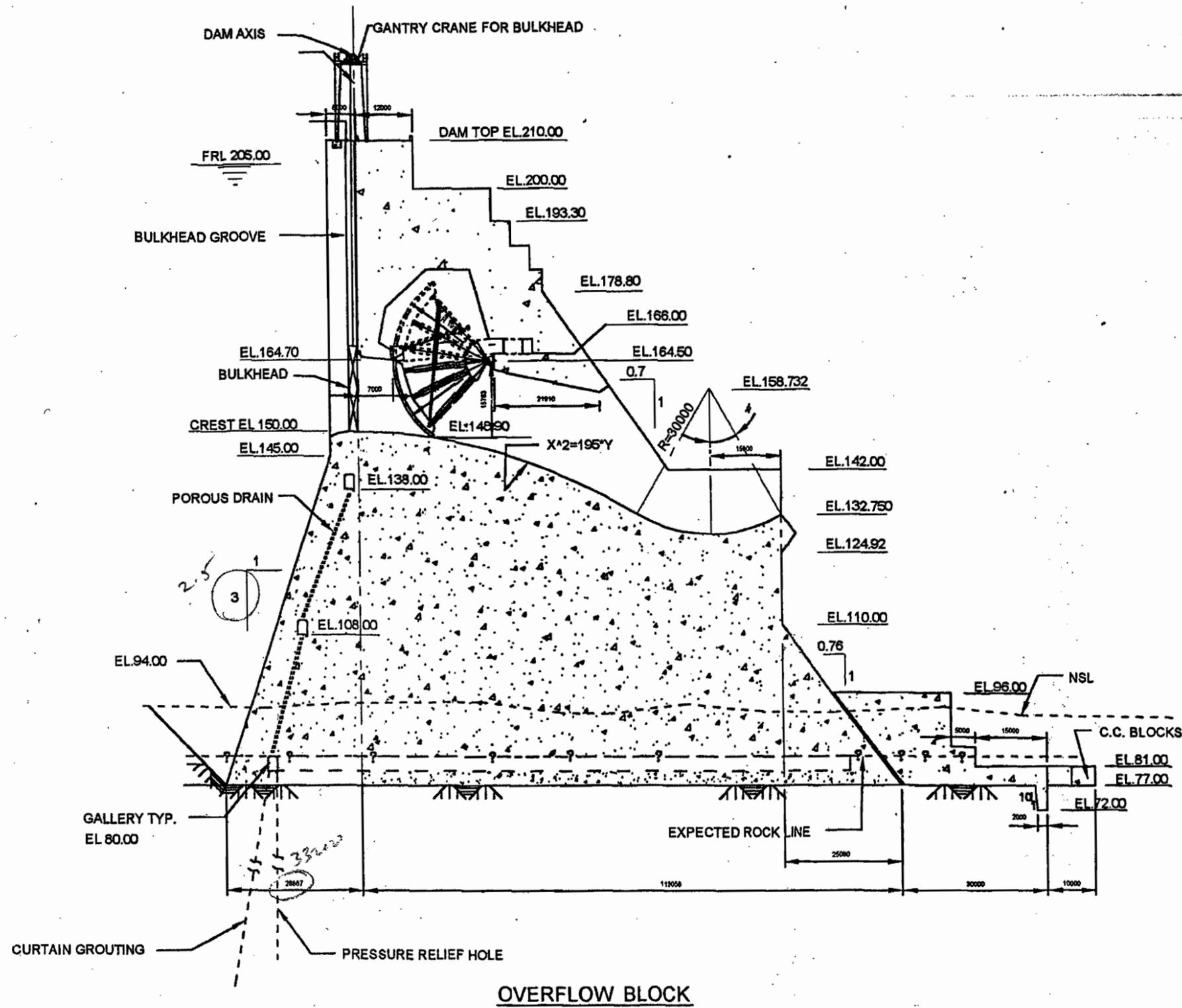
Sr. No.	CWC observations	Clarification by NHPC
1	<p>-Powerhouse arrangement has been changed from underground type to surface type with a provision of u/s surge arrangement. Hence the corresponding changes in Draft tube Gates and their hoisting arrangement shall be commented once these changes will be cleared from Civil Design Directorate of CWC.</p> <p>-However, provision of three Gantry Cranes to handle the three number Draft Tube Gates shall be reviewed and single Gantry Crane can be provided in place of three numbers of Gantry Crane.</p>	<p>-Clearance has been granted by Hydel Civil Designs (NW&S) Directorate, CWC vide letter No. 26/33/2015-HCD (NW&S)/2922-23 dated 22.12.2015. (Copy enclosed)</p> <p>-3 Nos. Gantry Cranes have been envisaged to isolate atleast one generating unit by closing the 3 Nos. Draft Tube Gates for a unit simultaneously to cater any emergent eventuality.</p>
2	<p>Crest level of spillway has been changed from 150m to 145m. Hence the opening size of Spillway Radial Gates and Bulkhead Gates have been changed Size of Diversion Tunnel Gates has also been increased and Tailrace Stoplog Gates has been deleted due to deletion of Tailrace Structure. Lengths of liner and pressure shaft have also been increased. The above changes are mainly due to the change in design of Civil structure. All the above changes include the change in sizes of gates without the change in gate type and their operating arrangement.</p>	
3	<p>DPR stage size of Spillway Radial Gates and Bulkhead Gates mentioned in Memorandum of Design Changes in Hydro mechanical components shall be reconciled with the sizes mentioned in the table 'Weight Estimation for HM Work'.</p>	<p>The requisite reconciliation, as suggested by CWC has been made. Accordingly, corrected Memorandum of changes is being enclosed for kind perusal.</p>
4	<p>As this 'Memorandum of Design Changes in Hydro mechanical Components of Subansiri Lower HEP' is mainly due to change in civil structure. In view of the</p>	<p>Clearances have been obtained from Hydel Civil Designs (NW&S) Directorate and</p>

<p>above the hydro mechanical components of the project can only be commented after the receipt of the clearance from relevant civil directorates of CWC. Further it is to intimate that this directorate has not been provided the relevant construction drawings of civil and hydro mechanical components. Kindly furnish the salient features of the project along with the civil and HM equipment drawings of DPR and construction stage to this directorate for reference and record.</p>	<p>CMDD (NW&S) Directorate, CWC vide letter No.26/33/2015-HCD (NW&S)/2922-23 dated 22.12.2015 and letter No. CWC UO No. 4/65/2014-CMDD (NW&S)/282 dated 07.11.2014 respectively (Copy enclosed) on memorandum of changes from DPR submitted to CEA/CWC.</p> <p>Following documents are being enclosed: -</p> <ol style="list-style-type: none"> 1. Salient Features 2. DPR Stage HM Drawings 3. Tender stage HM Drawings. 4. DPR & construction stage Civil drawings
--	--

It is requested to kindly vet the Change Memorandum of HM works as per clearance granted to change memorandum of Civil works.

Encl: As below:

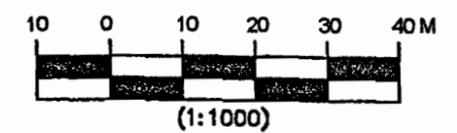
1. Hydrel Civil Designs (NW&S) Directorate and CMDD (NW&S) Directorate letters.
2. Salient Features & Civil Drawings
3. DPR Stage Civil & HM Drawings.
4. Tender Stage HM Drawings.
5. Corrected Memorandum of Changes from DPR for HM works



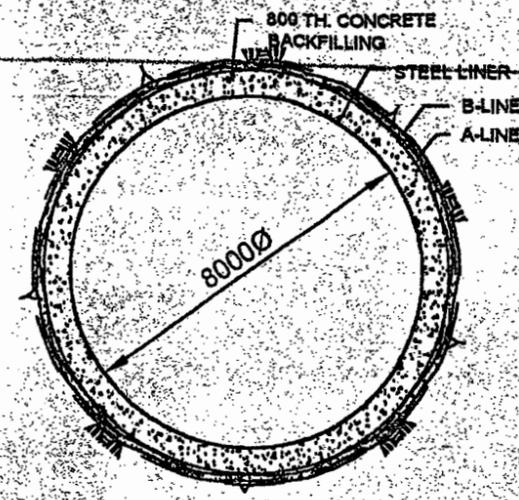
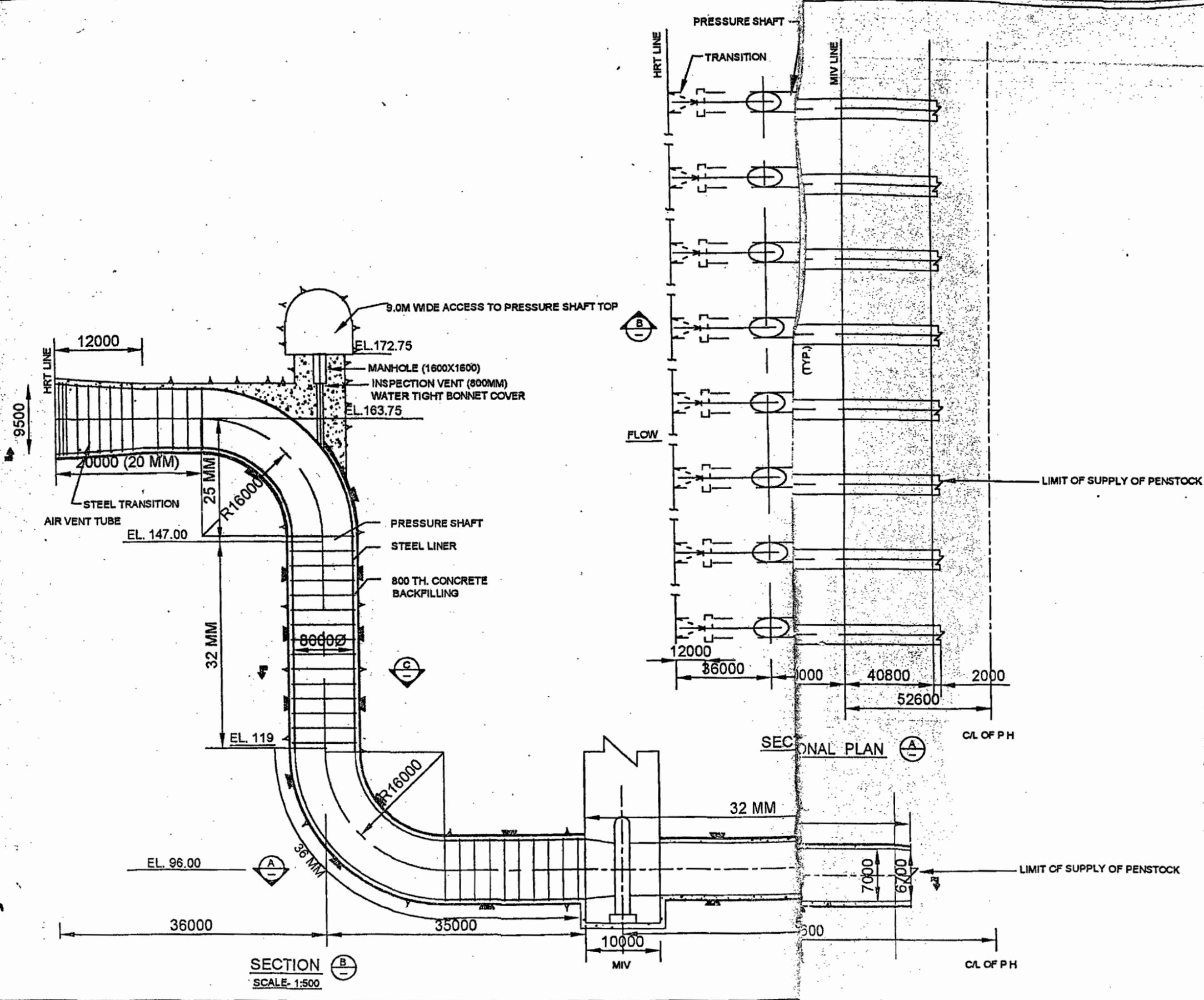
OVERFLOW BLOCK

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES AND ELEVATIONS IN METRES.
2. THIS DRAWING IS FOR DETAILED PROJECT REPORT ONLY.



नेशनल हाईड्रोइलेक्ट्रिक पावर कारपोरेशन लि. NATIONAL HYDROELECTRIC POWER CORPORATION LTD.			
सुबनसिरी लोअर जलविद्युत परियोजना SUBANSIRI LOWER HYDROELECTRIC PROJECT			
GENERAL ARRANGEMENT SPILLWAY RADIAL GATE			
DRAW 21/02/2001	SUBMITTED 21/02/2001	RECOMMENDED MANOJ KUMAR	APPROVED S. SHARMA
DATE 21/02/2001		DRG. NO. NHSB-2DA2-45-GA-02	



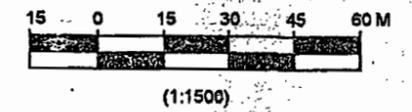
SECTION C
SCALE- 1:150

NOTES:

1. ALL DIMENSIOIS ARE IN MILLIMETRES AND ELEVATIONS IN METRES.
2. THIS DRAWING IS FOR DETAILED PROJECT REPORT ONLY.
3. THE PENSTOCK MATERIAL SHALL BE IS:2002 GR 3
4. THE STEEL TRANSITION OF 9500DIA TO 8000DIA STARTS FROM THE CONCRETE TRANSITION OF THE HRT.
5. 3 NOS. PERCOLATION RING AT DISTANCE OF 500MM AND STIFFENER RING OF HEIGHT 200MM AT A SPACING OF 1500 TO 2000 ARE PROVIDED HAVING THICKNESS OF THE PLATE THICKNESS.

DETAILED REPORT DRAWING
NOT FOR CONSTRUCTION

SCALE



NATIONAL HYDROELECTRIC POWER CORPORATION LTD.			
SUBANSIRI LOWER HYDROELECTRIC PROJECT			
PRESSURE SHAFTS PLAN AND SECTIONS			
DRAWN	M.K. Singh	SUBMITTED	M.K. Singh
DATE	MARCH 2001	RECOMMENDED	A. KUMAR
		APPROVED	G.S.SHARMA
DRG. NO. NHSB-3KA2-45-GA-03			

244-245

संस्था सं. 27/04/2009/GD(NW&S)/216-217
 भारत सरकार / Government Of India
 केंद्रीय जल आयोग / Central Water Commission
 गेट्स डिजाइन (न.व.सर्व.सं.) निदेशालय / Gates Design (NW&S) Directorate.

6th Floor, Sewa Bhawan
 New Delhi-110066
 दिनांक: 31/08/2017

विषय: Memorandum of changes in respect of Subansiri Lower HEP-reg.

संदर्भ: CWC Letter No. 27/4/09/GD(NW&S)/216-217 dated 07.08.2017

- 2. Letter No. 2/NHPC/26/के.वि.सू/2001-फो.रे.सू/1910-12 dated 17.08.2017.
- 3. CWC Letter No. 27/4/09/GD(NW&S)/238-239 dated 23.08.2017.
- 4. No. NH/PO/IP/SLP(RCC)/2161 dated 25.08.2017.

Please refer to the letter under reference dated 17.08.2017 on the above mentioned subject vide which reply to the observations of CWC issued on 07.08.2017 was furnished. Further copies of the detail design computations & general arrangement drawings of Radial Gate and their embedded parts were sought from the project authorities vide letter dated 23.08.2017. The project authorities have submitted the above sought detail design calculations and general arrangement drawing vide letter dated 25.08.2017.

The submissions of the project authorities have been examined and there are no further comments. Therefore, the Memorandum of changes (MoC) is considered acceptable as far as this directorate is concerned subject to incorporation of modifications/changes in draft tube gates & their hoisting arrangement as agreed by the project authorities.

This issues with the approval of Chief Engineer, Designs (NW&S)

[Handwritten initials]

[Signature]
 (हार्केश कुमार)
 (Harkesh Kumar)
 निदेशक / Director

Director PA(N) CWC, Sewa Bhawan, R.K. Puram, New Delhi:
 CWC U.O No 27/04/2009/GD(NW&S)/244-245, dated 31/08/2017

Copy to:
 Director PA(N) CWC, 3rd Floor, Sewa Bhawan R.K. Puram, New Delhi-60



एनएचपीसी लिमिटेड
(भारत सरकार का उद्यम)

NHPC Limited
(A Government of India Enterprise)

संदर्भ सं./Ref. No. _____

फोन/Phone : _____

दिनांक/Date : _____

NH/PD/IP/SLP (RCE)/2161

25.08.2017

Director, Gates Design (NW&S) Directorate,
Central Water Commission,
Sewa Bhawan, R. K. Puram,
New Delhi- 110066

Sub: Subansiri Lower HEP (2000 MW) in Arunachal Pradesh/Assam- Memorandum of Changes (MoC)- regarding.

Sir,

This is in reference to CEA's letter No. 2/NHPC/26/CEA/2001-PAC/1974 dated 23.08.2017 enclosing therewith CWC Letter No. 27/04/2009/GD (NW&S)/238-239 dated 23.08.2017 vide which detailed design calculations along with General arrangement & other relevant drawings for Spillway radial gates for assessment and confirmation of proposed weight of radial gates and embedded parts were sought.

In this regard, a copy of the design calculations and General arrangement drawings along with supporting documents for actual weight of the radial gates have already been submitted to CWC by hand on 24.08.2017. A copy of the same is again enclosed for necessary action please.

Therefore, it is requested to convey the requisite clearance as desired by CEA for SLP HE project at the earliest.

Thanking you,

Encl: As above.

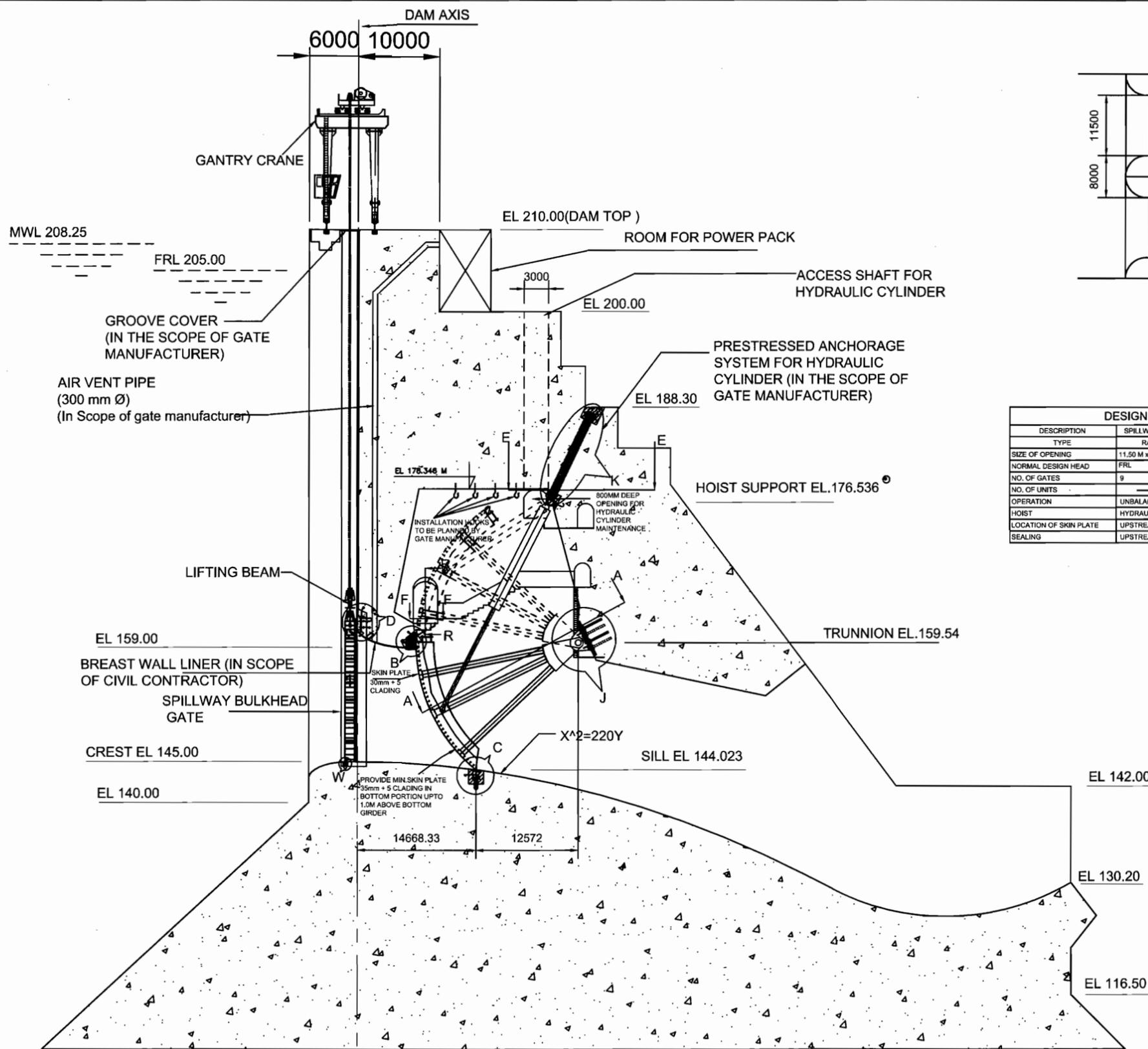
Yours faithfully,

(H. Bulchandani)

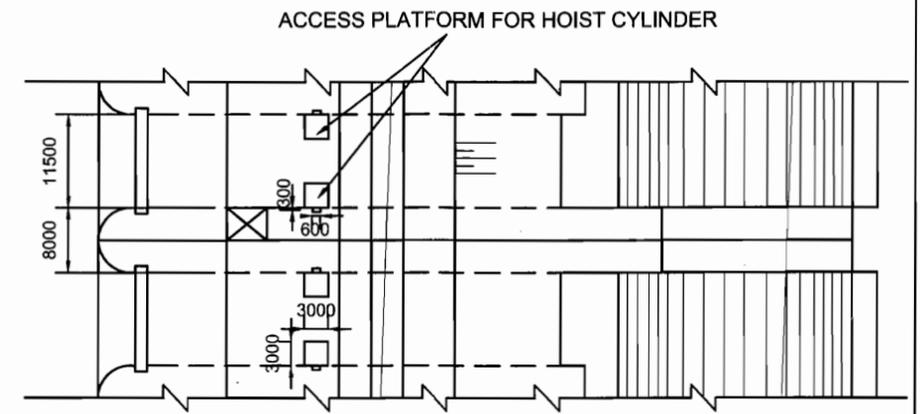
Chief Engineer (Plg.)

Copy to:

1. Director (PAC), PAC Directorate, 3rd floor, Central Electricity Authority, Sewa Bhawan, R. K. Puram, New Delhi – 110066.



SECTIONAL ELEVATION



KEY PLAN

DESCRIPTION	DESIGN DATA	
	SPILLWAY GATES	SPILLWAY BULKHEAD
TYPE	RADIAL GATE	SLIDING GATE
SIZE OF OPENING	11.50 M x 14.00 M	11.50 M x 16.34 M
NORMAL DESIGN HEAD	FRL	FRL
NO. OF GATES	9	TWO SETS
NO. OF UNITS	2 (TWO)	
OPERATION	UNBALANCED HEAD	BALANCED HEAD
HOIST	HYDRAULIC HOIST	GANTRY CRANE
LOCATION OF SKIN PLATE	UPSTREAM	UPSTREAM
SEALING	UPSTREAM	DOWN STREAM

NOTES:-

- ALL DIMENSIONS ARE IN mm AND LEVELS ARE IN METRES.
- 1st. STAGE AND 2nd. STAGE CONCRETE SHALL BE WELL BONDED BY PROVISION OF DOWEL BARS AT SUITABLE INTERVALS.
- FACES OF WALL PLATES AND SEAL SEATS SHALL BE IN A TRUE VERTICAL PLANE WITH A TOLERANCE OF +.5mm IN ANY 3.0m HEIGHT WITHOUT OFFSETS OR GAPS AT THE JOINTS.
- MINIMUM 28 DAYS CUBE STRENGTH OF CONCRETE IN BLOCKOUT SHALL BE 300 Kg/cm².
- FOR DETAILS OF CIVIL STRUCTURE REFER RELEVANT DWGS.
- ERECTION TOLERANCE SHALL BE AS PER IS:5620 & IS:4623.
- SUITABLE RECESS SHALL BE PROVIDED FOR SEALS ABOVE VENT OPENING OF RADIAL GATE. (MIN. 150 MM).
- OFFSET IN SKIN PLATE DUE TO DIFFERENCE IN THICKNESS OF SKIN PLATE SHALL BE PROVIDED ON THE DOWNSTREAM ONLY. THE UPSTREAM FACE SHALL HAVE A CONSTANT RADIUS.
- TEFLON COATED/F.C.COATED SIDE SEALS ARE PROVIDED. EMBEDDED LABYRINTH SEAL IS ALSO TEFLON /F.C COATED TYPE.
- THE ELEVATION OF BOTTOM MOST PART OF RADIAL GATE IN FULLY RAISED POSITION SHALL BE 165.75 M.
- TRUNNION BRACKET ASSEMBLY SHALL BE INSTALLED USING HOLDING DOWN ANCHORS PLACED IN FIRST STAGE CONCRETE.
- HYDRAULIC HOIST CYLINDERS SHALL BE INSTALLED FROM SUPPORT STRUCTURE PLACED IN PIER/DAM AS SHOWN.
- BULKHEAD SHALL BE OPERATED IN 2 UNITS.
- SUPPLY, INSTALLATION AND POST TENSIONING OF THE ANCHOR BARS, END FIXTURES AND DUCTS FOR THE PRESTRESSED ANCHORAGE SYSTEM SHALL BE IN THE SCOPE OF HM CONTRACTOR EXCEPT FOR EMBEDDING OF THE CABLE DUCTS INTO THE DAM BODY, WHICH SHALL BE IN THE SCOPE OF CIVIL CONTRACTOR.
- SUITABLE APPROACH LADDERS AND HAND RAILINGS SHALL BE PROVIDED TO ACCESS GATE SEALS, GUIDE ROLLER, TRUNNION AND CYLINDERS.
- DIMENSION AND LEVELS MARKED ⊙ ARE TENTATIVE AND MAY CONTRACTOR TO OPTIMIZE PERFORMANCE BE REVISED BY OF EQUIPMENT.
- FOR DETAILS REFER DRAWING NOS.
 - NHSRL-2DT3-45-GA-002-00
 - NHSRL-2DT3-45-GA-003-00
 - NHSRL-2DT3-45-GA-004-00
 - NHSRL-2DT3-45-GA-005-00
- 1st. STAGE AND 2nd. STAGE CONCRETE IS AS SHOWN.

LEGEND	
	FIRST STAGE CONCRETE
	SECOND STAGE CONCRETE

THIS IS A SPECIFICATION DRAWING ONLY

नेशनल हाईड्रोइलेक्ट्रिक पावर कारपोरेशन लि.
NATIONAL HYDROELECTRIC POWER CORPORATION LTD.

सुबानसिरी लोअर जलविद्युत परियोजना
SUBANSIRI LOWER HYDROELECTRIC PROJECT

SPILLWAY RADIAL GATE, BULHEAD GATE AND GANTRY CRANE
GENERAL ARRANGEMENT

DATE	NO.	REVISION OR ISSUES	BY	CH.	APP.	DATE	DRG. NO.
DEC-2004						DEC-2004	NHSRL-2DT3-45-GA-001-01

Government of India
Central Water Commission
Hydel Civil Designs (NW&S) Directorate

Wing No. I, 1st floor,
West Block-2, R.K Puram,
New Delhi-110066

Date 03.08.2016

Subject : Subansiri Lower HEP (2000MW) – Memorandum of Changes.

- Ref: 1. CEA Letter No. 2/NHPC/26/CEA/2001-PAC/6660-62 dt. 27.11.2013.
2. NHPC Letter No. NH/PD/IP/SLP(RCE)/1748 dt. 06.10.2015.
3. NHPC Letter No. NH/PD/IP/SLP(RCE)/ 2192 dt. 18.12.2015.
4. CWC Letter No. 26/33/2015-HCD (NW&S)/2922-23 dt. 22.12.2015.
5. NHPC Letter No. NH/PD/IP/SLP(RCE)/ 121 dt. 18.01.2016.
6. NHPC Letter No. NH/PD/IP/SLP(RCE)/ 1481 dt. 29.06.2016.
7. NHPC Letter No. NH/PD/IP/SLP(RCE)/ 1725 dt. 01.08.16.

In reply to this office observations vide CWC letter at Reference No. 2 regarding memorandum of changes of Subansiri Lower HEP, NHPC submitted details vide references at 5,6 & 7.

No further comment is being offered in respect of memorandum of changes of Subansiri Lower HEP.

This issues with the approval of Chief Engineer, Designs (NW&S).

[Signature]

Director

Director(PAC), 3rd Floor, CEA, Sewa Bhawan, R.K.Puram, New Delhi
CWC U.O.No. 26/33/2015-HCD (NW&S)/ 1114-20 dt. 03.08.2016

Copy to

Chief Engineer (Plg.), NHPC, NHPC Office Complex, Sector-33, Faridabad,
Haryana, PIN-121003.

[Handwritten initials]

[Handwritten signature]



LLSZ

एन एच पी सी लिमिटेड

(भारत सरकार का उद्यम)

NHPC Limited

(A Government of India Enterprise)

CIN – L40101HR1975GOI032564

संदर्भ सं./Ref. No. : _____

फोन/Phone : _____

दिनांक/Date : _____

NH/PD/IP/SLP (RCE)/ 1748

06.10.2015

Shri Sudista Kumar Das (Director),
Hydel Civil Designs (NW&S) Directorate,
Central Water Commission,
Wing No. 1, 1st Floor, West Block 2,
R.K. Puram, New Delhi – 110066

Sub: Subansiri Lower Hydro Electric Project (2000MW) in Arunachal Pradesh –
Memorandum of changes- Additional information regarding.

Sir,

This has reference to NHPC's letter No. NH/PD/IP/SLP (RCE)/1607 dtd.07.09.2015 (copy enclosed) on subject cited above vide which, as desired by CWC, the *Technical Report on mathematical model studies for Surge Tunnel Analysis, Technical note on Surge Arrangement and Design brief of Pressure Shaft Steel Liner* pertaining to Subansiri Lower Hydro Project (2000 MW) had been submitted to CWC.

Further, as desired by CWC, the **input file of transient study** and **Design calculation of Pressure Shaft Steel Liner** pertaining to Subansiri Lower HEP are enclosed.

Therefore, it is requested for examination of same & convey the approval on the proposed memorandum of changes early.

Thanking you,

Encl: As above

Yours faithfully,

(B.P.Rao)

Chief Engineer (Plg.)

Mobile No. 7042322552

Email- bprao_ce@yahoo.co.in

Copy to:

1. **Director (PAC)**, Central Electricity Authority, PAC Directorate, Sewa Bhawan, R.K. Puram, New Delhi – 110066– for information and further necessary action please.



8LSZ

एन एच पी सी लिमिटेड

(भारत सरकार का उद्यम)

NHPC Limited

(A Government of India Enterprise)

CIN – L40101HR1975GOI032564

संदर्भ सं./Ref. No. : _____

फोन/Phone : _____

दिनांक/Date : _____

NH/PD/IP/SLP (RCE)/ 1607

07.09.2015

Shri Sudista Kumar Das (Director),
Hydel Civil Designs (NW&S) Directorate,
Central Water Commission,
Wing No. 1, 1st Floor, West Block 2,
R.K. Puram, New Delhi – 110066

Sub: Subansiri Lower Hydro Electric Project (2000MW) in Arunachal Pradesh –
Memorandum of changes- Additional information regarding.

Ref: CWC letter No. 26/33/2015-HCD (NW&S)/217778 dtd. 24.08.2015

Sir,

This has reference to CWC's letter under reference on cited subject above. In this regard, the requisite information pertaining to Subansiri Lower Hydro Project (2000 MW) is appended as under

1. Technical Report on mathematical model studies for Surge Tunnel Analysis
2. Technical note on Surge Arrangement
3. Design brief of Pressure Shaft Steel Liner

Therefore, it is requested for examination of same & convey the approval on the proposed memorandum of changes early.

Thanking you,

Encl: As above

Yours faithfully,

(B.P.Rao)

Chief Engineer (Plg.)

Mobile No. 7042322552

Email- bprao_ce@yahoo.co.in

Copy to:

1. Director (PAC), Central Electricity Authority, PAC Directorate, Sewa Bhawan, R.K. Puram, New Delhi – 110066– for information and further necessary action please.

etc

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एनएचपीसी लिमिटेड

(भारत सरकार का उद्यम)

NHPC Limited

(A Govt. of India Enterprise)

**SUBANSIRI LOWER H.E. PROJECT
(8 X 250 MW)
(ARUNACHAL PRADESH & ASSAM, INDIA)**

**DESIGN CALCULATION OF
PRESSURE SHAFT STEEL LINER**

**DESIGN & ENGINEERING DIVISION
CORPORATE OFFICE, FARIDABAD**

SUBANSIRI LOWER HYDRO ELECTRIC PROJECT

DESIGN CALCULATION OF PRESSURE SHAFT STEEL LINER

DESCRIPTION

Eight numbers pressure shaft steel lined take off from 9.50m horse shoe shape to 8.0m circular starting from the HRT. Steel liner consist of transition/reducer, 8.0m & 7.0m diameter straight, horizontal bends and vertical ferrules, vertical bends, thrust collar etc., to feed eight nos. turbines placed in the power house.

Steel liner shall be designed for internal pressure equal to static head plus the induced water hammer due to normal Wicket gate operation.

The liner will be checked for the external pressure as per IS: 11639 (Part 2). It is observed that in most of reaches the external pressure will govern and 22 to 36mm thicknesses of liner have been adopted with provision of stiffeners of sizes 150 x 22 to 150 x 36 with respect to steel liner plate thickness at suitable spacings.

The material of Penstock steel liner including specials has been proposed, as ASTM A 537 CL. 1.

Design Data

Diameter of pressure shaft	: 8.0m and 7.0m
No. of Pressure shaft	: 8 Nos.
Water hammer/pressure rise	: 35% of the static head acting on the spiral case with full reservoir level i.e. EL.205m
Full Reservoir Level	: EL 205.0m
Max. Surge Level	: EL 216.0m
C/L of machine level	: EL 98.0m
C/L of start of steel lined pressure shaft	: EL 155.75m

Penstock Condition : (1) No Rock Participation
(2) External Pressure.
(3) Max. Internal Pressure incl. Over Pressure as per codal requirements.

Ref. codes : IS :11639 (Part 2 &3),
: IS : 2825.
: C E C T

Material Grade : ASTM A 537 CLASS -I
Yield Stress : 345 N/MM²
Tensile stress : 485 N/MM²

Classification as per IS: 2825 :As per clause 1.3 ,class 1 vessel with joint efficiency of 0.9 as per table 1.1 for back strip joints.

Permissible Stresses for Steel Liner Pressure Shaft

Following safety factors shall be applied in relation to the yield strength of the steel.

Conditions	Steel lining pressure shaft (without back strip)	Steel lining pressure shaft (with back strip)	Specials
Safety factor for normal operating condition as detailed in 3(a) of design criteria	1.67	1.85	2.0
Safety factor for intermittent operating condition as detailed in 3(b) of design criteria	1.5	1.67	1.8
Safety factor against buckling with external water pressure or grouting pressure on an empty lining	1.5	1.5	1.8

DESIGN DOCUMENTS APPLICABLE STANDARDS

- 1) IS : 11639 - 1995 : Structural Design of Penstocks Criteria Part-2
- 2) IS : 11639 - 1996 : Structural Design of Penstocks Criteria Part-3
- 3) IS : 2825 : Code of Practice for Unfired Pressure Vessels
- 4) CECT : Recommendations for the Design, Manufacture and erection of steel Penstocks of welded construction for Hydroelectric installation
Jan-79 Rev-84

DESIGN PRESSURE

Internal pressure : As per water hammer calculations including over pressure.

External pressure : Elevation difference between penstock and natural soil level, or Maximum Surge level to penstock level, which ever is less.

INPUT PARAMETERS:

Full Reservoir level	FRL := 205	M
Max. Up Surge Level	MSL := 216	M
Elevation at MIV center line in	Zv := 98.0	M
Length of Penstock up to MIV	Lp := 222.726	M
Elevation of design at Position	Zp := 98.0	M
Cumulative length of penstock up to the Position	Cl := 222.726	M
Load of Water hammer effect by water column	Hwhe := (FRL - Zv) · 0.35 = 37.45	M
Design head of water at the position including water hammer effect	$Hw := (FRL - Zp) + \frac{Cl \cdot Hwhe}{Lp} = 144.45$	M
Internal Design Pressure at the position	$Pw := Hw \cdot \frac{9.81}{1000} = 1.417$	N/mm ²

p_w = Water Pressure acting at that point in N/mm²

d = Internal Diameter of Steel Liner in MM.

S = Allowable Stress in N/mm²

t = Req. Thickness of the Liner at Pressure Point with out corrosion allowance in mm.

c = corrosion allowance in mm

t_1 = Thickness of liner with out corrosion allowance in mm

t_p = Selected thickness of liner including corrosion allowance in mm

PRESSURE SHAFT STEEL LINER, 8.0 & 7.0 M DIA. SUBANSIRI HE PROJECT

CALCULATION OF LINER THICKNESS ON THE BASIS OF INTERNAL PRESSURE

MATERIAL: ASTM A537 CLASS 1

Yield point = 345 N/mm²
 UTS= 485 N/mm²
 Permissible Tensile stress of the material = 207 N/mm²
 Factor of Safety = 1.67
 Allowable tensile stress with weld 207 N/mm²

Input Data	
h sr =	216 m
h r =	205 m
lges =	222.726 m
D _o =	8000 mm

M/c Center Line (h_{mc}l) = 98 m
 Allowable tensile stress with weld efficiency= 207 N/mm²

$P_w = (h_r - l_w) + (l_x / l_{ges}) * h_{whe}$
 $P_{w1} = h_{sr} - l_w$

l w = node elevation in meter
 h r = Reservoir level
 hsr = Max. Surge level
 h whe = Surplus head due to water hammer
 T p = designed thickness from internal pressure
 l x = distance of penstock from surge tank

h whe =	37.45 m
---------	---------

$P_w = (h_r - l_w) + (l_x / l_{ges}) * h_{whe}$

$P_{w1} = h_{sr} - l_w$

lges = total distance between surge chamber t Min handling thickness(D) = 8000 2.125 Cm

f = permissible tensile stress of material Min handling thickness(D) = 7000 1.875 Cm

D = internal diameter of penstock

t = thickness of plate excluding corrossion allowance

P = maximum allowable internal pressure

T = thickness of plate provided Take Corrosion Allowance= 1.5 mm

5

S.NO.	Description	Reach(m)	lw (m)	lx(m)	lges(m)	h r (FRL)	h sr (surge)	h whe	Pw=(h r-lw)+lx/lges*s*h whe	Pw1=hsr-lw	(design pres.) Pd	Adopted thick plate (in mm)	diamete r (mm)	Allowable pressure(P)	RESU LT	Material specification	NOS.
1	Length from the C/L of Surge chamber to start of trasion	8.266	155.75	8.27	222.73	205	216	37.45	50.64	60.25	0.5911	- CONCRETE LINING					
2	Upper Transition (9.5m dia circular to 8m dia circular)	6.5	155.75	14.77	222.73	205	216	37.45	51.73	60.25	0.5911	28	9500	1.152	OK	537	8
3	Upper Horizontal Portion	2.47	155.75	17.24	222.73	205	216	37.45	52.15	60.25	0.5911	22	8000	1.058	OK	537	8
4	8.0m dia Upper Vertical Bend, R=16m, Angle =90 degree, EL=155.75m to 139.75m	25.13	139.75	42.37	222.73	205	216	37.45	72.37	76.25	0.7480	22	8000	1.058	OK	537	8
5	8.0m dia Vertical Shaft (EL139.75-129.75m)	10	129.75	52.37	222.73	205	216	37.45	84.06	86.25	0.8461	28	8000	1.367	OK	537	8
6	8.0m dia Vertical Shaft (EL129.75m -114m)	15.75	114.00	68.12	222.73	205	216	37.45	102.45	102.00	1.0051	32	8000	1.572	OK	537	8
7	8.0m dia Lower Vertical Bend R=16m, Angle =90 degree, EL=114.0m to 98.0m	25.13	98.00	93.25	222.73	205	216	37.45	122.68	118.00	1.2035	36	8000	1.778	OK	537	8
8	8.0m dia Lower horizontal portion start from LVB upto 10.0m	10	98.00	103.25	222.73	205	216	37.45	124.36	118.00	1.2200	36	8000	1.778	OK	537	8
9	8.0m dia Lower hori. Portion	13.534	98.00	116.78	222.73	205	216	37.45	126.64	118.00	1.2423	32	8000	1.572	OK	537	8
10	8.0m dia lower Horizontal plan bend of R= 30.0m with angle 1.063degree	0.557	98.00	117.34	222.73	205	216	37.45	126.73	118.00	1.2432	32	8000	1.572	OK	537	8
11	8.0m dia Lower hori. Portion start from horizontal bend	15.722	98.00	133.06	222.73	205	216	37.45	129.37	118.00	1.2692	32	8000	1.572	OK	537	8
12	8.0m dia Lower hori. Portion	10	98.00	143.06	222.73	205	216	37.45	131.06	118.00	1.2857	32	8000	1.572	OK	537	8
13	8.0m dia Lower hori. Portion upto lower transition	10.94	98.00	154.00	222.73	205	216	37.45	132.89	118.00	1.3037	32	8000	1.572	OK	537	8
14	Lower Transition (8.0m dia circular to 7.0m dia circular)	6	98.00	160.00	222.73	205	216	37.45	133.90	118.00	1.3136	32	8000	1.572	OK	537	8
15	7.0m dia Lower Horizontal Part (d/s of transtion 7m dia)	10	98.00	170.00	222.73	205	216	37.45	135.58	118.00	1.3301	28	7000	1.561	OK	537	8
16	7.0m dia Lower Horizontal Portion	22.417	98.00	192.42	222.73	205	216	37.45	139.35	118.00	1.3671	28	7000	1.561	OK	537	8
17	7.0m dia Lower horizontal Plan Bend of R=30m, Angle 1.933 degree	1.012	98.00	193.43	222.73	205	216	37.45	139.52	118.00	1.3687	32	7000	1.796	OK	537	8
18	7.0m dia Lower Horizontal Portion	17.994	98.00	211.43	222.73	205	216	37.45	142.55	118.00	1.3984	28	7000	1.561	OK	537	8
19	thrust collar	2	98.00	213.43	222.73	205	216	37.45	142.89	118.00	1.4017	50	7000	2.849	OK	537	8
20	7.0m dia portion d/s of thrust collar	5	98.00	218.43	222.73	205	216	37.45	143.73	118.00	1.4100	28	7000	1.561	OK	537	8
21	C/L of MIV	4.3	98.00	222.73	222.73	205	216	37.45	144.45	118.00	1.4171						
	Total Length (m)	222.726															

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PRESSURE SHAFT STEEL LINER, 8.0 & 7.0 M DIA. SUBANSIRI HE
PROJECT

**CALCULATION OF LINER THICKNESS AND STIFFENER SIZE ON THE BASIS OF
EXTERNAL PRESSURE**

MATERIAL: ASTM A537 CLASS 1

Yield point = 345 N/mm²
UTS= 485 N/mm²

l w = node elevation in meter
l x = distance of penstock from surge tank
Pex.= external water pressure in N/mm²

Pcrt.= Critical pressure occurred
Pperm.= design external water pressure in N/mm²
T p = designed thickness from internal pressure
hxt = height x thickness of stiffener
'@' = center to center distance of stiffener

lw	lx	Pex.	Pperm.=1.5xPex.	Pcrt.	T D	hxt	@	Remark
155.75	8.27							
155.75	14.77	0.493	0.7388	1.3406	28	150x28	625 & 1250	
155.75	17.24	0.493	0.7388	0.852	22	nil	nil	
139.75	42.37	0.653	0.9788	1.787	22	150x22	900	
129.75	52.37	0.753	1.1288	1.22	28	150x28	1250	
114.00	68.12	0.910	1.3650	1.434	32	150x32	1250	
98.00	93.25	1.020	1.5300	1.656	36	150x36	900	
98.00	103.25	1.020	1.5300	1.656	36	150x36	1250	
98.00	116.78	0.880	1.3200	1.434	32	150x32	1250	
98.00	117.34	0.800	1.2000	1.18	32	nil	nil	
98.00	133.06	0.800	1.2000	1.433	32	150x32	1250	
98.00	143.06	0.680	1.0200	1.433	32	150x32	1250	
98.00	154.00	0.580	0.8700	1.433	32	150x32	1250	
98.00	160.00	0.520	0.7800	1.433	32	150x32	1250	
98.00	170.00	0.430	0.6450	1.524	28	150x28	1250	
98.00	192.42	0.410	0.6150	1.524	28	150x28	1250	
98.00	193.43	0.280	0.4200	0.867	32	nil	nil	
98.00	211.43	0.280	0.4200	0.666	28	nil	nil	
98.00	213.43	0.280	0.4200	1.99	50	nil	nil	
98.00	218.43	0.280	0.4200	0.666	28	nil	nil	

REDUCER/TRANSITION - ϕ 9.5m to ϕ 8.0 m at EL 155.75 m

Thickness of the Reducer as per IS:11639 (Part3) 1996

- P_w = Internal Water Pressure in N/MM²
- d_a = Internal Diameter of the Reducer at the larger end in MM.
- α = Half of Apex Angle
- S = Allowable Stress in N/MM²
- C = Corrosion Allowance in MM.
- d_1 = Internal diameter of the reducer at the smaller end in MM

$L := 6500$ MM $C := 1.5$ MM $d_1 := 8000$ $\sigma_t := 345$

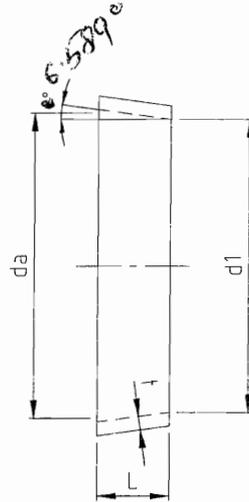
$d_a := 9500$ $S := \frac{\sigma_t}{1.67}$ $P := 0.5911$

Angle of Reducer

$\alpha := \text{atan} \left[\frac{(d_a - d_1)}{2 \cdot L} \right] = 0.115$

$t := \frac{P \cdot d_a}{[2 \cdot \cos(\alpha) \cdot (S - 0.6 \cdot P)]}$ $t = 13.705$

$t := 14$



Adding the corrosion allowance of 1.5 mm to the calculated thickness

$t_r := t + C$ $t_r = 15.5$ MM

However Select thickness as that of the ferrule $t_p := 28$ MM Use 28 MM thick

EL : 155.75 M ASTM A 537 CL-I

NSL LEVEL = 205 M

PENSTOCK EL = 155.75 M

EXT PR. = 0.493 N/MM²

$R := 4.75$ $t := 0.028$ $F := 345000000$ $y_o := 0.0003 \cdot R$ $f_s := 4.92$

$k := 2 \cdot \frac{R}{t}$ $k = 339.286$ $E := 200345000000$ $f_n := \frac{F}{f_s}$ $f_n = 7.012 \times 10^7$

$E1 := \frac{E}{0.91}$ $E1 = 2.202 \times 10^{11}$ $f_1 := \frac{F}{0.88882}$ $f_1 = 3.882 \times 10^8$

$$A := \left(\frac{y_0}{R} + \frac{f_n}{E1} \right) \cdot \left(1 + 3 \cdot k^2 \cdot \frac{f_n}{E1} \right)^{\frac{3}{2}}$$

$$A = 0.723$$

$$B := 1.68 \cdot k \cdot \frac{f_1 - f_n}{E1} \cdot \left(1 - \frac{k}{4} \cdot \frac{f_1 - f_n}{E1} \right)$$

$$B = 0.723$$

$$p_{Cr} := \left[1 - 0.175 \cdot \frac{k \cdot (f_1 - f_n)}{E1} \right] \cdot 2 \cdot \frac{f_n}{k}$$

$$p_{Cr} = 3.779 \times 10^5$$

$$p_{Cr1} := \frac{p_{Cr}}{1.5 \cdot 1000000}$$

$$p_{Cr1} = 0.252 \quad \frac{N}{MM^2}$$

As calculated pressure is less than required pressure, rings are required.

$$d := 9.50 \text{ M} \quad t_w := 0.028 \text{ M} \quad L_w := 1.250 \text{ M} \quad ES := 2.00345 \cdot 10^8 \frac{KN}{M^2} \quad \mu := 0.30$$

$$k_w := \frac{d}{t}$$

$$\lambda := \frac{L}{t}$$

$$E1_w := \frac{ES}{1 - \mu^2}$$

$$n := 17$$

$$P_{Cr} := 2 \cdot \frac{E1}{k} \left[\frac{1 - \mu^2}{(n^2 - 1) \cdot \left(1 + \frac{4 \cdot n^2 \cdot \lambda^2}{\pi^2 \cdot k^2} \right)^2} + \frac{1}{3 \cdot k^2} \left[(n^2 - 1) + \frac{2 \cdot n^2 - 1 - \mu}{\frac{4 \cdot n^2 \cdot \lambda^2 - 1}{\pi^2 \cdot k^2}} \right] \right]$$

$$P_{Cr} = 2.598 \times 10^3 \quad \frac{KN}{M^2}$$

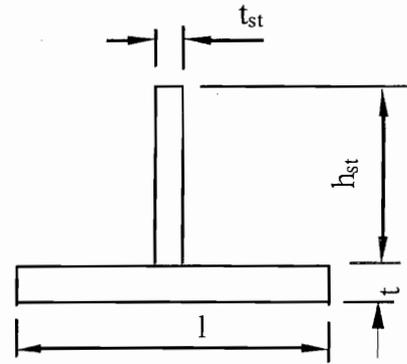
$$p_{crw} := \frac{P_{Cr}}{1.5 \cdot 1000}$$

$$p_{cr1} = 1.732 \quad \frac{KN}{M^2} \quad \text{SAFE}$$

SIZE OF Stiffener Rings

F = allowable yield strength in N /sq.M

$$E_{\text{st}} := \frac{ES \cdot 1000}{(1 - \mu^2)} \quad \frac{N}{M^2} \quad F_{\text{st}} := \frac{345000000}{1.5} \quad \frac{N}{M^2}$$



$$L_{\text{st}} := 1.25 \quad M \quad y_{0\text{st}} := 0.0003 \cdot FM$$

$$t_{\text{st}} := \frac{28}{1000} \quad M \quad h_{\text{st}} := \frac{150}{1000} \quad M \quad d := 9.5 \quad M$$

$$I_{\text{st}} := t_{\text{st}} + 1.56 \sqrt{\frac{d}{2}} \cdot t \quad A_{\text{st}} := t_{\text{st}} \cdot h_{\text{st}} + l \cdot t \quad A_r := t_{\text{st}} \cdot h_{\text{st}} \quad R := \frac{9.5}{2} = 4.75$$

$$X := \frac{l \cdot t \cdot \frac{t}{2} + t_{\text{st}} \cdot h_{\text{st}} \cdot \left(t + \frac{h_{\text{st}}}{2} \right)}{A} \quad X = 0.032$$

$$I := \frac{l \cdot t^3}{12} + l \cdot t \cdot \left(X - \frac{t}{2} \right)^2 + \frac{t_{\text{st}} \cdot h_{\text{st}}^3}{12} + t_{\text{st}} \cdot h_{\text{st}} \cdot \left(\frac{h_{\text{st}}}{2} + t - X \right)^2$$

$$V_{\text{st}} := h_{\text{st}} + t - X \quad t1 := t + \frac{A_r}{l}$$

$$K_1 := \frac{R^4}{E1 \cdot t1} \quad K_1 = 6.6 \times 10^{-8}$$

$$K_2 := R^3 \cdot \left(\frac{y_0}{R} + \frac{l}{R \cdot V \cdot A} \right) \quad K_2 = 0.295$$

$$K_3 := l \cdot F \cdot \frac{t1}{A \cdot V} \cdot \left(\frac{l}{A \cdot V} + R \right) \quad K_3 = 4.464 \times 10^5$$

$$K_4 := \frac{l^2 \cdot F^2 \cdot t^2}{4 \cdot A^2 \cdot V^2 \cdot R} \quad K_4 = 2.954 \times 10^8$$

Vary P and check whether provided rings can take the load or not

$$P_{\text{st}} := 2680000$$

$$M := K_1 \cdot P^3 \quad M = 1.27 \times 10^{12}$$

$$N := K_2 \cdot P^2 \quad N = 2.116 \times 10^{12}$$

$$Q := K_3 \cdot P$$

$$Q = 1.196 \times 10^{12}$$

$$Z := K_4$$

$$Z = 2.954 \times 10^8$$

$$G1 := M + N + Z$$

$$G1 = 3.387 \times 10^{12}$$

$$G2 := Q$$

$$G2 = 1.196 \times 10^{12}$$

$$P_{\text{req}} := \frac{P}{1.5 \cdot 10^6}$$

$$P_{\text{req}} = 1.787$$

$$\frac{N}{\text{MM}^2}$$

As the required pressure is 0.493 N/SQ.MM ,the ring section provided is safe.

Provide 28x 150 @1250 mm as rings

REDUCER/TRANSITION - ϕ 8.0m to ϕ 7.0 m at EL 98.0 m

Thickness of the Reducer as per IS:11639 (Part3) 1996

- p_w = Internal Water Pressure in N/MM²
 d_a = Internal Diameter of the Reducer at the larger end in MM.
 α = Half of Apex Angle
 S = Allowable Stress in N/MM²
 C = Corrosion Allowance in MM.
 d_1 = Internal diameter of the reducer at the smaller end in MM

$$L := 6000 \quad \text{MM} \quad C := 1.5 \quad \text{MM} \quad d_1 := 7000 \quad \sigma_t := 345$$

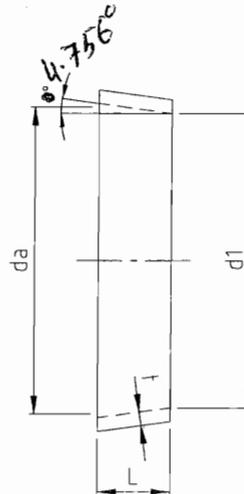
$$d_a := 8000 \quad S_w := \frac{\sigma_t}{1.67} \quad P_w := 1.3136$$

Angle of Reducer

$$\alpha_w := \text{atan} \left[\frac{(d_a - d_1)}{2 \cdot L} \right] = 0.083$$

$$t_w := \frac{P \cdot d_a}{[2 \cdot \cos(\alpha) \cdot (S - 0.6 \cdot P)]} \quad t = 25.62$$

$$t_w := 26$$



Adding the corrosion allowance of 1.5 mm to the calculated thickness

$$t_r := t + C \quad t_r = 27.5 \quad \text{MM}$$

However Select thickness as that of the ferrule

$$t_{\text{ferrule}} := 32 \quad \text{MM}$$

Use 32 MM thick

EL : 93.0 M ASTM A 537 CL-I (For External Pressure)

NSL LEVEL = 205 M

PENSTOCK EL = 155.75 M

EXT PR. = 0.52 N/MM²

$R := 4.0$ $t := 0.032$ $F := 345000000$ $\lambda_D := 0.0003 \cdot R$ $f_s := 3.72$

$k := 2 \cdot \frac{R}{t}$ $k = 250$ $E := 200345000000$ $f_m := \frac{F}{f_s}$ $f_n = 9.274 \times 10^7$

$E1 := \frac{E}{0.91}$ $E1 = 2.202 \times 10^{11}$ $f_1 := \frac{F}{0.88882}$ $f_1 = 3.882 \times 10^8$

$A := \left(\frac{y_0}{R} + \frac{f_n}{E1} \right) \cdot \left(1 + 3 \cdot k^2 \cdot \frac{f_n}{E1} \right)^{\frac{3}{2}}$ $A = 0.516$

$B := 1.68 \cdot k \cdot \frac{f_1 - f_n}{E1} \cdot \left(1 - \frac{k}{4} \cdot \frac{f_1 - f_n}{E1} \right)$ $B = 0.516$

$P_{cr} := \left[1 - 0.175 \cdot \frac{k \cdot (f_1 - f_n)}{E1} \right] \cdot 2 \cdot \frac{f_n}{k}$ $P_{cr} = 6.984 \times 10^5$

$P_{cr1} := \frac{P_{cr}}{1.5 \cdot 1000000}$ $P_{cr1} = 0.466$ $\frac{N}{MM^2}$

As calculated pressure is less than required pressure, rings are required.

$d := 8.0$ M $t := 0.032$ M $L := 1.250$ M $ES := 2.00345 \cdot 10^8$ $\frac{KN}{M^2}$ $\mu := 0.30$

$k := \frac{d}{t}$ $\lambda := \frac{L}{t}$ $E1 := \frac{ES}{1 - \mu^2}$ $n := 14$

$P_{cr} := 2 \cdot \frac{E1}{k} \left[\frac{1 - \mu^2}{(n^2 - 1) \cdot \left(1 + \frac{4 \cdot n^2 \cdot \lambda^2}{\pi^2 \cdot k^2} \right)^2} + \frac{1}{3 \cdot k^2} \left[(n^2 - 1) + \frac{2 \cdot n^2 - 1 - \mu}{\frac{4 \cdot n^2 \cdot \lambda^2 - 1}{\pi^2 \cdot k^2}} \right] \right]$ $P_{cr} = 4.675 \times 10^3$ $\frac{KN}{M^2}$

$P_{cr1} := \frac{P_{cr}}{1.5 \cdot 1000}$ $P_{cr1} = 3.117$ $\frac{KN}{M^2}$ **SAFE**

SIZE OF Stiffener Rings

F = allowable yield strength in N /sq.M

$$E_{\text{eff}} := \frac{ES \cdot 1000}{(1 - \mu^2)} \quad \frac{N}{M^2} \quad F_{\text{eff}} := \frac{345000000}{1.5} \quad \frac{N}{M^2}$$

$$L_{\text{eff}} := 1.25 \quad M \quad y_{\text{ov}} := 0.0003 \cdot F \cdot M$$

$$t_{\text{st}} := \frac{32}{1000} \quad M \quad h_{\text{st}} := \frac{150}{1000} \quad M \quad d := 8.0 \quad M$$

$$l := t_{\text{st}} + 1.56 \sqrt{\frac{d}{2}} \cdot t \quad A_{\text{st}} := t_{\text{st}} \cdot h_{\text{st}} + l \cdot t \quad A_{\text{st}} := t_{\text{st}} \cdot h_{\text{st}} \quad R := \frac{8.0}{2} = 4$$

$$X := \frac{l \cdot \frac{t}{2} + t_{\text{st}} \cdot h_{\text{st}} \cdot \left(t + \frac{h_{\text{st}}}{2} \right)}{A} \quad X = 0.034$$

$$I_{\text{eff}} := \frac{l \cdot t^3}{12} + l \cdot t \cdot \left(X - \frac{t}{2} \right)^2 + \frac{t_{\text{st}} \cdot h_{\text{st}}^3}{12} + t_{\text{st}} \cdot h_{\text{st}} \cdot \left(\frac{h_{\text{st}}}{2} + t - X \right)^2$$

$$V_{\text{eff}} := h_{\text{st}} + t - X \quad t_{\text{eff}} := t + \frac{A_r}{l}$$

$$K_{1\text{eff}} := \frac{R^4}{E \cdot l \cdot t_{\text{eff}}} \quad K_1 = 2.897 \times 10^{-8}$$

$$K_{2\text{eff}} := R^3 \cdot \left(\frac{y_0}{R} + \frac{l}{R \cdot V \cdot A} \right) \quad K_2 = 0.213$$

$$K_{3\text{eff}} := l \cdot F \cdot \frac{t_1}{A \cdot V} \left(\frac{l}{A \cdot V} + R \right) \quad K_3 = 4.483 \times 10^5$$

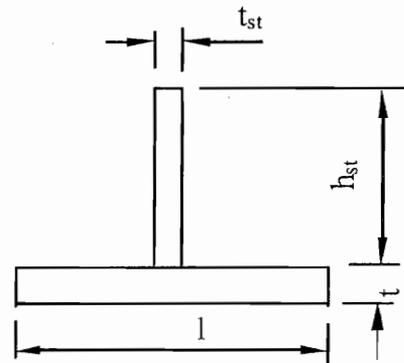
$$K_{4\text{eff}} := \frac{l^2 \cdot F^2 \cdot t^2}{4 \cdot A^2 \cdot V^2 \cdot R} \quad K_4 = 4.961 \times 10^8$$

Vary P and check whether provided rings can take the load or not

$$P_{\text{eff}} := 2680000$$

$$M_{\text{eff}} := K_1 \cdot P^3 \quad M = 5.577 \times 10^{11}$$

$$N_{\text{eff}} := K_2 \cdot P^2 \quad N = 1.529 \times 10^{12}$$



$$Q := K_3 \cdot P$$

$$Q = 1.201 \times 10^{12}$$

$$Z := K_4$$

$$Z = 4.961 \times 10^8$$

$$G1 := M + N + Z$$

$$G1 = 2.087 \times 10^{12}$$

$$G2 := Q$$

$$G2 = 1.201 \times 10^{12}$$

$$Pa := \frac{P}{1.5 \cdot 10^6}$$

$$Pa = 1.787$$

$$\frac{N}{MM^2}$$

As the required pressure is 0.520 N/SQ.MM ,the ring section provided is safe.

Provide 32 x 150 @1250 mm as rings

Upper Vertical Bend at EL 155.75 to 139.75

t= required elbow wall thickness in mm

p=design pressure in N/mm²

D=outer diameter of elbow in mm

f=allowable tensile stress at design pressure in N/mm²

S=segment length along inside of elbow in mm

θ= segment deflection angle in radians

$$p := 0.748$$

$$d := 8000$$

$$t := 22$$

$$f := 206.6$$

$$D := d + 2 \cdot t$$

$$D = 8.044 \times 10^3$$

$$\theta := 6.4286 \cdot \frac{\pi}{180}$$

$$R := 16000 \text{ mm}$$

$$S := 2 \cdot R \cdot \tan\left(\frac{\theta}{2}\right) \quad S = 1.797 \times 10^3 \text{ mm}$$

$$t := \frac{p \cdot D}{S \cdot f} \cdot \left(\frac{D}{3} \cdot \tan\left(\frac{\theta}{2}\right) + \frac{S}{2} \right) \quad t = 17.002$$

Adopt t= 22

EL : 155.75 to 139.75 M ASTM A 537 CL-I (For External Pressure)

NSL LEVEL = 205 M

PENSTOCK EL = 139.75 M

EXT PR. = 0.653 N/MM²

$$R := 4.0$$

$$t := 0.022$$

$$F := 345000000$$

$$y_{\alpha} := 0.0003 \cdot R$$

$$f_s := 5.265$$

$$k := 2 \cdot \frac{R}{t}$$

$$k = 363.636$$

$$E := 200345000000$$

$$f_{\alpha} := \frac{F}{f_s}$$

$$f_n = 6.553 \times 10^7$$

$$\frac{E1}{\mu} := \frac{E}{0.91} \quad E1 = 2.202 \times 10^{11}$$

$$f_{1k} := \frac{F}{0.88882} \quad f_1 = 3.882 \times 10^8$$

$$A := \left(\frac{y_0}{R} + \frac{f_n}{E1} \right) \cdot \left(1 + 3 \cdot k^2 \cdot \frac{f_n}{E1} \right)^{\frac{3}{2}} \quad A = 0.776$$

$$B := 1.68 \cdot k \cdot \frac{f_1 - f_n}{E1} \cdot \left(1 - \frac{k}{4} \cdot \frac{f_1 - f_n}{E1} \right) \quad B = 0.776$$

$$P_{crk} := \left[1 - 0.175 \cdot \frac{k \cdot (f_1 - f_n)}{E1} \right] \cdot 2 \cdot \frac{f_n}{k} \quad P_{cr} = 3.268 \times 10^5$$

$$P_{cr1} := \frac{P_{cr}}{1.5 \cdot 1000000} \quad P_{cr1} = 0.218 \quad \frac{N}{MM^2}$$

As calculated pressure is less than required pressure, rings are required.

$$d := 8.0 \quad M \quad t := 0.022 \quad M \quad L := 0.90 \quad M \quad \frac{ES}{\mu} := 2.00345 \cdot 10^8 \quad \frac{KN}{M^2} \quad \mu := 0.30$$

$$k := \frac{d}{t} \quad \lambda := \frac{L}{t} \quad \frac{E1}{1 - \mu^2} \quad n := 18$$

$$P_{crw} := 2 \cdot \frac{E1}{k} \left[\frac{1 - \mu^2}{(n^2 - 1) \cdot \left(1 + \frac{4 \cdot n^2 \cdot \lambda^2}{\pi^2 \cdot k^2} \right)^2} + \frac{1}{3 \cdot k^2} \left[(n^2 - 1) + \frac{2 \cdot n^2 - 1 - \mu}{\frac{4 \cdot n^2 \cdot \lambda^2 - 1}{\pi^2 \cdot k^2}} \right] \right] \quad P_{cr} = 2.655 \times 10^3 \quad \frac{KN}{M^2}$$

$$P_{cr1} := \frac{P_{cr}}{1.5 \cdot 1000} \quad P_{cr1} = 1.77 \quad \frac{KN}{M^2} \quad \text{SAFE}$$

SIZE OF Stiffener Rings

F = allowable yield strength in N /sq.M

$$E_{\text{st}} := \frac{ES \cdot 1000}{(1 - \mu^2)} \quad \frac{\text{N}}{\text{M}^2} \quad F_{\text{st}} := \frac{345000000}{1.5} \quad \frac{\text{N}}{\text{M}^2}$$

$$L_{\text{st}} := 0.9 \quad \text{M} \quad \gamma_{\text{st}} := 0.0003 \cdot F \cdot \text{M}$$

$$t_{\text{st}} := \frac{22}{1000} \quad \text{M} \quad h_{\text{st}} := \frac{150}{1000} \quad \text{M} \quad d := 8.0 \quad \text{M}$$

$$l := t_{\text{st}} + 1.56 \sqrt{\frac{d}{2}} \cdot t \quad A := t_{\text{st}} \cdot h_{\text{st}} + l \cdot t \quad A_{\text{st}} := t_{\text{st}} \cdot h_{\text{st}} \quad R := \frac{8.0}{2} = 4$$

$$X := \frac{l \cdot \frac{t}{2} + t_{\text{st}} \cdot h_{\text{st}} \cdot \left(t + \frac{h_{\text{st}}}{2} \right)}{A} \quad X = 0.031$$

$$I := \frac{l \cdot t^3}{12} + l \cdot t \cdot \left(X - \frac{t}{2} \right)^2 + \frac{t_{\text{st}} \cdot h_{\text{st}}^3}{12} + t_{\text{st}} \cdot h_{\text{st}} \cdot \left(\frac{h_{\text{st}}}{2} + t - X \right)^2$$

$$V := h_{\text{st}} + t - X \quad t_1 := t + \frac{A_r}{l}$$

$$K_{1v} := \frac{R^4}{E1 \cdot t1} \quad K_1 = 4.036 \times 10^{-8}$$

$$K_{2v} := R^3 \cdot \left(\frac{y_0}{R} + \frac{l}{R \cdot V \cdot A} \right) \quad K_2 = 0.225$$

$$K_{3v} := l \cdot F \cdot \frac{t1}{A \cdot V} \cdot \left(\frac{l}{A \cdot V} + R \right) \quad K_3 = 3.418 \times 10^5$$

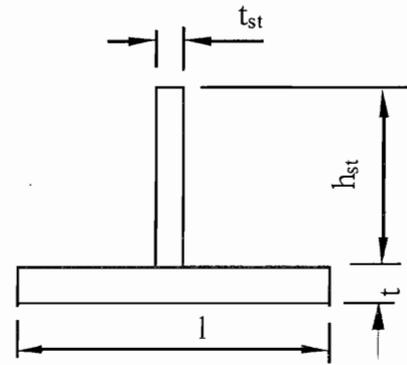
$$K_{4v} := \frac{l^2 \cdot F^2 \cdot t^2}{4 \cdot A^2 \cdot V^2 \cdot R} \quad K_4 = 2.645 \times 10^8$$

Vary P and check whether provided rings can take the load or not

$$P := 2680000$$

$$M := K_1 \cdot P^3 \quad M = 7.77 \times 10^{11}$$

$$N := K_2 \cdot P^2 \quad N = 1.615 \times 10^{12}$$



965Z

$$Q := K_3 \cdot P$$

$$Q = 9.161 \times 10^{11}$$

$$Z := K_4$$

$$Z = 2.645 \times 10^8$$

$$G1 := M + N + Z$$

$$G1 = 2.393 \times 10^{12}$$

$$G2 := Q$$

$$G2 = 9.161 \times 10^{11}$$

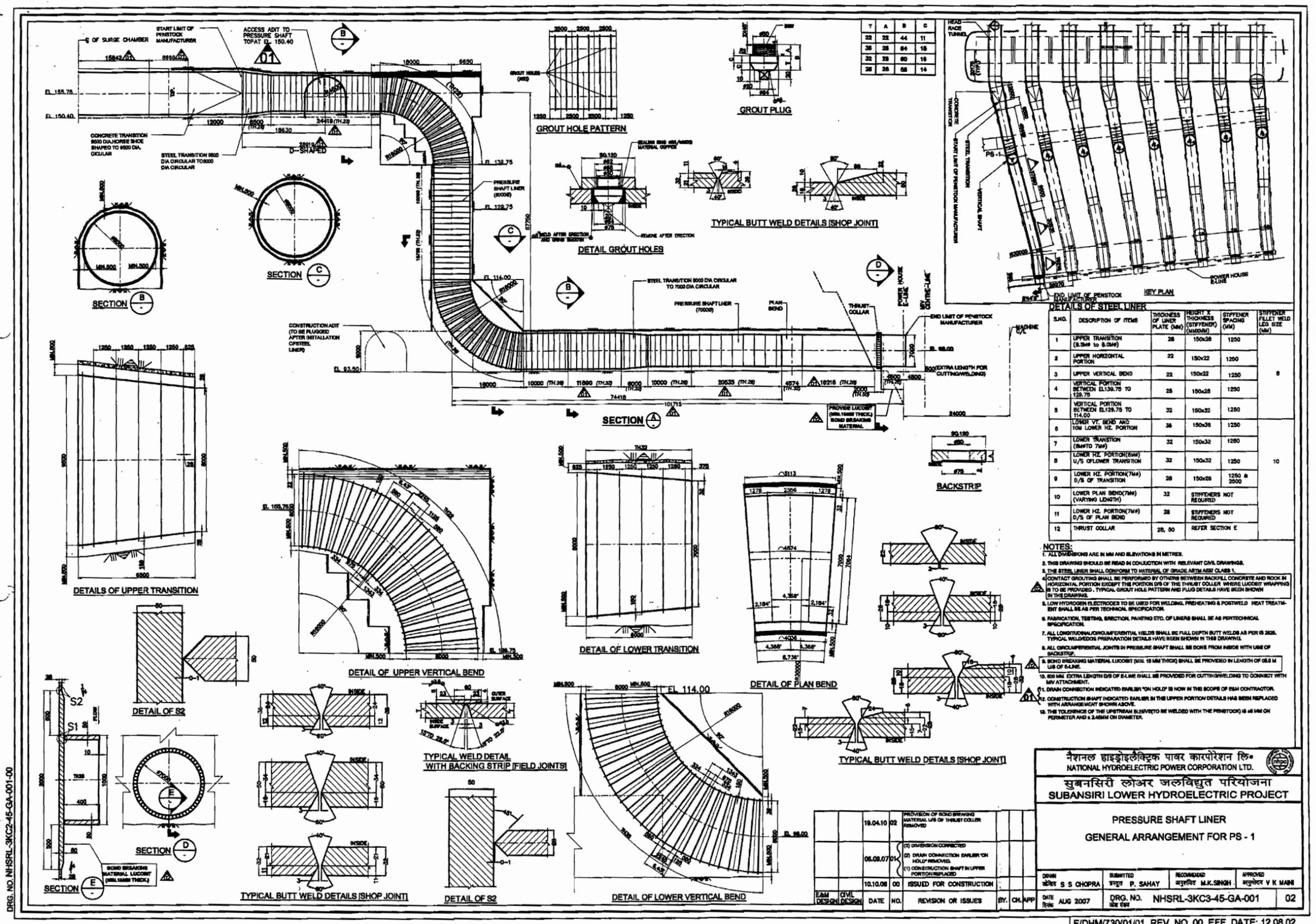
$$Pa := \frac{P}{1.5 \cdot 10^6}$$

$$Pa = 1.787$$

$$\frac{N}{MM^2}$$

As the required pressure is 0.653 N/SQ.MM ,the ring section provided is safe.

Provide 22 x 150 @900 mm as rings



T	A	B	C
22	22	44	11
32	28	84	18
32	28	80	18
28	28	68	14

S.NO.	DESCRIPTION OF ITEMS	THICKNESS OF LINER PLATE (MM)	HEIGHT X THICKNESS (STIFFENER) (MMxMM)	STIFFENER SPACING (MM)	STIFFENER FLLET WELD LEG SIZE (MM)
1	UPPER TRANSITION (8.5m to 8.0m)	28	150x28	1250	
2	UPPER HORIZONTAL PORTION	22	150x22	1250	
3	UPPER VERTICAL BEND	22	150x22	1250	
4	VERTICAL PORTION BETWEEN EL.134.75 TO 129.75	28	150x28	1250	
5	VERTICAL PORTION BETWEEN EL.129.75 TO 114.00	32	150x32	1250	
6	LOWER V.T. BEND AND 1/3 LOWER HZ. PORTION	36	150x36	1250	
7	LOWER TRANSITION (8m to 7m)	32	150x32	1250	
8	LOWER HZ. PORTION (8m) 1/3 OF LOWER TRANSITION	32	150x32	1250	10
9	LOWER HZ. PORTION (7m) 2/3 OF TRANSITION	28	150x28	1250	2500
10	LOWER PLAN BEND (7m) (VARYING LENGTH)	32			STIFFENERS NOT REQUIRED
11	LOWER HZ. PORTION (7m) 2/3 OF PLAN BEND	28			STIFFENERS NOT REQUIRED
12	THRUST COLLAR	28, 60			REFER SECTION E

- NOTES:**
- ALL DIMENSIONS ARE IN MM AND ELEVATIONS IN METRES.
 - THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH RELEVANT CIVIL DRAWINGS.
 - THE STEEL LINER SHALL CONFORM TO MATERIAL OF GRADE ASTM A572 CLASS 50.
 - CONTACT GROUTING SHALL BE PERFORMED BY OTHERS BETWEEN BACKFILL CONCRETE AND ROCK IN HORIZONTAL PORTION EXCEPT THE PORTION D/B OF THE THRUST COLLAR WHERE LUGOBT WRAPPING IS TO BE PROVIDED. TYPICAL GROUT HOLE PATTERN AND PLUG DETAILS HAVE BEEN SHOWN IN THIS DRAWING.
 - LOW HYDROGEN ELECTRODES TO BE USED FOR WELDING. PREHEATING & POSTWELD HEAT TREATMENT SHALL BE AS PER TECHNICAL SPECIFICATION.
 - FABRICATION, TESTING, SPECTATION, PAINTING ETC. OF LINERS SHALL BE AS PERTH TECHNICAL SPECIFICATION.
 - ALL LONGITUDINAL/CIRCUMFERENTIAL WELDS SHALL BE FULL DEPTH BUTT WELDS AS PER IS 2828. TYPICAL WELDING PREPARATION DETAILS HAVE BEEN SHOWN IN THIS DRAWING.
 - ALL CIRCUMFERENTIAL JOINTS IN PRESSURE SHAFT SHALL BE DONE FROM INSIDE WITH USE OF BACKSTRIP.
 - BOND BREAKING MATERIAL LUGOBT (MIN. 15 MM THICK) SHALL BE PROVIDED IN LENGTH OF 0.8 M LIS OF EACH.
 - 800 MM EXTRA LENGTH D/B OF S-LINE SHALL BE PROVIDED FOR CUTTING/WELDING TO CONNECT WITH NEW ATTACHMENT.
 - DRAIN CONNECTION INDICATED EARLIER 'ON HOLD' IS NOW IN THE SCOPE OF ESM CONTRACTOR.
 - CONSTRUCTION SHAFT INDICATED EARLIER IN THE UPPER PORTION DETAILS HAS BEEN REPLACED WITH ARRANGEMENT SHOWN ABOVE.
 - THE TOLERANCE OF THE UPSTREAM BUSH/TO BE WELDED WITH THE PENSTOCK IS 48 MM ON PERIMETER AND 2.48MM ON DIAMETER.

DATE	NO.	REVISION OR ISSUES	BY	CH. APP.
19.04.10	02	PROVISION OF BOND BREAKING MATERIAL USE OF THRUST COLLAR REMOVED		
06.08.07	01	(2) DIMENSION CORRECTED (3) DRAIN CONNECTION EARLIER 'ON HOLD' REMOVED (1) CONSTRUCTION SHAFT IN UPPER PORTION REPLACED		
10.10.08	00	ISSUED FOR CONSTRUCTION		

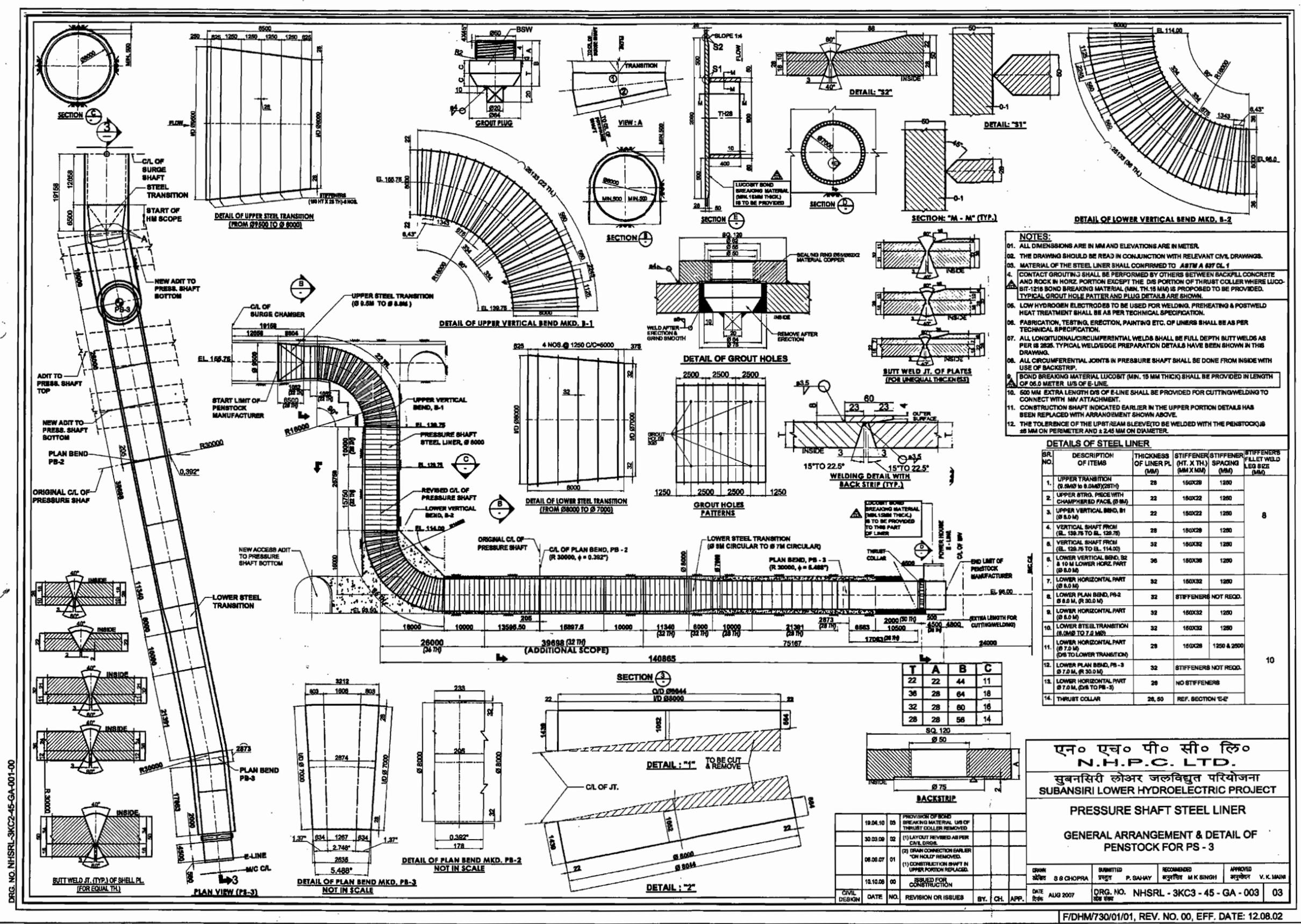
नेशनल हाइड्रोइलेक्ट्रिक पावर कारपोरेशन लि.
 NATIONAL HYDROELECTRIC POWER CORPORATION LTD.

सुबानसिरी लोअर जलविद्युत परियोजना
 SUBANSIRI LOWER HYDROELECTRIC PROJECT

PRESSURE SHAFT LINER
GENERAL ARRANGEMENT FOR PS - 1

DRWN S S CHOPRA	SUBMITTED P. SAHAY	RECOMMENDED M.K.SINGH	APPROVED V K MANN
DATE AUG 2007	DRG. NO. NHSRL-3KC3-45-GA-001	02	

DRG. NO. NHSRL-3KC2-45-GA-001-00



- NOTES:**
01. ALL DIMENSIONS ARE IN MM AND ELEVATIONS ARE IN METER.
 02. THE DRAWING SHOULD BE READ IN CONJUNCTION WITH RELEVANT CIVIL DRAWINGS.
 03. MATERIAL OF THE STEEL LINER SHALL CONFORM TO ASTM A 517 CL. 1
 04. CONTACT GROUTING SHALL BE PERFORMED BY OTHERS BETWEEN BACKFILL CONCRETE AND ROCK IN HORIZ. PORTION EXCEPT THE DIS. PORTION OF THRUST COLLAR WHERE LUCO-BIT-1216 BOND BREAKING MATERIAL (MIN. TH. 15 MM) IS PROPOSED TO BE PROVIDED. TYPICAL GROUT HOLE PATTERN AND PLUG DETAILS ARE SHOWN.
 05. LOW HYDROGEN ELECTRODES TO BE USED FOR WELDING. PREHEATING & POSTWELD HEAT TREATMENT SHALL BE AS PER TECHNICAL SPECIFICATION.
 06. FABRICATION, TESTING, ERECTION, PAINTING ETC. OF LINERS SHALL BE AS PER TECHNICAL SPECIFICATION.
 07. ALL LONGITUDINAL/CIRCUMFERENTIAL WELDS SHALL BE FULL DEPTH BUTT WELDS AS PER IS 2825. TYPICAL WELD EDGE PREPARATION DETAILS HAVE BEEN SHOWN IN THIS DRAWING.
 08. ALL CIRCUMFERENTIAL JOINTS IN PRESSURE SHAFT SHALL BE DONE FROM INSIDE WITH USE OF BACKSTRIP.
 09. BOND BREAKING MATERIAL LUCO-BIT (MIN. 15 MM THICK) SHALL BE PROVIDED IN LENGTH OF 05.0 METER U/S OF E-LINE.
 10. 500 MM EXTRA LENGTH D/S OF E-LINE SHALL BE PROVIDED FOR CUTTING/WELDING TO CONNECT WITH MV ATTACHMENT.
 11. CONSTRUCTION SHAFT INDICATED EARLIER IN THE UPPER PORTION DETAILS HAS BEEN REPLACED WITH ARRANGEMENT SHOWN ABOVE.
 12. THE TOLERANCE OF THE UPSTREAM SLEEVE TO BE WELDED WITH THE PENSTOCK IS 58 MM ON PERIMETER AND ± 2.45 MM ON DIAMETER.

DETAILS OF STEEL LINER

SRL NO.	DESCRIPTION OF ITEMS	THICKNESS OF LINER PL. (MM)	STIFFENER (HT. X TH.) (MM X MM)	STIFFENER SPACING (MM)	STIFFENERS FILED WELD LEG SIZE (MM)
1.	UPPER TRANSITION (Ø 800 TO Ø 800) (28T)	28	160X28	1200	
2.	UPPER STRG. PIECE WITH CHAMFERED FACE (Ø 800)	22	160X22	1200	
3.	UPPER VERTICAL BEND, B1 (Ø 8.0 M)	22	160X22	1200	8
4.	VERTICAL SHAFT FROM (EL. 139.75 TO EL. 129.75)	28	160X28	1200	
5.	VERTICAL SHAFT FROM (EL. 129.75 TO EL. 114.00)	32	160X32	1200	
6.	LOWER VERTICAL BEND, B2 (Ø 8.0 M, R 30.0 M)	36	160X36	1200	
7.	LOWER HORIZONTAL PART (Ø 8.0 M)	32	160X32	1200	
8.	LOWER PLAN BEND, PB-2 (Ø 8.0 M, R 30.0 M)	32	STIFFENERS NOT RECD.		
9.	LOWER HORIZONTAL PART (Ø 8.0 M)	32	160X32	1200	
10.	LOWER STEEL TRANSITION (Ø 800 TO Ø 800)	32	160X32	1200	
11.	LOWER HORIZONTAL PART (Ø 7.0 M, (D/S TO LOWER TRANSITION))	28	160X28	1250 & 2000	10
12.	LOWER PLAN BEND, PB-3 (Ø 7.0 M, R 30.0 M)	32	STIFFENERS NOT RECD.		
13.	LOWER HORIZONTAL PART (Ø 7.0 M, (D/S TO PB-3))	28	NO STIFFENERS		
14.	THRUST COLLAR	28, 50	REF. SECTION 'E-E'		

T A B C

22	22	44	11
36	28	64	18
32	28	60	16
28	28	56	14

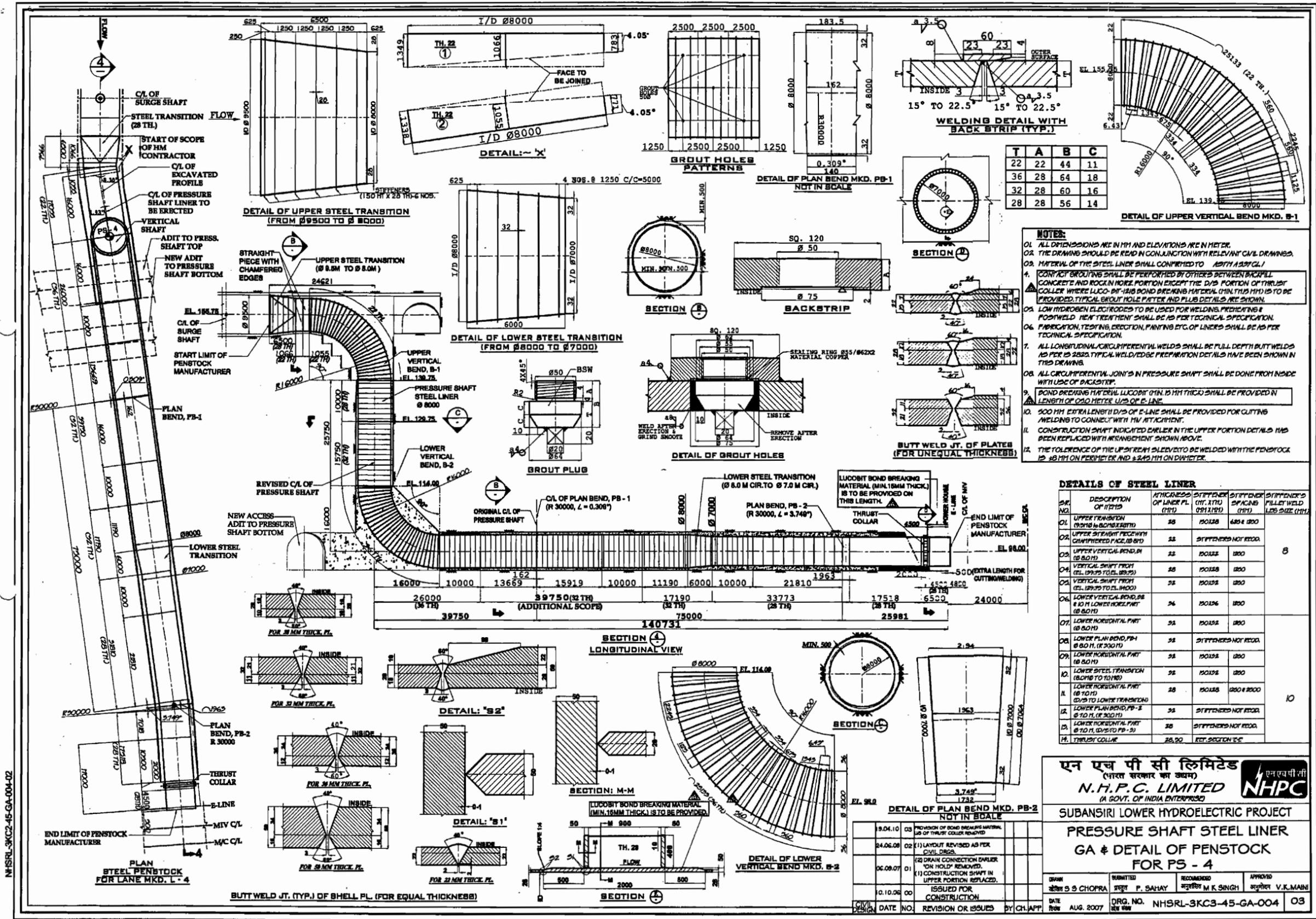
एन० एच० पी० सी० लि०
N.H.P.C. LTD.
 सुबंसिरी लोअर जलविद्युत परियोजना
 SUBANSIRI LOWER HYDROELECTRIC PROJECT

**PRESSURE SHAFT STEEL LINER
 GENERAL ARRANGEMENT & DETAIL OF
 PENSTOCK FOR PS - 3**

DATE	NO.	REVISION OR ISSUE	BY	CHK.	APP.
19.04.10	03	PROVISION OF BOND BREAKING MATERIAL. USE OF THRUST COLLAR REMOVED.			
30.03.09	02	(1) LAYOUT REVISED AS PER CIVIL DRS.			
06.08.07	01	(1) DRAIN CONNECTION EARLIER 'ON HOLD' REMOVED. (1) CONSTRUCTION SHAFT IN UPPER PORTION REPLACED.			
10.10.06	00	ISSUED FOR CONSTRUCTION			

DRWN	SUBMITTED	RECOMMENDED	APPROVED
संश्लेषक S S CHOPRA	प्रेषक P. SAHAY	संश्लेषक M K BINGH	अनुमोदित V. K. MAUN

DATE: AUG 2007
 DRG. NO. NHSRL - 3KC3 - 45 - GA - 003
 03



NOTES:

1. ALL DIMENSIONS ARE IN MM AND ELEVATIONS ARE IN METER.
2. THE DRAWING SHOULD BE READ IN CONJUNCTION WITH RELEVANT C/A/L DRAWINGS.
3. MATERIAL OF THE STEEL LINER SHALL CONFORM TO IS 2062 (A307) C/L.
4. CONTACT GROUTING SHALL BE PERFORMED BY OTHERS BETWEEN BACKFILL CONCRETE AND ROCK IN HORIZ. PORTION EXCEPT THE D/S PORTION OF THRUST COLLAR WHERE LUGO-BIT BOND BREAKING MATERIAL (MIN. 15MM THICK) IS TO BE PROVIDED. TYPICAL GROUT HOLE PATTERN AND PLUG DETAILS ARE SHOWN.
5. LOW HYDROGEN ELECTRODES TO BE USED FOR WELDING. PREHEATING & POSTWELD HEAT TREATMENT SHALL BE AS PER TECHNICAL SPECIFICATION.
6. FABRICATION, TESTING, ERECTION, PAINTING ETC. OF LINERS SHALL BE AS PER TECHNICAL SPECIFICATION.
7. ALL LONGITUDINAL/CIRCUMFERENTIAL WELDS SHALL BE FULL DEPTH BUTT WELDS AS PER IS 2825. TYPICAL WELD/EDGE PREPARATION DETAILS HAVE BEEN SHOWN IN THIS DRAWING.
8. ALL CIRCUMFERENTIAL JOINTS IN PRESSURE SHAFT SHALL BE DONE FROM INSIDE WITH USE OF BACKSTRIP.
9. BOND BREAKING MATERIAL LUGO-BIT (MIN. 15MM THICK) SHALL BE PROVIDED IN LENGTH OF 0.50 METER UPS/D/S OF E-LINE.
10. 500 MM EXTRA LENGTH D/S OF E-LINE SHALL BE PROVIDED FOR CUTTING WELDING TO CONNECT WITH HV ATTACHMENT.
11. CONSTRUCTION SHOWN INDICATED EARLIER IN THE UPPER PORTION DETAILS HAS BEEN REPLACED WITH REARRANGEMENT SHOWN ABOVE.
12. THE TOLERANCE OF THE UPSTREAM SLEEVES TO BE WELDED WITH THE PENSTOCK IS ±5 MM ON PERIMETER AND ±2.45 MM ON DIAMETER.

DETAILS OF STEEL LINER

SR. NO.	DESCRIPTION OF ITEMS	THICKNESS OF LINER PL. (MM)	STIFFENER (HT. (MM) (X) X (MM) (Y))	STIFFENER SPACING (MM)	STIFFENER FILLET WELD L/S SIZE (MM)
01	UPPER TRANSITION (2500 x 8000 x 2500)	28	150x28	680 x 1200	
02	UPPER STRAIGHT PIECE WITH CHAMFERED EDGE, (8000)	28	STIFFENERS NOT RECD.		8
03	UPPER VERTICAL BEND, B-1 (8000 H)	28	150x28	1200	
04	VERTICAL SHAFT FROM EL. 128.75 TO EL. 138.75	28	150x28	1200	
05	VERTICAL SHAFT FROM EL. 138.75 TO EL. 140.00	28	150x28	1200	
06	LOWER VERTICAL BEND, B-2 (8000 H)	28	150x28	1200	
07	LOWER HORIZONTAL PART (8000 H)	28	150x28	1200	
08	LOWER PLAN BEND, PB-1 (8000 H, R 30000)	28	STIFFENERS NOT RECD.		
09	LOWER HORIZONTAL PART (8000 H)	28	150x28	1200	
10	LOWER STEEL TRANSITION (8000 H TO 7000 H)	28	150x28	1200	
11	LOWER HORIZONTAL PART (8000 H) (D/S TO LOWER TRANSITION)	28	150x28	1200 x 2000	10
12	LOWER PLAN BEND, PB-2 (8000 H, R 30000)	28	STIFFENERS NOT RECD.		
13	LOWER HORIZONTAL PART (8000 H) (U/S TO PB-2)	28	STIFFENERS NOT RECD.		
14	THRUST COLLAR	28, 20	SEE SECTION E-E		

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NHPC

SUBANSIRI LOWER HYDROELECTRIC PROJECT

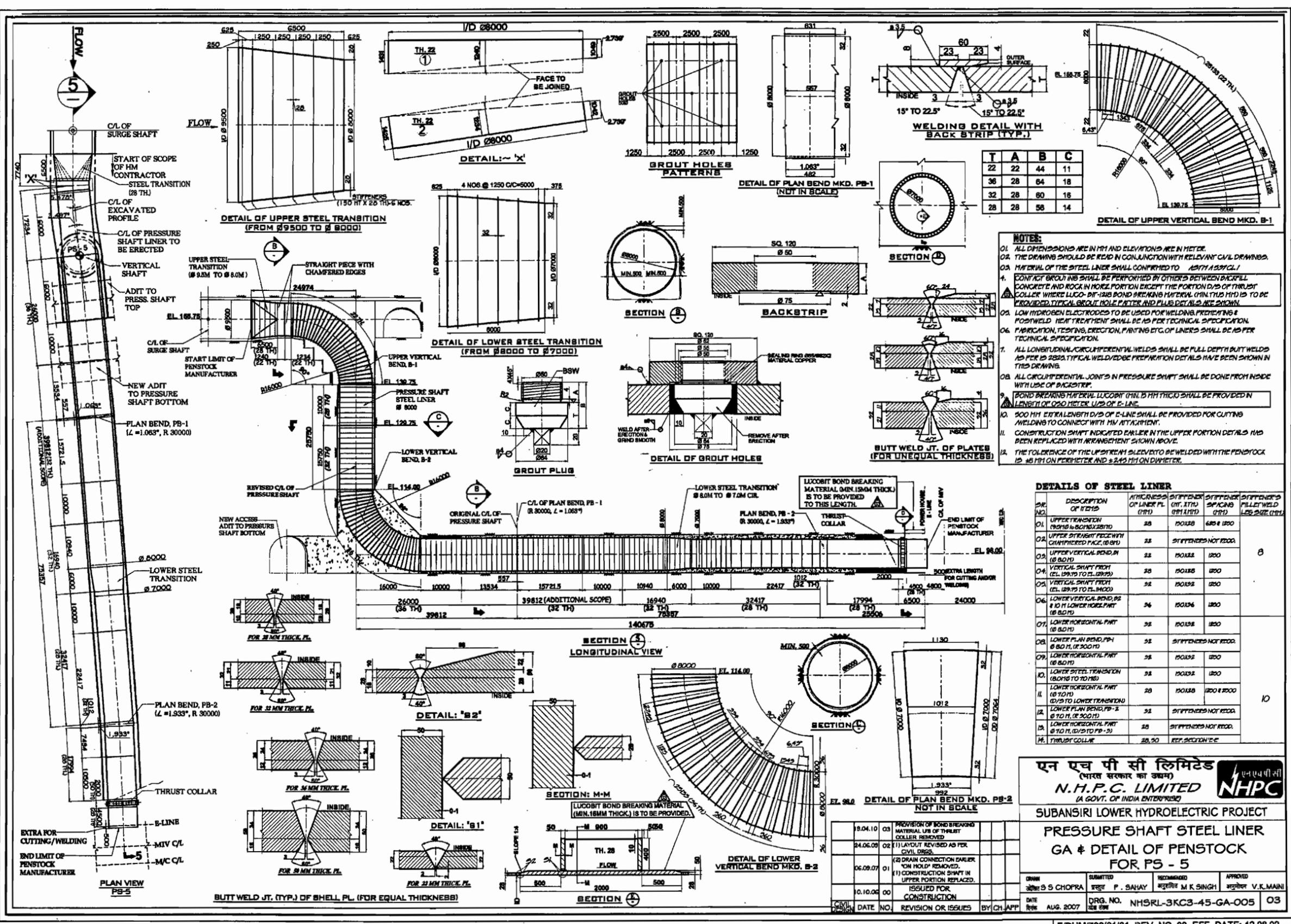
PRESSURE SHAFT STEEL LINER
GA & DETAIL OF PENSTOCK
FOR PS - 4

DRWN	REVISIT	RECHECKED	APPROVED
श्रीराम S S CHOPRA	श्रीराम P. SAHAY	श्रीराम M. K. SINGH	श्रीराम V. K. MAINI
DATE	REV	DATE	REV
AUG. 2007	03		

DRG. NO. NHSRL-3KC3-45-GA-004

DATE NO. REVISION OR ISSUES BY CH. APP.

NHSRL-3KC2-45-GA-005-02



T	A	B	C
22	22	44	11
36	28	64	18
32	28	60	16
28	28	56	14

- NOTES:**
01. ALL DIMENSIONS ARE IN MM AND ELEVATIONS ARE IN METER.
 02. THE DRAWING SHOULD BE READ IN CONJUNCTION WITH RELEVANT CIVIL DRAWINGS.
 03. MATERIAL OF THE STEEL LINER SHALL CONFORM TO IS 4371 (BS 4361).
 04. CONTACT GROUTING SHALL BE PERFORMED BY OTHERS BETWEEN BACKFILL CONCRETE AND ROCK IN HOPE PORTION EXCEPT THE PORTION D/D OF THRUST COLLAR WHERE LUGOIT BOND BREAKING MATERIAL (MIN. 16MM THICK) IS TO BE PROVIDED. TYPICAL GROUT HOLE PATTERN AND PLAN DETAILS ARE SHOWN.
 05. LOW HYDROGEN ELECTRODES TO BE USED FOR WELDING. PREHEATING & POSTWELD HEAT TREATMENT SHALL BE AS PER TECHNICAL SPECIFICATION.
 06. FABRICATION, TESTING, ERECTION, PAINTING ETC. OF LINERS SHALL BE AS PER TECHNICAL SPECIFICATION.
 07. ALL LONGITUDINAL/CIRCUMFERENTIAL WELDS SHALL BE FULL DEPTH BUTT WELDS AS PER IS 2825. TYPICAL WELD/EDGE PREPARATION DETAILS HAVE BEEN SHOWN IN THIS DRAWING.
 08. ALL CIRCUMFERENTIAL JOINTS IN PRESSURE SHAFT SHALL BE DONE FROM INSIDE WITH USE OF BACKSTRIP.
 09. BOND BREAKING MATERIAL LUGOIT (MIN. 16MM THICK) SHALL BE PROVIDED IN LENGTH OF 0.20 METER 1/20 OF E-LINE.
 10. 300 MM EXTRA LENGTH D/D OF E-LINE SHALL BE PROVIDED FOR CUTTING/WELDING TO CONNECT WITH HM ATTACHMENT.
 11. CONSTRUCTION SHAFT INDICATED EARLIER IN THE UPPER PORTION DETAILS HAS BEEN REPLACED WITH ARRANGEMENT SHOWN ABOVE.
 12. THE TOLERANCE OF THE UPSTREAM SLEEVE TO BE WELDED WITH THE PENSTOCK IS ±5 MM ON PERIMETER AND ±2.45 MM ON DIAMETER.

DETAILS OF STEEL LINER

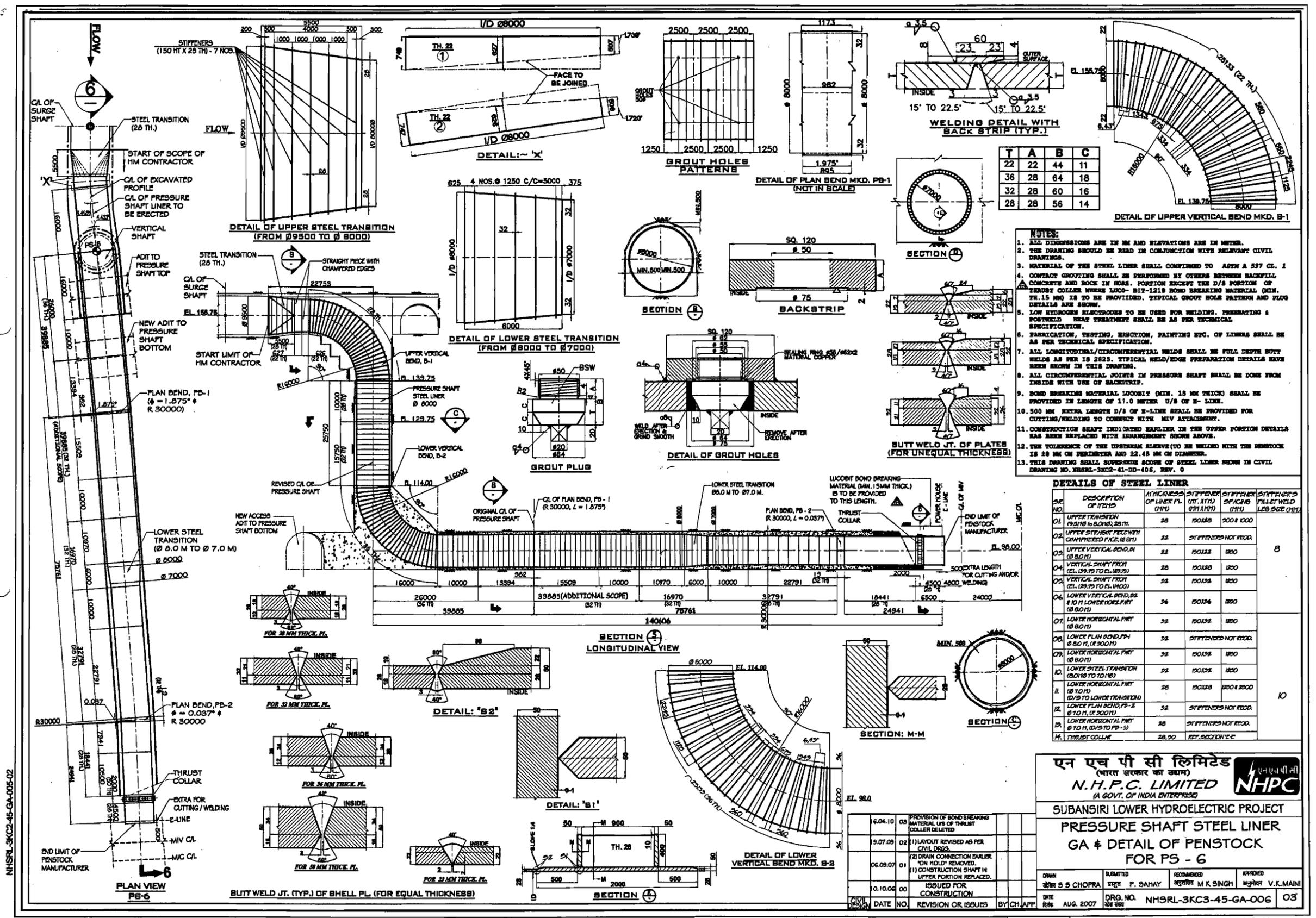
SR. NO.	DESCRIPTION OF ITEMS	THICKNESS OF LINER PL. (MM)	DIFFERENCES (INT. DIA) (MM)	DIFFERENCES (EXT. DIA) (MM)	DIFFERENCES PILET WELD LEG SIZE (MM)
01	UPPER TRANSITION (BONG TO BONG) (Ø 8000)	28	150X28	680 & 1200	
02	UPPER STRAIGHT PIECE WITH CHAMFERED ENDS (Ø 8000)	28	DIFFERENCES NOT RECD.		
03	UPPER VERTICAL BEND, B-1 (Ø 8000)	28	150X28	1200	8
04	VERTICAL SHAFT FROM (EL. 129.75 TO EL. 136.75)	28	150X28	1200	
05	VERTICAL SHAFT FROM (EL. 129.75 TO EL. 122.75)	28	150X28	1200	
06	LOWER VERTICAL BEND, B-2 (Ø 8000)	28	150X28	1200	
07	LOWER HORIZONTAL PART (Ø 8000)	28	150X28	1200	
08	LOWER PLAN BEND, PB-1 (Ø 8000, L=1.083)	28	DIFFERENCES NOT RECD.		
09	LOWER HORIZONTAL PART (Ø 8000)	28	150X28	1200	
10	LOWER STEEL TRANSITION (BONG TO TO HB)	28	150X28	1200	10
11	LOWER HORIZONTAL PART (Ø 7000)	28	150X28	1200 & 1200	
12	LOWER PLAN BEND, PB-2 (Ø 7000, L=1.933)	28	DIFFERENCES NOT RECD.		
13	LOWER HORIZONTAL PART (Ø 7000, D/D TO PB-2)	28	DIFFERENCES NOT RECD.		
14	THRUST COLLAR	28, 20	REF. SECTION 'E'		

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SUBANSIRI LOWER HYDROELECTRIC PROJECT
PRESSURE SHAFT STEEL LINER
GA & DETAIL OF PENSTOCK
FOR PS - 5

DRWN	SUBMITTED	RECOMMENDED	APPROVED
श्री 5 S CHOPRA	श्री P. SAHAY	श्री M K SINGH	श्री V.K. MAINI
DATE	DRG. NO.	NHSRL-3KC3-45-GA-005	03
28.08.07	REV. NO.		

F/DHM730/01/01, REV. NO. 00, EFF. DATE: 12.08.02



	A	B	C
22	22	44	11
36	28	64	18
32	28	60	16
28	28	56	14

- NOTES:**
1. ALL DIMENSIONS ARE IN MM AND ELEVATIONS ARE IN METERS.
 2. THE DRAWING SHOULD BE READ IN CONJUNCTION WITH RELEVANT CIVIL DRAWINGS.
 3. MATERIAL OF THE STEEL LINER SHALL CONFORM TO AS EN 537 CL. 1.
 4. CONTACT GROUTING SHALL BE PERFORMED BY OTHERS EXCEPT THE D/S PORTION OF THRUST COLLAR WHERE LUGS-BIT-1218 BOND BREAKING MATERIAL (MIN. 15 MM THK) IS TO BE PROVIDED. TYPICAL GROUT HOLE PATTERN AND PVD DETAILS ARE SHOWN.
 5. LOW HYDROGEN ELECTRODES TO BE USED FOR WELDING. PREHEATING & POSTWELD HEAT TREATMENT SHALL BE AS PER TECHNICAL SPECIFICATION.
 6. FABRICATION, TESTING, INSPECTION, PAINTING ETC. OF LINERS SHALL BE AS PER TECHNICAL SPECIFICATION.
 7. ALL LONGITUDINAL/CIRCUMFERENTIAL WELDS SHALL BE FULL DEPTH BUTT WELDS AS PER IS 2825. TYPICAL WELD/EDGE PREPARATION DETAILS HAVE BEEN SHOWN IN THIS DRAWING.
 8. ALL CIRCUMFERENTIAL JOINTS IN PRESSURE SHAFT SHALL BE DONE FROM INSIDE WITH USE OF BACKSTRIP.
 9. BOND BREAKING MATERIAL (MIN. 15 MM THICK) SHALL BE PROVIDED IN LENGTH OF 17.0 METERS U/S OF P-LINE.
 10. 500 MM KEEN LENGTH D/S OF P-LINE SHALL BE PROVIDED FOR CUTTING/WELDING TO CONNECT WITH NEW ATTACHMENT.
 11. CONSTRUCTION SHAFT INDICATED EARLIER IN THE UPPER PORTION DETAILS HAS BEEN REPLACED WITH ARRANGEMENT SHOWN ABOVE.
 12. THE TOLERANCE OF THE UPSTREAM RESERVE TO BE WELDED WITH THE HEBBROCK IS 28 MM ON PERIPHERY AND 12.45 MM ON DIAMETER.
 13. THIS DRAWING SHOWS SUPERSEDED SCOPE OF STEEL LINER SHOWN IN CIVIL DRAWING NO. NH3RL-3KC3-41-DD-406, REV. 0

DETAILS OF STEEL LINER

SR. NO.	DESCRIPTION OF ITEMS	THICKNESS OF LINER PL. (MM)	STIFFENERS (MT. KTY) @ (MT)	STIFFENERS SPACING (MT)	STIFFENERS FILLET WELD LEG SIZE (MM)
01	UPPER TRANSITION (Ø 8000 to Ø 8000), 28 TH.	28	15028	2000	1000
02	UPPER STRAIGHT PVD WITH CHAMFERED EDGES (Ø 8000)	22	STIFFENERS NOT REQR.		
03	UPPER VERTICAL BEND, B-1 (Ø 8000)	22	15028	1200	
04	VERTICAL SHAFT FROM (EL. 156.75 TO EL. 152.75)	28	15028	1200	
05	VERTICAL SHAFT FROM (EL. 152.75 TO EL. 114.00)	28	15028	1200	
06	LOWER VERTICAL BEND, B-2 (Ø 8000)	26	15028	1200	
07	LOWER HORIZONTAL PART (Ø 8000)	22	15028	1200	
08	LOWER PLAN BEND, PB-1 (Ø 8000 to Ø 7000)	22	STIFFENERS NOT REQR.		
09	LOWER HORIZONTAL PART (Ø 7000)	22	15028	1200	
10	LOWER STEEL TRANSITION (Ø 7000 to Ø 6000)	22	15028	1200	
11	LOWER HORIZONTAL PART (Ø 6000 TO LOWER TRANSITION)	28	15028	1200 & 2000	
12	LOWER PLAN BEND, PB-2 (Ø 6000 to Ø 5000)	22	STIFFENERS NOT REQR.		
13	LOWER HORIZONTAL PART (Ø 5000 TO P-2)	28	STIFFENERS NOT REQR.		
H	THRUST COLLAR	28, 20	REF. SECTION 'E'		

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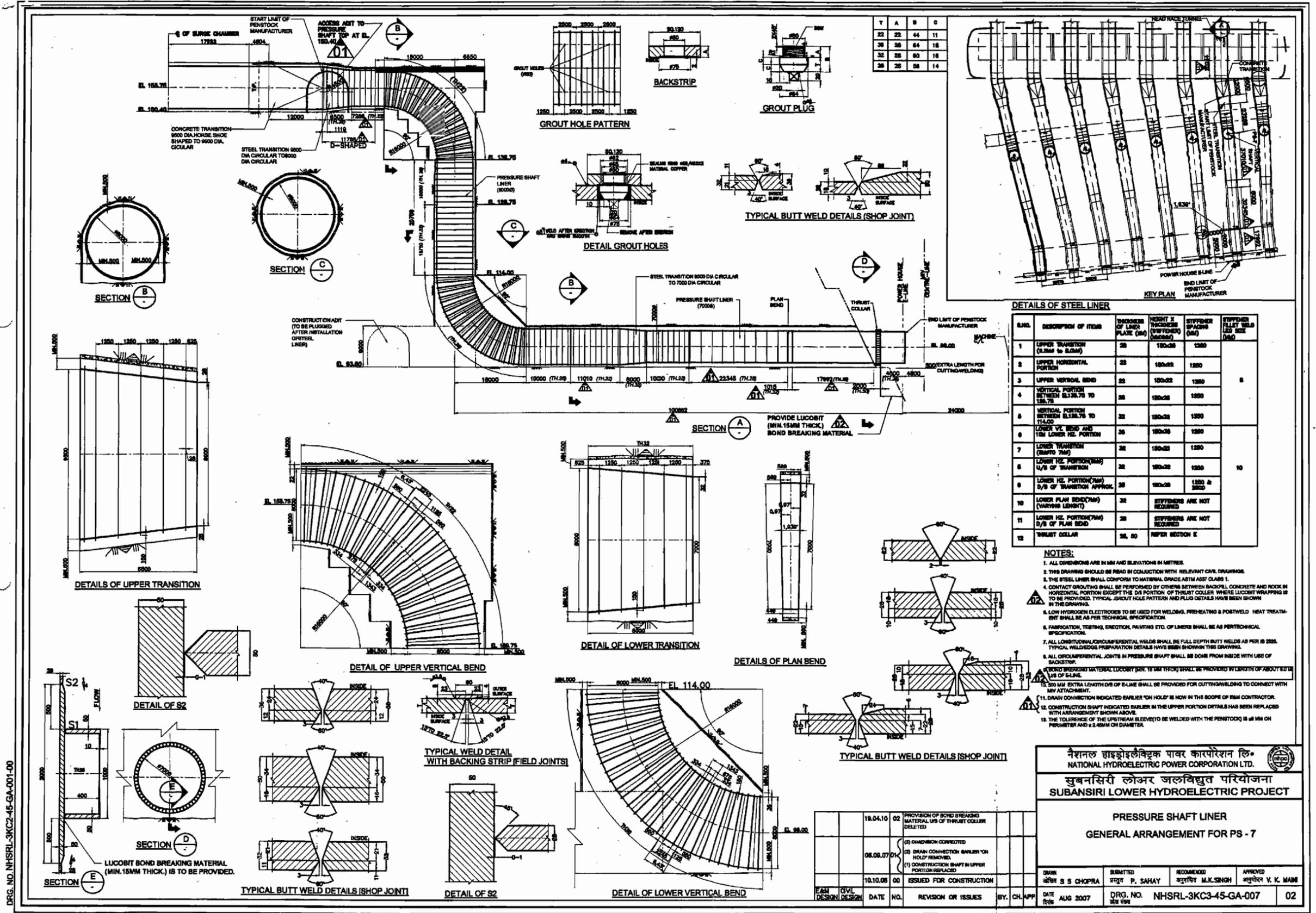
SUBANSIRI LOWER HYDROELECTRIC PROJECT
PRESSURE SHAFT STEEL LINER
GA & DETAIL OF PENSTOCK
FOR PS - 6

DATE	NO.	REVISION OR ISSUES	BY	APP.
06.04.10	03	PROVISION OF BOND BREAKING MATERIAL U/S OF THRUST COLLAR DELETED		
19.07.09	02	(1) LAYOUT REVISED AS PER CIVIL DESG.		
06.09.07	01	(2) DRAIN CONNECTION EARLIER 'ON HOLD' REMOVED. (1) CONSTRUCTION SHAFT IN UPPER PORTION REPLACED.		
10.10.06	00	ISSUED FOR CONSTRUCTION		

DATE: 08 AUG 2007
DRG. NO: NH3RL-3KC3-45-GA-006
REV: 03

NH3RL-3KC3-45-GA-006-02

155



DRG. NO. NHSRL-3KC2-45-GA-001-00

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NATIONAL HYDROELECTRIC POWER CORPORATION LTD.

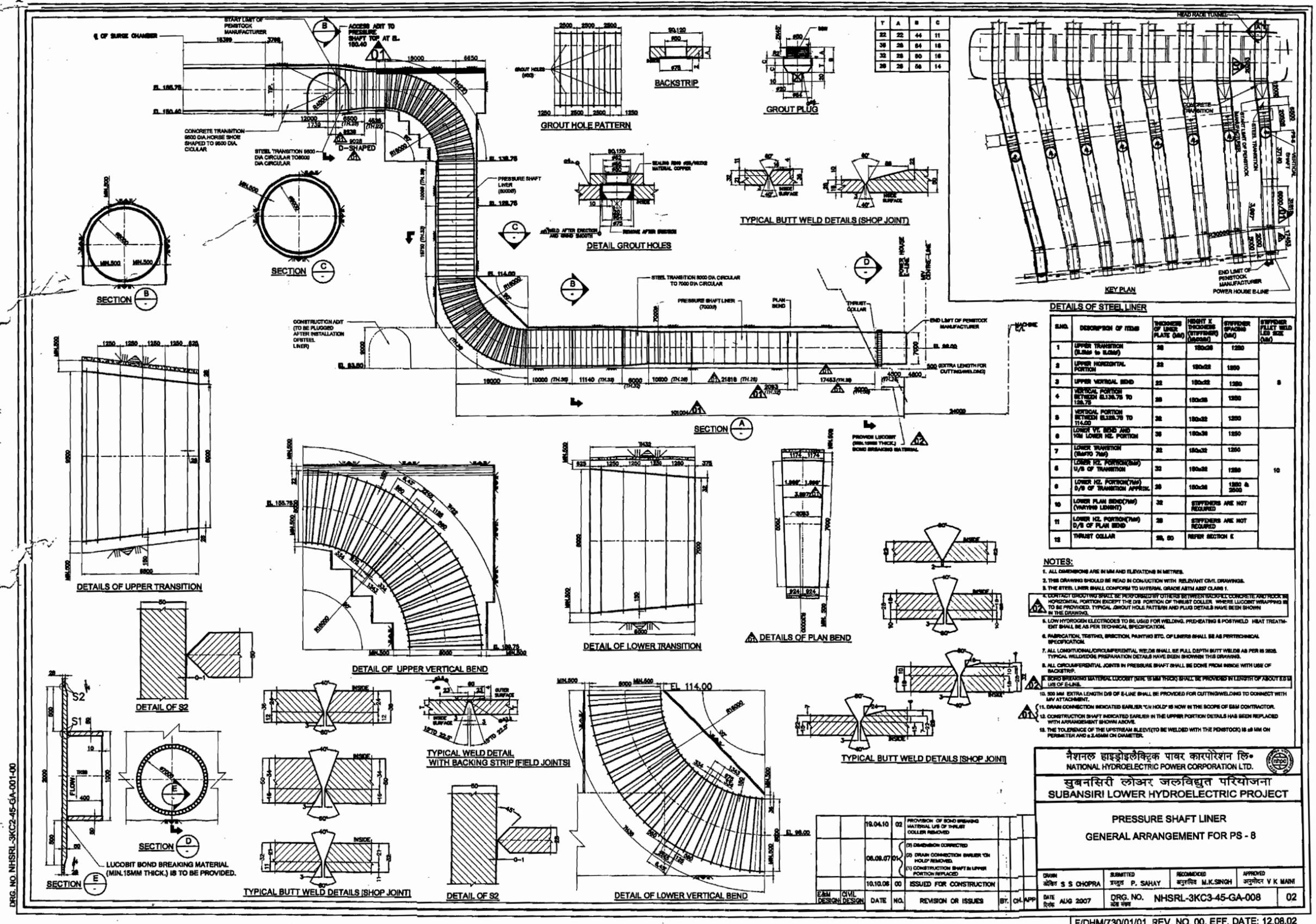
सुबानसिरी लोअर जलविद्युत परियोजना
SUBANSIRI LOWER HYDROELECTRIC PROJECT

PRESSURE SHAFT LINER
GENERAL ARRANGEMENT FOR PS - 7

DATE	NO.	REVISION OR ISSUES	BY	CH.	APP.
18.04.10	02	PROVISION OF BOND BREAKING MATERIAL L/S OF THRUST COLLAR DELETED			
06.09.07	01	(S) DIMENSION CORRECTED (D) DRAIN CONNECTION EARLIER 'ON HOLD' REMOVED (U) CONSTRUCTION SHAFT IN UPPER PORTION REPLACED			
10.10.06	00	ISSUED FOR CONSTRUCTION			

DRWN	SUBMITTED	RECOMMENDED	APPROVED
अशोक S S CHOPRA	अशोक P. SAHAY	अशोक M.K.SINGH	अशोक V. K. MANN

DATE: AUG 2007
DRG. NO. NHSRL-3KC3-45-GA-007



S.NO.	DESCRIPTION OF ITEMS	THICKNESS OF PLATE (MM)	HEIGHT X (STIFFENERS) (MM)	STIFFENER SPACING (MM)	STIFFENER FLEET WELD LEG SIZE (MM)
1	UPPER TRANSITION (S/S to E/S)	28	180x28	1200	
2	UPPER HORIZONTAL PORTION	28	180x28	1200	
3	UPPER VERTICAL BEND	28	180x28	1200	
4	VERTICAL PORTION BETWEEN EL.138.75 TO 158.75	28	180x28	1200	
5	VERTICAL PORTION BETWEEN EL.138.75 TO 114.00	28	180x28	1200	
6	LOWER V. PORTION (S/S TO LOWER HZ. PORTION)	28	180x28	1200	
7	LOWER TRANSITION (S/S TO HZ)	28	180x28	1200	
8	LOWER HZ. PORTION (S/S) 1/8 OF TRANSITION	28	180x28	1200	8
9	LOWER HZ. PORTION (S/S) 5/8 OF TRANSITION APPROX.	28	180x28	1200 & 2500	10
10	LOWER PLAN BEND (H/S) (WHOLE LENGTH)	28			STIFFENERS ARE NOT REQUIRED
11	LOWER HZ. PORTION (H/S) 5/8 OF PLAN BEND	28			STIFFENERS ARE NOT REQUIRED
12	THRUST COLLAR	28, 50			REFER SECTION E

- NOTES:**
- ALL DIMENSIONS ARE IN MM AND ELEVATIONS IN METRES.
 - THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH RELEVANT CIVIL DRAWINGS.
 - THE STEEL LINER SHALL CONFORM TO MATERIAL GRADE ASTM A572 GR. 50.
 - CONTACT SURFACES SHALL BE PROVIDED BY OTHER CONTRACTORS. CONCRETE AND ROCK IN HORIZONTAL PORTION EXCEPT THE D/S PORTION OF THRUST COLLAR, WHERE LUCOBIT WRAPPING IS TO BE PROVIDED. TYPICAL GROUT HOLE PATTERN AND PLUG DETAILS HAVE BEEN SHOWN IN THE DRAWINGS.
 - LOW HYDROGEN ELECTRODES TO BE USED FOR WELDING. PRE-HEATING & POSTWELD HEAT TREATMENT SHALL BE AS PER TECHNICAL SPECIFICATION.
 - FABRICATION, TESTING, INSPECTION, PAINTING ETC. OF LINERS SHALL BE AS PER TECHNICAL SPECIFICATION.
 - ALL LONGITUDINAL/CIRCUMFERENTIAL WELDS SHALL BE FULL DEPTH BUTT WELDS AS PER IS 8083. TYPICAL WELDING PREPARATION DETAILS HAVE BEEN SHOWN IN THIS DRAWING.
 - ALL CIRCUMFERENTIAL JOINTS IN PRESSURE SHAFT SHALL BE DONE FROM INSIDE WITH USE OF BACKSTRIP.
 - BOND BREAKING MATERIAL LUCOBIT (MIN. 15MM THICK) SHALL BE PROVIDED IN LENGTHS OF ABOUT 500MM LIS OF S-LINE.
 - 300 MM EXTRA LENGTH D/S OF E-LINE SHALL BE PROVIDED FOR CUTTING/WELDING TO CONNECT WITH S/W ATTACHMENT.
 - DRAIN CONNECTION INDICATED EARLIER 'C/H HOLD' IS NOW IN THE SCOPE OF S/W CONTRACTOR.
 - CONSTRUCTION SHAFT INDICATED EARLIER IN THE UPPER PORTION DETAILS HAS BEEN REPLACED WITH ARRANGEMENT SHOWN ABOVE.
 - TOLERANCE OF THE UPSTREAM BLEEVE TO BE WELDED WITH THE PENSTOCK IS 28 MM ON PERIMETER AND 2.8MM ON DIAMETER.

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 NATIONAL HYDROELECTRIC POWER CORPORATION LTD.

सुबानसिरी लोअर जलविद्युत परियोजना
 SUBANSIRI LOWER HYDROELECTRIC PROJECT

PRESSURE SHAFT LINER
 GENERAL ARRANGEMENT FOR PS - 8

DRWN	S S CHOPRA	SUBMITTED	शश्वर P. SAHAY	RECOMMENDED	मनमोहन M.K.SINGH	APPROVED	जयदेव V K MAINI
DATE	AUG 2007	DRG. NO.	NHSRL-3KC3-45-GA-008	REV.			02

DATE	NO.	REVISION OR ISSUES	BY	CH. APP.
15.04.10	02	PROVISION OF BOND BREAKING MATERIAL LIS OF THRUST COLLAR REMOVED		
08.09.07	01	(1) DIMENSION CORRECTED (2) DRAIN CONNECTION BRASSER 'C/H HOLD' REMOVED (3) CONSTRUCTION SHAFT IN UPPER PORTION REPLACED		
10.10.06	00	ISSUED FOR CONSTRUCTION		

TEC

GOVERNMENT OF INDIA
CENTRAL ELECTRICITY AUTHORITY
SEWA BHAWAN : R.K. PURAM
NEW DELHI - 110066

File No.2/NHPC/26/01-PAC/267-34

Dated: 13th January, 2003.

OFFICE MEMORANDUM

Subject: 8x250 MW (2000 MW) Subansiri Lower Hydro-Electric Project in Arunachal Pradesh / Assam by National Hydro-Electric Power Corporation Limited (NHPC) at an Estimated Present Day Cost (at December, 2002 Price Level) of US \$ 39.648 Million + Rs.6418.37 Crores including IDC & FC of Rs.705.58 Crores at Foreign Exchange Rate of 1 US \$ = Rs.48.00 - Issue of Techno Economic Clearance.

With reference to letter No.NH/PD/PC/LS/695, dated 7.6.2001 from NHPC, submitting generation scheme under section 29 of the Electricity (Supply) Act, 1948 (returned on 24.7.2001 for want of tying-up of essential inputs / clearances and thereafter revived on 3.1.2003) and in accordance with the Ministry of Power letter No.16/23/99-DO(NHPC), dated 10.10.2002 under Section 18-A of E(S) Act, 1948, it is stated that the proposal for establishment of 8x250 MW (2000 MW) Subansiri Lower Hydro-Electric Project in Lower Subansiri / Dhemaji Districts in Arunachal Pradesh / Assam proposed by National Hydro-Electric Power Corporation Limited (NHPC), as specified in the Detailed Project Report and other documents, papers, notes etc. submitted by NHPC to CEA and various clarifications made in CEA Meeting and specified in the Agenda note circulated vide CEA letter No.3/106/256th/2001-PAC/35-57, dated 10.1.03 has been considered in the 256th Meeting of CEA held on 13.1.03 at Sewa Bhawan, R.K. Puram, New Delhi-110066. Subsequently, documents submitted by NHPC vide their various letters, latest being dated 13.1.2003 in pursuance to decisions taken in the above meetings, have also been considered.

2. In exercise of the powers vested with the Authority as per the GOI direction contained in the Gazette Notification vide F.No.2(ii)/76-EL II, dated 23.11.1977 issued under Section 4(B) of E(S) Act, 1948, the Central Electricity Authority accords techno-economic clearance to the aforesaid scheme at an Estimated Present Day Cost (at December, 2002 Price Level) of US \$ 39.648 Million + Rs.6418.37 Crores including IDC & FC of Rs.705.58 Crores at Foreign Exchange Rate of 1 US \$ = Rs.48.00, with the stipulations that:

- i) The completed cost of the scheme shall not exceed the above cost except on account of:-
 - a. Change in rates of Indian taxes and duties such as custom duty, excise duty, sales tax, works tax & service tax and additional taxes and duties levied, if any, subsequent to issue of techno-economic clearance.
 - b. Change in Indian Law resulting in change in cost.
 - c. Price variation formula agreed at the time of placement of order.

- ii) Interest During Construction and the Financing Charges shall be as per actuals but not exceeding the amount as indicated at Annex-I except for pro-rata variation on account of variations in hard cost as indicated in 2(i) a, b & c above.
- iii) The abstract of the Present Day Cost (at December, 2002 Price Level) approved by CEA is furnished at Annex-I, Summary of Financial Package, as submitted by NHPC and considered by CEA, is at Annex-II and the Salient Features of the Scheme are set-forth at Annex-III.
3. This techno-economic clearance is subject to the fulfillment of the following conditions:
- i) The following conditions/circumstances shall not be a re-opener of completed cost/ techno-economic clearance:
 - a) Non-acquisition of land.
 - b) Non-finalisation of Power Purchase Agreement.
 - c) Delay in obtaining investment approval for the project.
 - ii) NHPC shall take into account suggestions of GSI / CWC conveyed to NHPC from time to time at the time of detailed design. The additional investigation as suggested by GSI shall be carried out by NHPC and the results shall be submitted to CEA / CWC from time to time.
 - iii) NHPC shall obtain environmental and forest clearance of the project from MOE&F.
 - iv) Integrated flood studies including reservoir operation in respect of all three projects viz. Subansiri Upper, Subansiri Middle and Subansiri Lower shall be finalised in consultation with Brahmaputra Board and CWC before taking up execution of the Subansiri Lower Hydro-Electric Project.
 - v) NHPC have kept the rated head of the turbine at 86 m. NHPC shall examine the possibility of reducing the rated head so that higher peaking capability from the reservoirs could be achieved during low head condition.
 - vi) NHPC shall have to identify the prospective buyers for the power from the project and obtain the letters of comfort indicating the quantum of power.
 - vii) NHPC shall identify the agency for implementing the transmission system from the project to the beneficiaries.
 - viii) The civil cost estimate as cleared by Central Water Commission includes a provision of Rs.583.957 Crores on account of increase in quantities / extra items to take into account the observations of Central Water Commission on design aspects of various project components. Accordingly, no increase in the civil cost of the project shall be allowed at a later date on account of variation in the quantities of civil works except on account of geological surprises as approved by Expert Committee to be constituted by Ministry of Power, Government of India



- ix) A provision of Rs.164.70 Crores has been allowed in the civil cost for the procurement of Q-Special T&P considering the project would be executed departmentally. In case project is executed through contract, the requirement of Q-Special T&P shall be reassessed by the Project Authorities and only general purpose T&P alone be procured and resultant saving in the head of Q-Special T&P be passed on to the project.
- x) The moratorium period beyond Commercial Operating Date (COD) shall not be applicable for computation of tariff.
- xi) The tariff shall be decided by Central Electricity Regulatory Commission.
- xii) Submission of Final Financial Package shall be duly approved by the competent Government for approval of the Authority.
- xiii) Final Financial Package shall be approved by the Authority.
- xiv) The final financial package shall not be inferior to the tentative financial package (presently submitted by NHPC) adjusted for variation in hard cost and IDC.
- xv) In case of geological surprises, NHPC shall systematically maintain a record of geological surprises, that are encountered and treatment provided. At the same time, NHPC shall request Ministry of Power to constitute an Expert Committee consisting of representatives of concerned State Governments, Geological Survey of India, CWC and CEA. Once a Committee is constituted, NHPC shall submit their proposal for the enhanced cost to the Expert Committee, which in turn, shall examine and recommend the cost thereof.

4. The commissioning schedule of the project shall be as under (from the date of CEA Clearance):-

1 st & 2 nd Unit	-	77 th month
3 rd & 4 th Unit	-	81 st month
5 th & 6 th Unit	-	82 nd month
7 th & 8 th Unit	-	84 th month

5. (a) Monthly Progress Report of the project shall be submitted to Hydro-Monitoring Division of CEA. Three (3) copies of the semi-annual progress reports on physical progress of the scheme and expenditure actually incurred, duly certified by statutory auditors shall be submitted to the Authority till the Commercial Operating Date of the plant. The project promoters/project authorities shall give free accessibility to the CEA officers and staff to have on the spot assessment of various aspects of the project.

(b) Final Financial Package and issues related to that shall be submitted to Secretary, CEA.

6. Monthly status of the project from the period of TEC to Financial closure/ Investment decision shall be furnished to Secretary, CEA as per the proforma enclosed at Annex-IV.

SA

7. The completion cost of the scheme shall be submitted to the Authority duly recommended by Competent Government for approval as soon as possible after the Commercial Operating Date of the plant but not later than three (3) months from the Commercial Operating Date of the Plant. Authority shall be intimated the Commercial Operating Date duly certified by the Competent Government within two weeks from its occurrence.

8. The concurrence of CEA to the scheme under Section 31 of the Electricity (Supply) Act, 1948 shall be considered by the Authority on submission of Firm Financial Package (FFP) and tying-up of balance inputs/ clearances by the company within a period of six months from the date of issue of TEC.

9. In case the time gap between the Techno-Economic Clearance of the scheme by CEA and actual start of work on the project by the generating company is three years or more, a fresh Techno-Economic Clearance of CEA shall be obtained by the generating company before start of actual work.

10. The Authority reserves the right to revoke the Techno-Economic Clearance, if the conditions stipulated in this Office Memorandum are not complied with to the satisfaction of the Authority.

Encls: Annexes I, II, III, & IV.


(GURDIAL SINGH)
SECRETARY, CEA

- ✓ 1. Chairman & Managing Director, M/s National Hydro-Electric Power Corporation Limited, NHPC Office Complex, Sector-33, Faridabad - 121003 (Haryana).
2. Principal Secretary (Power Department), Government of Assam, Dispur - 781005.
3. Commissioner (PWD & Power), Government of Arunachal Pradesh, Itanagar - 791111
4. Chairman, Central Electricity Regulatory Commission, Core-3, 5th Floor, Scope Complex, 7, Institutional Area, Lodhi Road, New Delhi-110003.
5. Chairman & Managing Director, Power Grid Corporation of India Limited, B-9, Qutub Institutional Area, Katwaria Sarai, New Delhi - 100016.
6. Secretary, Ministry of Power, Govt. of India, Shram Shakti Bhawan, New Delhi-110001
7. Secretary, Ministry of Environment & Forests, Government of India, Paryavaran Bhawan, Lodhi Road, New Delhi - 110003.
8. Chairman, Central Water Commission, Sewa Bhawan, R.K. Puram, New Delhi - 110066
9. Joint Secretary (IPC)/ (Hydro), Ministry of Power, Shram Shakti Bhawan, New Delhi-110001.
10. Adviser (Energy), Planning Commission, Yojana Bhawan, New Delhi - 110001.

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11. Shri S. Chopra, Director, Geological Survey of India, Room No.203/204, C-II, Pushpa Bhawan, Madangir Road, New Delhi - 110062.
12. Member (D&R), Central Water Commission, Sewa Bhawan, R.K. Puram, New Delhi-66.
13. Member (Hydro / Planning / Thermal / Grid Operation / Economic & Commercial / Power Systems), CEA, Sewa Bhawan, R.K. Puram, New Delhi - 110066.
14. Chief Engineer (HPA/ SP&PA/ F&CA/ TCD/ Legal/ HPM / IRP/ LD&T), CEA, Sewa Bhawan, R.K. Puram, New Delhi - 110066.
15. Chief Engineer (PAO), CWC, Sewa Bhawan, R.K. Puram, New Delhi - 110066.



Subansiri Lower HE Project (8x250 MW) in Arunachal Pradesh / Assam by NHPC
Abstract of Cost Estimates

Cost at December, 2002 price level

1 US \$ = Rs. 48.00

	<u>MUS \$</u>	<u>INR (Rs.Crs.)</u>
1. Civil Works (including flood control)		3989.76
2. E&M works:		
a) E&M works without taxes & duties and overheads	39.648	1278.05
b) Taxes & duties		262.19
c) Overhead		182.79
Total E&M works	39.648	1723.03
3. Total Cost (excluding IDC & FC)	39.648	5712.79
4. IDC		705.58
5. FC		
6. Total Project Cost (including IDC & FC)	39.648	6418.37

66

Ansiri Lower Hydro Electric Project (8x250 MW) in Arunachal Pradesh by M/s National Hydroelectric Power Corporation (NHPC).

Tentative Financial Package for Present Day Cost
(Based on NHPC's letter dated 13.01.2003)

Debt	70%
Equity	30% #

Up front deployment of equity.

Equity: Rs. Crores 1982.60

Debt: Rs. Crores 4626.08

Total (Debt + Equity): Rs. Crores 6608.68

Terms of Loan

S.No.	Source of Funds	Rupee Term Loan
1.	Loan Amount	Rs. Crores 4626.08
2.	Interest Rate p.a.	10.5%
3.	Repayment Period	12 years
4.	Financing Charges	Nil

CS

**Subansiri Lower H.E. Project
Salient Features**

Particulars	As per DPR of NHPC
1. Location	
State	Arunachal Pradesh/Assam
District	Lower Subansiri/ Dhemajii District
2. Hydrology	
Catchment Area (Sq. Km)	34900
Design Flood (Cumec)	37500
3. Reservoir	
Full reservoir level (m)/ Storage (Mcum)	205.0/ 1365
Minimum reservoir level (m)/ Storage (Mcum)	190.0/ 923
Minimum draw down level (m)/ Storage (Mcum)	181/ 720
4. Diversion tunnel	
Number/ Size (m)	5/ 9.5 dia horse shoe
Length (m)	From 485 to 640
Diversion capacity (Cub. m/ Second)	4550
5. Dam	
Type	Concrete gravity dam
Top Elevation of dam (m)	210
Height of dam above river bed level (m)	116
Height of dam above deepest Foundation Level (m)	133
6. Spillway	
Design flood (Cumec)	37500
Crest Level	EL 150 meters
7. Intake	
Invert Level (m)	160
No. & Size	8 Numbers/ 7.3 m X 9.5 m
8. Head race Tunnel	
Number	8 on left bank
Size & shape	9.5 m dia horse shoe
Length (m)	Left bank: 225 to 390
Design discharge (Cumec)	322.4
9. Pressure Shaft	
Number	8/ Circular steel lined
Diameter/ Height (m)	8/ 68.25 Vertical + 48 m horizontal
10. Power House	
Type/ Capacity	Underground/ 8X250 = 2000 MW
Power House Cavern (m)	24 X 62.4 X 337
Transformer cum MIV Cavern (m)	15 X 42 X 327

Gross Head/ Design head (m)	91/ 86
Diameter of MIV	7 Meter
11. Surge Chamber Cum Draft Tube gate Cavern	
Size (m)	15 X 62.5 X 249 (Compartmented into 8 Nos.)
Draft tube opening (m)	12 X 10 incl. an intermediate pier of 2 m width
12. Tail race tunnel	
Shape/ Length/ Diameter	Horse Shoe/ 450 to 780 m length/ 9.5 m dia
13. Switchyard	
Size & location	100 m X 300 m at EL. 190 m
14. Access Tunnel	
Size and Total Length	8 m D shaped Length 2422 m 5m X 7.5 m D shaped- 343 m length 9m X 10 m D shaped- 300 m length
15. Design Energy (Gwh)	
Subansiri Lower (Alone)	7421.59 ✓
Subansiri Lower with regulated releases from Subansiri Upper and Subansiri Middle	7722.90

et

PROFORMA

Monthly status of progress in respect of Power Generation Schemes already accorded TEC by CEA and which are yet to achieve financial closure/ investment sanction.

- | | | |
|-----|--|---|
| 1. | Name of the Project | Subansiri Lower Hydro-Electric Project
(8x250 MW) in Arunachal Pradesh / Assam |
| 2. | Name of Power Company | National Hydro-Electric Power
Corporation Limited |
| 3. | Date of TEC | 13.1.2003 |
| 4. | Status of Power Purchase Agreement | |
| 5. | Status of tie-up of Finances | |
| 6. | Status of EPC Contract | |
| 7. | Status of O&M Contract | |
| 8. | *Status of Fuel Linkage and
Fuel Supply Agreement | |
| 9. | *Status of Rail Transport Agreement | |
| 10. | Status of Firm Financial Package
to be submitted by 12.7.2003 | |
| 11. | Date of Financial Closure | |
| 12. | Expected COD | |
| 13. | Status of Site Activities
(Land acquisition, R&R activities,
site development works etc.) | |
| 14. | Status of Compliance of the conditions
Imposed at the time of issue of TEC | |
| 15. | Reasons/ constraints for delays in achieving
the financial closure
*Applicable for Thermal Power Projects. | |

CS

ANNEXURE-V

SUBANSIRI LOWER

H.E. PROJECT

2000 MW

ARUNACHAL PRADESH

GOVERNMENT OF INDIA
CENTRAL ELECTRICITY AUTHORITY
SEWA BHAWAN : R.K. PURAM
NEW DELHI - 110066

File No.2/NHPC/26/01-PAC/ 267-34

Dated: 13th January, 2003.

OFFICE MEMORANDUM

Subject: 8x250 MW (2000 MW) Subansiri Lower Hydro-Electric Project in Arunachal Pradesh / Assam by National Hydro-Electric Power Corporation Limited (NHPC) at an Estimated Present Day Cost (at December, 2002 Price Level) of US \$ 39.648 Million + Rs.6418.37 Crores including IDC & FC of Rs.705.58 Crores at Foreign Exchange Rate of 1 US \$ = Rs.48.00 - Issue of Techno Economic Clearance.

With reference to letter No.NH/PD/PC/LS/695, dated 7.6.2001 from NHPC, submitting generation scheme under section 29 of the Electricity (Supply) Act, 1948 (returned on 24.7.2001 for want of tying-up of essential inputs / clearances and thereafter revived on 3.1.2003) and in accordance with the Ministry of Power letter No.16/23/99-DO(NHPC), dated 10.10.2002 under Section 18-A of E(S) Act, 1948, it is stated that the proposal for establishment of 8x250 MW (2000 MW) Subansiri Lower Hydro-Electric Project in Lower Subansiri / Dhemaji Districts in Arunachal Pradesh / Assam proposed by National Hydro-Electric Power Corporation Limited (NHPC), as specified in the Detailed Project Report and other documents, papers, notes etc. submitted by NHPC to CEA and various clarifications made in CEA Meeting and specified in the Agenda note circulated vide CEA letter No.3/106/256th/2001-PAC/35-57, dated 10.1.03 has been considered in the 256th Meeting of CEA held on 13.1.03 at Sewa Bhawan, R.K. Puram, New Delhi-110066. Subsequently, documents submitted by NHPC vide their various letters, latest being dated 13.1.2003 in pursuance to decisions taken in the above meetings, have also been considered.

2. In exercise of the powers vested with the Authority as per the GOI direction contained in the Gazette Notification vide F.No.2(ii)/ 76-EL II, dated 23.11.1977 issued under Section 4(B) of E(S) Act, 1948, the Central Electricity Authority accords techno-economic clearance to the aforesaid scheme at an Estimated Present Day Cost (at December, 2002 Price Level) of US \$ 39.648 Million + Rs.6418.37 Crores including IDC & FC of Rs.705.58 Crores at Foreign Exchange Rate of 1 US \$ = Rs.48.00, with the stipulations that:

- i) The completed cost of the scheme shall not exceed the above cost except on account of:-
 - a. Change in rates of Indian taxes and duties such as custom duty, excise duty, sales tax, works tax & service tax and additional taxes and duties levied, if any, subsequent to issue of techno-economic clearance.
 - b. Change in Indian Law resulting in change in cost.
 - c. Price variation formula agreed at the time of placement of order.

- ii) Interest During Construction and the Financing Charges shall be as per actuals but not exceeding the amount as indicated at Annex-I except for pro-rata variation on account of variations in hard cost as indicated in 2(i) a, b & c above.
 - iii) The abstract of the Present Day Cost (at December, 2002 Price Level) approved by CEA is furnished at Annex-I, Summary of Financial Package, as submitted by NHPC and considered by CEA, is at Annex-II and the Salient Features of the Scheme are set-forth at Annex-III.
3. This techno-economic clearance is subject to the fulfillment of the following conditions:
- i) The following conditions/circumstances shall not be a re-opener of completed cost/ techno-economic clearance:
 - a) Non-acquisition of land.
 - b) Non-finalisation of Power Purchase Agreement.
 - c) Delay in obtaining investment approval for the project.
 - ii) NHPC shall take into account suggestions of GSI / CWC conveyed to NHPC from time to time at the time of detailed design. The additional investigation as suggested by GSI shall be carried out by NHPC and the results shall be submitted to CEA / CWC from time to time.
 - iii) NHPC shall obtain environmental and forest clearance of the project from MOE&F.
 - iv) Integrated flood studies including reservoir operation in respect of all three projects viz. Subansiri Upper, Subansiri Middle and Subansiri Lower shall be finalised in consultation with Brahmaputra Board and CWC before taking up execution of the Subansiri Lower Hydro-Electric Project.
 - v) NHPC have kept the rated head of the turbine at 86 m. NHPC shall examine the possibility of reducing the rated head so that higher peaking capability from the reservoirs could be achieved during low head condition.
 - vi) NHPC shall have to identify the prospective buyers for the power from the project and obtain the letters of comfort indicating the quantum of power.
 - vii) NHPC shall identify the agency for implementing the transmission system from the project to the beneficiaries.
 - viii) The civil cost estimate as cleared by Central Water Commission includes a provision of Rs.583.957 Crores on account of increase in quantities / extra items to take into account the observations of Central Water Commission on design aspects of various project components. Accordingly, no increase in the civil cost of the project shall be allowed at a later date on account of variation in the quantities of civil works except on account of geological surprises as approved by Expert Committee to be constituted by Ministry of Power, Government of India.



- ix) A provision of Rs.164.70 Crores has been allowed in the civil cost for the procurement of Q-Special T&P considering the project would be executed departmentally. In case project is executed through contract, the requirement of Q-Special T&P shall be reassessed by the Project Authorities and only general purpose T&P alone be procured and resultant saving in the head of Q-Special T&P be passed on to the project.
- x) The moratorium period beyond Commercial Operating Date (COD) shall not be applicable for computation of tariff.
- xi) The tariff shall be decided by Central Electricity Regulatory Commission.
- xii) Submission of Final Financial Package shall be duly approved by the competent Government for approval of the Authority.
- xiii) Final Financial Package shall be approved by the Authority.
- xiv) The final financial package shall not be inferior to the tentative financial package (presently submitted by NHPC) adjusted for variation in hard cost and IDC.
- xv) In case of geological surprises, NHPC shall systematically maintain a record of geological surprises, that are encountered and treatment provided. At the same time, NHPC shall request Ministry of Power to constitute an Expert Committee consisting of representatives of concerned State Governments, Geological Survey of India, CWC and CEA. Once a Committee is constituted, NHPC shall submit their proposal for the enhanced cost to the Expert Committee, which in turn, shall examine and recommend the cost thereof.

4. The commissioning schedule of the project shall be as under (from the date of CCEA Clearance):-

1 st & 2 nd Unit	-	77 th month
3 rd & 4 th Unit	-	81 st month
5 th & 6 th Unit	-	82 nd month
7 th & 8 th Unit	-	84 th month

5. (a) Monthly Progress Report of the project shall be submitted to Hydro-Monitoring Division of CEA. Three (3) copies of the semi-annual progress reports on physical progress of the scheme and expenditure actually incurred, duly certified by statutory auditors shall be submitted to the Authority till the Commercial Operating Date of the plant. The project promoters/project authorities shall give free accessibility to the CEA officers and staff to have on the spot assessment of various aspects of the project.

(b) Final Financial Package and issues related to that shall be submitted to Secretary, CEA.

6. Monthly status of the project from the period of TEC to Financial closure/ Investment decision shall be furnished to Secretary, CEA as per the proforma enclosed at Annex-IV.

SA

7. The completion cost of the scheme shall be submitted to the Authority duly recommended by Competent Government for approval as soon as possible after the Commercial Operating Date of the plant but not later than three (3) months from the Commercial Operating Date of the Plant. Authority shall be intimated the Commercial Operating Date duly certified by the Competent Government within two weeks from its occurrence.

8. The concurrence of CEA to the scheme under Section 31 of the Electricity (Supply) Act, 1948 shall be considered by the Authority on submission of Firm Financial Package (FFP) and tying-up of balance inputs/ clearances by the company within a period of six months from the date of issue of TEC.

9. In case the time gap between the Techno-Economic Clearance of the scheme by CEA and actual start of work on the project by the generating company is three years or more, a fresh Techno-Economic Clearance of CEA shall be obtained by the generating company before start of actual work.

10. The Authority reserves the right to revoke the Techno-Economic Clearance, if the conditions stipulated in this Office Memorandum are not complied with to the satisfaction of the Authority.

Encls: Annexes I, II, III, & IV.


13/11/03
(GURDIAL SINGH)
SECRETARY, CEA

- ✓ 1. Chairman & Managing Director, M/s National Hydro-Electric Power Corporation Limited, NHPC Office Complex, Sector-33, Faridabad - 121003 (Haryana).
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15. Chief Engineer (PAO), CWC, Sewa Bhawan, R.K. Puram, New Delhi - 110066.



Subansiri Lower HE Project (8x250 MW) in Arunachal Pradesh / Assam by NHPC
Abstract of Cost Estimates

Cost at December, 2002 price level

1 US \$ = Rs. 48.00

	<u>MUS \$</u>	<u>INR (Rs.Crs.)</u>
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2. E&M works:		
a) E&M works without taxes & duties and overheads	39.648	1278.05
b) Taxes & duties	-	262.19
c) Overhead	-	182.79
Total E&M works	39.648	1723.03
3. Total Cost (excluding IDC & FC)	39.648	5712.79
4. IDC	-	705.58
5. FC	-	-
6. Total Project Cost (including IDC & FC)	39.648	6418.37

[Signature]

Ansiri Lower Hydro Electric Project (8x250 MW) in Arunachal Pradesh by M/s National Hydroelectric Power Corporation (NHPC).

Tentative Financial Package for Present Day Cost
(Based on NHPC's letter dated 13.01.2003)

Debt	70%
Equity	30% #

Up front deployment of equity.

Equity: Rs. Crores 1982.60

Debt: Rs. Crores 4626.08

Total (Debt + Equity): Rs. Crores 6608.68

Terms of Loan

S.No.	Source of Funds	Rupac Term Loan
1.	Loan Amount	Rs. Crores 4626.08
2.	Interest Rate p.a.	10.5%
3.	Repayment Period	12 years
4.	Financing Charges	Nil

ES

Subansiri Lower H.E. Project
Salient Features

Particulars	As per DPR of NHPC
1. Location	
State	Arunachal Pradesh/Assam
District	Lower Subansiri/ Dhemaji District
2. Hydrology	
Catchment Area (Sq. Km)	34900
Design Flood (Cumec)	37500
3. Reservoir	
Full reservoir level (m)/ Storage (Mcum)	205.0/ 1365
Minimum reservoir level (m)/ Storage (Mcum)	190.0/ 923
Minimum draw down level (m)/ Storage (Mcum)	181/ 720
4. Diversion tunnel	
Number/ Size (m)	5/ 9.5 dia horse shoe
Length (m)	From 485 to 640
Diversion capacity (Cub. m/ Second)	4550
5. Dam	
Type	Concrete gravity dam
Top Elevation of dam (m)	210
Height of dam above river bed level (m)	116
Height of dam above deepest Foundation Level (m)	133
6. Spillway	
Design flood (Cumec)	37500
Crest Level	EL 150 meters
7. Intake	
Invert Level (m)	160
No. & Size	8 Numbers/ 7.3 m X 9.5 m
8. Head race Tunnel	
Number	8 on left bank
Size & shape	9.5 m dia horse shoe
Length (m)	Left bank: 225 to 390
Design discharge (Cumec)	322.4
9. Pressure Shaft	
Number	8/ Circular steel lined
Diameter/ Height (m)	8/ 68.25 Vertical + 48 m horizontal
10. Power House	
Type/ Capacity	Underground/ 8X250 = 2000 MW
Power House Cavern (m)	24 X 62.4X 337
Transformer cum MIV Cavern (m)	15 X 42 X 327

EL

Gross Head/ Design head (m)	91/ 86
Diameter of MIV	7 Meter
11. Surge Chamber Cum Draft Tube gate Cavern	
Size (m)	15 X 62.5 X 249 (Compartmented into 8 Nos.)
Draft tube opening (m)	12 X 10 incl. an intermediate pier of 2 m width
12. Tail race tunnel	
Shape/ Length/ Diameter	Horse Shoe/ 450 to 780 m length/ 9.5 m dia
13. Switchyard	
Size & location	100 m X 300 m at EL 190 m
14. Access Tunnel	
Size and Total Length	8 m D shaped Length 2422 m 5m X 7.5 m D shaped- 343 m length 9m X 10 m D shaped- 300 m length
15. Design Energy (Gwh)	
Subansiri Lower: (Alone)	7421.59
Subansiri Lower with regulated releases from Subansiri Upper and Subansiri Middle	7722.90

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PROFORMA

Annex-IV

Monthly status of progress in respect of Power Generation Schemes already accorded TEC by CEA and which are yet to achieve financial closure/ investment sanction.

- | | | |
|-----|--|---|
| 1. | Name of the Project | Subansiri Lower Hydro-Electric Project
(8x250 MW) in Arunachal Pradesh / Assam |
| 2. | Name of Power Company | National Hydro-Electric Power
Corporation Limited |
| 3. | Date of TEC | 13.1.2003 |
| 4. | Status of Power Purchase Agreement | |
| 5. | Status of tie-up of Finances | |
| 6. | Status of EPC Contract | |
| 7. | Status of O&M Contract | |
| 8. | *Status of Fuel Linkage and
Fuel Supply Agreement | |
| 9. | *Status of Rail Transport Agreement | |
| 10. | Status of Firm Financial Package
to be submitted by 12.7.2003 | |
| 11. | Date of Financial Closure | |
| 12. | Expected COD | |
| 13. | Status of Site Activities
(Land acquisition, R&R activities,
site development works etc.) | |
| 14. | Status of Compliance of the conditions
Imposed at the time of issue of TEC | |
| 15. | Reasons/ constraints for delays in achieving
the financial closure
*Applicable for Thermal Power Projects. | |

GS



नैशनल हाइड्रोइलेक्ट्रिक पावर कारपोरेशन लिमिटेड
(भारत सरकार का उद्यम)
National Hydroelectric Power Corporation Ltd.
(A GOVT. OF INDIA ENTERPRISE)

फोन/ TEL.

फरीदाबाद/Faridabad 23-12-2002

संदर्भ सं./Ref. No. NH/PD/PC/3343

Shri Amarjeet Singh
Director (PAC),
Central Electricity Authority,
Sewa Bhawan,
R.K. Puram,
New Delhi.

Subject: Revision of design energy: Subansiri Lower HE Project (8x250 MW) in Arunachal Pradesh

Ref: Our letter NH/PD/PC/3264 dated 16.12.2002

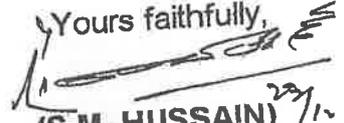
Sir,
As advised in the meeting held in CEA on 20th of December, 2002, detail of Design Energy calculations considering the following options are enclosed at Annexure-1 and Annexure-2 for scrutiny in CEA.

- 1) Option -1 -Design Energy considering availability as 95% of Installed Capacity.
 - a) Without any upstream project - 7546.94 MU
 - b) With upstream project as per Alternative -1: 7830.51 MU
 - c) With upstream Project as per Alternative -2: 7820.60 MU
- 2) Option - 2 -Design Energy considering availability as 95% of Available Capacity
 - a) Without any upstream project - 7421.59 MU
 - b) With upstream project as per Alternative -1: 7722.90 MU
 - c) With upstream Project as per Alternative -2: 7717.21 MU

This supercedes our earlier projection for design energy submitted vide letter under reference.

Thanking you,

Encl: as above.

Yours faithfully,

(S.M. HUSSAIN)
General Manager (Plg.)

N.O.O:

Copy to:

1. ED (E&M Design) for information with respect to his note dated 23.12.02
2. CE (cost Engg.), for information and necessary action please

पंजीकृत कार्यालय : एन.एच.पी.सी. कार्यालय परिसर, सेक्टर - 33, फरीदाबाद - 121003 (हरियाण)
Regd. Office : N.H.P.C. OFFICE COMPLEX, SECTOR - 33, FARIDABAD - 121003 (HARYAN)
केबल/ CABLE : "HYDROCORP" टैलेक्स / TELEX : 343-311 NHPC IN फैक्स / FAX : 2779

62-201-199

**SUBANSIRI LOWER H.E. PROJECT
RESERVOIR OPERATION STUDY**

Without any upstream projects & 95% energy at peaking capability

Overall Efficiency 92% MDDL (m) - 181

Rated Head (m) - 86.00

Machine Availability 95%

Head Loss 5.00

M.R.L. (m) 181.00

Design Discharge (m³/s) 2579.39

FRL (m) - 205

2000

Installed Capacity (MW)

Year 13-14

PERIOD	Starting Reservoir Level (m)	Initial Storage (Mcm)	Inflows into the Reservoir		Area of Reservoir (Ha)	Evaporation Loss (mm)	Exhaustion Loss		Total storage		Turbine discharge		Net storage (Mcm)	Closing Reservoir Level (m)	Spill		Tail water Level (m)	Net Head (ft)	Power (P) (MW)	Energy (E) (GWh)	Energy with 95% m/c avail. (GWh)	Peaking Capability (MW)	Peaking Hours (Hrs.)	Energy X Net Head (E x H)	Nitec. Downstream Discharge (Mcm)
			Mcm	m ³ /s			Mcm	m ³ /s	Mcm	m ³ /s	Mcm	m			Mcm	m									
Jun-13	190.00	923.00	1282.66	1484.56	2500.00	37.67	0.94	2290.40	1277.40	1478.47	923.00	190.00	190.00	0.00	0.00	108.96	76.04	1013.64	243.27	243.27	1662.91	14.63	18499.24	4.32	
Jul-13	190.00	923.00	1300.79	1505.55	2500.00	37.67	0.94	3243.78	2094.04	2423.66	923.00	190.00	190.00	0.00	0.00	108.96	75.93	1028.03	246.73	246.73	1662.91	14.84	18716.85	4.32	
Aug-13	190.00	923.00	1326.05	1602.18	2500.00	40.67	1.02	2918.07	1995.07	2309.11	923.00	190.00	190.00	0.00	0.00	108.96	76.04	1089.63	398.20	398.20	1659.18	24.00	20235.11	4.32	
Sep-13	190.00	923.00	1441.38	1653.85	2500.00	40.67	1.02	3581.34	2088.58	2417.34	923.00	190.00	190.00	0.00	0.00	108.96	75.53	1583.23	395.10	395.10	1646.23	22.85	28892.52	4.32	
Oct-13	190.00	923.00	1491.36	1726.11	2500.00	38.33	0.96	3860.13	2084.37	2412.46	923.00	190.00	190.00	0.00	0.00	108.96	76.04	1662.91	439.01	439.01	1662.91	24.00	33383.48	4.75	
Nov-13	190.00	923.00	1501.13	1751.14	2500.00	38.33	0.96	4262.76	2074.33	2400.84	1061.13	195.02	195.02	0.00	0.00	108.96	74.51	1612.75	387.06	387.06	1612.75	24.00	29542.83	4.32	
Dec-13	190.00	923.00	1491.36	1653.85	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
Jan-14	190.00	923.00	1484.00	1638.74	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
Feb-14	190.00	923.00	1484.00	1638.74	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
Mar-14	190.00	923.00	1484.00	1638.74	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
Apr-14	190.00	923.00	1484.00	1638.74	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
May-14	190.00	923.00	1484.00	1638.74	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
Jun-14	190.00	923.00	1484.00	1638.74	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
Jul-14	190.00	923.00	1484.00	1638.74	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
Aug-14	190.00	923.00	1484.00	1638.74	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
Sep-14	190.00	923.00	1484.00	1638.74	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
Oct-14	190.00	923.00	1484.00	1638.74	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
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Dec-14	190.00	923.00	1484.00	1638.74	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
Jan-15	190.00	923.00	1484.00	1638.74	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
Feb-15	190.00	923.00	1484.00	1638.74	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
Mar-15	190.00	923.00	1484.00	1638.74	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
Apr-15	190.00	923.00	1484.00	1638.74	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
May-15	190.00	923.00	1484.00	1638.74	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
Jun-15	190.00	923.00	1484.00	1638.74	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
Jul-15	190.00	923.00	1484.00	1638.74	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
Aug-15	190.00	923.00	1484.00	1638.74	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
Sep-15	190.00	923.00	1484.00	1638.74	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
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Dec-15	190.00	923.00	1484.00	1638.74	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
Jan-16	190.00	923.00	1484.00	1638.74	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
Feb-16	190.00	923.00	1484.00	1638.74	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
Mar-16	190.00	923.00	1484.00	1638.74	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
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May-16	190.00	923.00	1484.00	1638.74	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
Jun-16	190.00	923.00	1484.00	1638.74	2500.00	32.67	0.90	2547.26	1483.26	1624.15	1144.00	198.04	198.04	0.00	0.00	108.96	81.07	1187.07	284.90	284.90	1813.92	15.57	23095.28	4.32	
Jul-																									

26 MAR 2012
HPI



**Government of India
Central Electricity Authority
Hydro Planning & Investigation Division**



(12/2012)

708 (N), Sewa Bhawan,
B.K. Puram, New Delhi - 110016
Telefax : 011-26164478
e-mail: jaiideepbharati@cea.gov.in

Sub. A pros-cons integrated study for Subansiri Lower based on demands for peaking/ firm power as desired by Technical Expert Committee constituted by Planning Commission for Subansiri Lower Project, Arunachal Pradesh/ Assam.

Reference is invited to MoP letter No.2/4/2004-NHPC Vol.IV dated 12.3.2012 on the above subject. In connection with the above, it is to be mentioned that Subansiri Lower HE Project (2030 MW) was accorded techno-economic clearance by CEA in Jan., 2002 as a peaking station with availability of minimum 4 hrs. peaking during lean season. The project was taken up for construction in the year 2005. The project involves submergence both in Assam and Arunachal Pradesh though the power house is located in Arunachal Pradesh. There has been resistance from Govt. of Assam to the implementation of the project in view of its likely adverse effect in the down-stream of the project within Assam. Accordingly, a comprehensive down-stream impact assessment study was awarded by NHPC in May, 2008 to Guwahati University in association with Dibrugarh University and IIT, Guwahati. The Expert Group submitted its report in March, 2011 and have made certain recommendations relating to design and safety of the dam. In addition, the Expert Group has also recommended the minimum discharge in the river be maintained by running at least one unit continuously for sustenance of river ecology and ground water recharging. Subsequently, a Technical Expert Committee consisting of Shri C.D. Phette, former Secy. (Water Resources) and Shri M.S. Reddy, former Secy (Water Resources) has been set up by Planning Commission to examine the technical aspects as well as downstream impact of Lower Subansiri Hydro Electric Project. The Technical Expert Committee has decided that a pros-cons integrated study may be undertaken for the project for maintaining minimum discharge in the river by running at least one unit continuously based on the demands/ peaking/ firm power needs of the dependent states.

Lower Subansiri-Pros-Cons Integrated Study directed by Expert Committee-Dec-2011 doc. 13

Gen/Plg
27/3

CE-I
Anil / S.N. I
[Signature]

Don (Donu)

28/3

In view of the on-going stalemate in the construction position on account of the continual agitations by some of the groups, and as desired by the above Technical Expert Committee, a study was carried out by NHPC vide their letter No. NH/PD/EW.82/TEC/3073 dated 5.12.2011 by operating one machine at part load continuously by sacrificing some peaking capability. Later, another study was also carried out by NHPC vide their letter No. NHPC letter no. NH/PD/Env.83/193 dated 17.1.2012 for the power supply position of NE region with and without Subansiri Lower which indicated that there would be no change in peak power and energy availability, since the installed capacity of the project is being retained as 2000 MW.

The monthly power output and peaking capability has been summarized corresponding to the scenarios at the time of TEC and being envisaged now (1 Unit continuous operation) and is given in Annex -I and Annex.-II respectively. The studies carried out by NHPC with regard to the power supply position of the region, with and without Subansiri have been examined in CEA considering the maximum monthly power output capability of the project as envisaged now vis-à-vis the state of the time of TEC and the following observations are made:

- i) NHPC have concluded that there would be no change in peak power and energy availability, since the installed capacity of the project is being retained as 2000 MW. However, this does not seem to be in order since in the two Scenarios i.e. 2000 MW Subansiri operating in Peaking and 250 MW base + 1,750 MW in Peaking, there would be a change in Peak Power and Energy availability.
- ii) With a view to assess the impact of operating 2000 MW Subansiri MW in base + 1,750 MW in Peaking, Seasonal Studies for power absorption in North-Eastern region were carried out in CEA for two Scenarios viz. considering capacity and energy availability from Subansiri Lower as per TEC i.e. 2000 MW in Peaking and considering capacity and energy availability with one unit of 250 MW running on a continuous basis and remaining 1,750 MW in Peaking to maintain minimum discharge in the river. Studies have been carried out for 2016-17 considering 18th EPS Demand. The share of North Eastern Region from Subansiri Lower is 50% and remaining 50% power is allocated to other regions. Subansiri Lower project has been considered for commissioning during the last year of 12th Plan i.e.2016-17 and seasonal capacity of the project has been considered for carrying out the studies. Seasonal energy

availability from other hydro stations and thermal stations has also been considered.

From the above study results, it is observed that there is no shortage either in peak or energy in North Eastern Region corresponding to both the above mentioned Scenarios of operation of Subansiri Lower HEP. Therefore, operation of one unit of Subansiri with 250 MW running on a continuous basis and remaining 1,750 MW in Peaking appears to be in order.

In view of the above, MoP may like to take a suitable view in the matter, so that the construction activities could be normalized and the project could be commissioned expeditiously. In this connection, it is further brought out that NHPC on their part have already indicated that they do not have any objection to the operation of one machine continuously at part load for 24 hrs. a day.

Encl.: As above.

Ashraf
(J.S. Bawa)
Director (HPSM)

✓ Sh. Kamal Bose, US (NHPC), MoP, Shram Shakti Bhawan, Rafi Marg, New Delhi-110001. Fax No.: 011-23324357 e-mail: kamal.bose@nhpc.nic.in
सं. 7/18/2012/एच.पी.एवं आई (1)/ 315 दिनांक 27th March, 2012

Copy forwarded for information and necessary action to:

- 1) Sh. A.K. Sarkar, Executive Director (Planning), NHPC Ltd., NHPC Office Complex, Sector-33, Faridabad (Haryana)-121 003. Fax No. 0129-2277941.
- 2) CE (HPM), CEA.
- 3) CE (IRP), CEA.

Subansiri Lower HE Project (2000 MW)

Power Output and Peaking Capability as per TCC

PERIOD	Power	Energy	Energy with 95% m/c avail.	Peaking Capability	Peaking Hours
	(MW)	(MU)	(MU)	(MW)	Hrs.
	17	18	19	20	21
Jun	1013.64	243.27	243.27	1582.91	14.53
	1028.03	246.73	246.73	1562.91	14.53
	1659.18	398.20	373.29	1659.18	24.55
Jul	1583.13	379.95	379.14	1562.91	22.65
	1646.23	395.10	375.34	1646.23	24.00
	1662.91	439.01	417.06	1662.91	24.00
Aug	1636.28	392.71	373.07	1636.28	24.00
	1612.75	387.06	367.71	1612.75	24.00
	1813.92	478.87	454.93	1813.92	24.00
Sep	1187.07	284.90	284.90	1830.36	15.57
	1041.55	249.97	249.97	1933.37	12.30
	1119.72	268.73	268.73	2000.00	13.44
Oct	1841.85	442.04	442.04	2000.00	22.10
	903.58	216.86	216.86	2000.00	10.84
	806.70	212.97	212.97	2000.00	9.68
Nov	633.40	152.02	152.02	2000.00	7.60
	602.01	144.48	144.48	2000.00	7.22
	437.11	104.91	104.91	2000.00	5.25
Dec	334.17	80.20	80.20	2000.00	4.01
	334.17	80.20	80.20	2000.00	4.01
	334.17	88.22	88.22	2000.00	4.01
Jan	334.17	80.20	80.20	2000.00	4.01
	334.17	80.20	80.20	2000.00	4.01
	313.17	82.68	82.68	1874.34	4.01
Feb	277.11	66.51	66.51	1658.52	4.01
	260.25	62.46	62.46	1557.61	4.01
	221.72	42.57	42.57	1402.57	3.75
Mar	230.01	55.20	55.20	1376.61	4.01
	253.11	60.75	60.75	1514.87	4.01
	315.49	83.29	83.29	1838.19	4.01
Apr	480.86	117.81	117.81	2000.00	5.59
	788.37	189.21	189.21	2000.00	9.46
	752.07	180.50	180.50	2000.00	9.02
May	873.56	209.66	209.66	2000.00	10.49
	1333.54	320.05	320.05	2000.00	16.00
	869.24	229.48	229.48	1562.91	12.55
		7546.94	7421.89		375

Subsiri Lower HE Project (2500 MW)
Power Output and Peaking Capability as being envisaged

Annex 1

Month	Power Output as per TEC	Continuous Output with one unit Operation		Balance Power Output		Peaking of 1750 MW			Total Available Capacity		
	Power	Permissible Capacity	Energy (for Corr. MW)	Power	Energy	Peaking Capability	Peaking Hours	Total Energy	Total Monthly Capacity	Availability	Peaking Hours
	(MW)	(MW)	MU	MW	MU	MW	Hrs	MU	MW	MW	Hrs
Jun	1013.64	207.86	49.89	805.78	193.39	1467.45	13.16	293.37	1673.34	1750	10.78
	1228.03	207.86	49.89	920.17	196.84	1487.46	13.41	245.73	1875.89	1750	10.41
	1859.18	207.40	49.78	1461.78	348.43	1464.30	23.79	398.90	1871.20	1750	10.41
Jul	1582.13	207.86	49.89	1375.26	330.08	1407.65	22.49	379.35	1727.00	1750	9.85
	1546.27	207.78	49.39	1440.45	345.71	1453.35	23.79	399.10	1812.45	1750	10.35
	1982.91	207.86	54.88	1455.05	384.13	1467.45	29.30	429.03	1821.48	1750	10.39
Aug	1536.28	204.53	49.09	1431.74	343.62	1444.98	22.73	391.74	1816.72	1750	10.32
	1612.75	201.56	48.38	1411.16	338.80	1425.11	23.78	391.74	1816.72	1750	10.32
	1813.82	228.74	59.86	1587.18	338.80	1425.11	23.78	391.74	1816.72	1750	10.32
Sep	1187.07	228.80	54.91	958.27	229.89	1584.44	23.98	479.89	1821.33	1750	10.35
	1041.55	241.87	58.00	799.88	191.97	1584.44	23.98	479.89	1821.33	1750	10.35
	1118.72	250.00	60.00	869.72	208.73	1584.44	23.98	479.89	1821.33	1750	10.35
Oct	1841.85	250.00	60.00	1591.85	382.04	1750.00	1.93	268.75	2000.00	1750	10.35
	903.58	250.00	60.00	653.58	156.86	1750.00	21.93	442.04	2000.00	1750	10.35
	806.70	250.00	60.00	556.70	140.97	1750.00	0.88	218.86	2000.00	1750	10.35
Nov	603.40	250.00	60.00	353.40	92.02	1750.00	7.63	213.97	2000.00	1750	10.35
	502.01	250.00	60.00	252.01	64.48	1750.00	5.28	152.92	2000.00	1750	10.35
	437.11	250.00	60.00	187.11	44.01	1750.00	4.83	144.43	2000.00	1750	10.35
Dec	334.17	250.00	60.00	84.17	20.20	1750.00	2.57	104.91	2000.00	1750	10.35
	334.17	250.00	60.00	84.17	20.20	1750.00	1.15	30.20	2000.00	1750	10.35
	334.17	250.00	60.00	84.17	20.20	1750.00	1.15	30.20	2000.00	1750	10.35
	334.17	250.00	60.00	84.17	20.20	1750.00	1.15	30.20	2000.00	1750	10.35
	334.17	250.00	60.00	84.17	20.20	1750.00	1.15	30.20	2000.00	1750	10.35
	334.17	250.00	60.00	84.17	20.20	1750.00	1.15	30.20	2000.00	1750	10.35
Jan	277.11	234.29	61.85	78.88	29.82	1645.06	1.15	82.68	2000.00	1750	10.35
	260.25	194.70	46.73	66.55	16.73	1463.75	1.14	83.51	2000.00	1750	10.35
	221.72	175.32	35.86	46.40	8.91	1246.81	1.14	82.43	2000.00	1750	10.35
Feb	230.01	172.08	41.30	57.93	19.90	1224.98	1.14	82.43	2000.00	1750	10.35
	253.11	189.36	45.45	63.75	15.30	1342.28	1.14	82.43	2000.00	1750	10.35
	315.49	238.02	62.31	79.46	20.98	1658.85	1.15	82.29	2000.00	1750	10.35
Mar	490.86	250.00	60.00	240.86	57.81	1750.00	3.30	117.91	2000.00	1750	10.35
	788.37	250.00	60.00	538.37	129.21	1750.00	7.28	188.21	2000.00	1750	10.35
	752.07	250.00	60.00	502.07	120.60	1750.00	6.80	188.21	2000.00	1750	10.35
Apr	873.56	250.00	60.00	623.56	148.56	1750.00	8.55	209.06	2000.00	1750	10.35
	1333.54	250.00	60.00	1083.54	280.05	1750.00	14.88	320.06	2000.00	1750	10.35
	869.24	207.86	54.88	661.37	174.60	1467.45	10.82	228.48	2000.00	1750	10.35
			2001.87		5646.07			7688.94		1675.33	1487.47

ANNEXURE-VI

No.11/1/2002-DO(NHPC) Vol.II

Government of India
Ministry of Power

Shram Shakti Bhawan, Rafi Marg,
New Delhi, the September 9, 2003.

The Chairman & Managing Director
National Hydro-electric Power Corporation
NHPC Office Complex, Sector-33
FARIDABAD-121003.

Sub: Execution of Subansiri Lower Hydro-electric Project (8 X 250 MW) in the
Central sector -- approval to the cost estimate.

Sir,

In continuation to this Ministry's letter of even number dated 12.6.2002, I am directed to convey the approval of the President of India in terms of the Articles of Association of the National Hydro-electric Power Corporation (NHPC) for setting up of Subansiri Lower Hydro-electric Project (8 X 250 MW) in Arunachal Pradesh in the Central sector by NHPC at an estimated cost of Rs.6285.33 crores including IDC of Rs.670.92 crores at December 2002 price level, with a debt equity ratio of 70 : 30 which includes Rs.40.91 crores sanctioned for stage-II activities. The project cost is subject to adjustment in accordance with the final recommendation of CEA/CWC on the component of Establishment Cost. The abstract of cost is at Annex to this letter.

2. The project would be completed within a period of 7 years from the date of approval by the Government of India. The sanction accorded above is subject to the following further conditions:

- (i) The economy instructions issued by the Government of India from time to time, should be observed;
- (ii) The actual expenditure should not exceed the budget allocation of each year.
- (iii) The expenditure will be related to the purpose for which it is sanctioned.
- (iv) Cost of implementation of R&R plan has been fixed at Rs.186.20 crores at December, 2002 PL.

3. NHPC will submit a quarterly report to the Ministry of Power indicating financial and physical progress of implementation of the project.

4. The expenditure on the project is to be met by NHPC with debt equity ratio of 70 : 30. The budgetary support from the Government in the form of equity for this project is debitable to the following Heads in the Demands for the Grants of the Ministry of Power for the current year and the subsequent years for which these funds have been / will be released:-

: 2 :

Major Head – 4552 -Capital outlay on North-Eastern Region
Minor Head – 0.800- other expenditure
15 - projects/schemes for the benefit of NER and Sikkim
15.02.42-Lump-sum provision

5. In terms of the direction of the competent authority, the Ministry of Power would closely monitor the project to ensure timely completion within the approved cost estimates.

6. This issues with the concurrence of Finance Branch of Ministry of Power vide their Dy. No.1283/Bud/03 dated 8.9.2003.

Yours faithfully,

Nisha Gaur
(Nisha Gaur)
Desk Officer

Tel.23715507 Ext.290

Encl: as above

Copy to:

1. Controller of Accounts, Ministry of Power, Sewa Bhawan, R.K. Puram, New Delhi.
2. Principal Pay and Accounts Officer, Ministry of Power, New Delhi.
3. Principal director of Audit (commercial) and Member Audit Board II, "A" Block Hutments, Behind South Block, New Delhi.
4. Principal Director of Audit, Economic & Service Ministry, AGCR Building, New Delhi.
5. Chairman, Central Electricity Authority, Sewa Bhawan, R.K. Puram, New Delhi.
6. Cabinet Secretariat (Shri P. Gopalakrishnan, Director (Cabinet), Rashtrapati Bhawan, New Delhi w.r.t. letter No.CCEA/9/2003(i) dated 1st September, 2003.
7. Adviser(Energy), Planning Commission, Yojna Bhawan, New Delhi.
8. Ministry of Finance (Department of Expenditure) PF Division, North Block, New Delhi.
9. Ministry of Planning (Department of Programme Implementation), Sardar Patel Bhawan, New Delhi.
10. Ministry of Finance (Department of Economic Affairs), North Block, New Delhi.
11. Finance Commission Division, Department of Economic Affairs, CGO Complex, New Delhi.
12. PS to Minister of Power/PS to Minister of State for Power
13. PPS to Secretary(Power), SPPS to SS(P)/PS to JS&FA/PS to AS(F)/PS to JS(H)/Dir(H) Ministry of Power, New Delhi.
14. Finance Section/Budget Section, Ministry of Power, New Delhi.

Nisha Gaur
(Nisha Gaur)
Desk Officer

SUBANSIRI LOWER H. E. PROJECT (2000 MW), ARUNACHAL PRADESH		
ABSTRACT OF COST		
S. No.	Description	Amount (Rs. In Crores)
		(Dec' 2002 Price Level)
A CIVIL WORKS		
1	DIRECT CHARGES	
	I - Works	
	A - Preliminary	37.07
	B - Land	3.07
	C - Works	1858.19
	J - Power Plant Civil Works	1342.84
	K - Buildings	44.18
	M - Plantation	0.50
	O - Miscellaneous	58.18
	P - Maintenance	33.21
	Q-Spl. Tools & Plants	164.70
	R - Communication	75.36
	X - Environment & Ecology	20.13
	Y - Losses on Stock	8.30
	TOTAL OF I - WORKS	3705.70
	II - Establishment	148.50
	III - Tool and Plants	36.91
	IV - Suspense	0.00
	V - Receipt & Recoveries (-)	-121.69
	TOTAL DIRECT CHARGES	3769.41
2	INDIRECT CHARGES	
	Capitalised Value of Abatement of Land Revenue	0.05
	Audit and Account Charges	38.91
	TOTAL INDIRECT CHARGES	38.96
	TOTAL CIVIL COST (Net)	3806.37
ABSTRACT :		
	1 Civil works(net)	3806.37
	2 Electrical works (<u>excluding Establishment</u>)	1808.04
	Total Cost	5614.41
	Interest during construction	670.92
	Grand Tot.	6285.33

4 Pro. Signal

ANNEXURE-VII



Government of India
विद्युत मंत्रालय
Ministry of Power
केन्द्रीय विद्युत प्राधिकरण
Central Electricity Authority
सचिव का कार्यालय
Office of Secretary
परियोजना मूल्याङ्कन समन्वय निदेशालय
Project Appraisal Co-ordination Directorate

पत्र सं. 2/NHPC/52/CEA/05-PAC/ 694-701

दिनांक : 14th/15th March, 2018

✓ **Chairman & Managing Director,**
M/s NHPC Ltd.
NHPC Office Complex, Sector-33,
Faridabad, Haryana-121003

Subject: Subansiri Lower HEP (2000 MW) in Arunachal Pradesh - Memorandum of Changes reg.

Ref: i) NHPC letter no. NH/PD/IP/SLP/2890 dated 05.11.2013
ii) NHPC letter no. NH/PD/IP/SLP/1810 dated 14.10.2015
iii) NHPC letter no. NH/PD/IP/SLP-MoC/282 dated 27.02.2018

Sir,

Reference is invited to NHPC letters referred at i) & ii) above vide which proposals of Memorandum of Changes (MoC) carried out in project features of Subansiri Lower HEP (8x250 MW = 2000 MW) in Arunachal Pradesh from the concurred DPR in respect of Civil structures etc and HM (Hydro-Mechanical) components respectively were submitted for approval.

CEA, hereby, accords approval to MoC, as detailed in "Addendum to the concurred DPR", submitted by NHPC vide letter under reference iii), & as summarized at Annex.

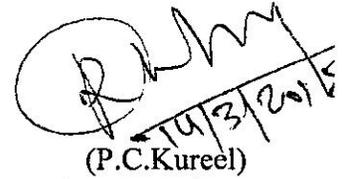
This approval is subject to compliance by NHPC to following conditions: -

- (i) NHPC shall also submit the "Addendum to the Concurred DPR" to the Govt. of Arunachal Pradesh & Assam, appropriate Electricity Regulatory Commission and State/Central Transmission Utility under intimation to CEA.
- (ii) Approval is subject to compliance by NHPC of various policies / guidelines etc. issued by Govt. of India/Arunachal Pradesh/Assam from time to time.
- (iii) The broad technical aspects of the project in the proposal/MoC have been scrutinized in CEA in consultation with CWC, GSI, CSMRS and other concerned agencies. The scrutiny is based on the data, assessment and certificates presented in the proposal and information/ clarifications received as compliances to the observations on the assumption that the data and information furnished are accurate and have been collected reliably by the project authorities from dependable sources and / or after carrying out detailed surveys and investigations as presented in the proposal.

- (iv) Monthly status report of compliance of the conditions stipulated in the earlier DPR appraisal letter/ Memo of Changes appraisal letter shall be submitted to Secretary, CEA.
- (v) Monthly Progress Report of the project shall be submitted to Hydro Project Monitoring (HPM) Division of CEA. Three (3) copies of the semi-annual progress report on physical progress of the scheme and expenditure actually incurred, duly certified by statutory auditors shall be submitted to the Authority till the commercial operation date of the plant. The project authorities shall give free accessibility to CEA officers and staff to have on the spot assessment of various aspects of the project.
- (vi) The e-flow shall be maintained as per recommendations of MoEF&CC. Further, as per MoEF&CC recommendations issued vide letter dated 27.04.2016 and the subsequent corrigendum dated 27.06.2016, one unit of turbine of Subansiri Lower HEP should continuously run to ensure at least 240 cumec release in Subansiri river downstream for sustenance of aquatic system.

Above approval/concurrence is in continuation to the concurrence accorded to Subansiri Lower Hydro Electric Project in favor of M/s National Hydroelectric Power Corporation Ltd (renamed later as M/s NHPC Ltd.) by CEA u/s 8 of the Electricity Act, 2003 vide OM No. 2/NHPC/26/01-PAC/207-37 dated 13th Jan., 2003.

Encl: As above


14/3/2016

(P.C.Kureel)
Secretary,CEA
Ph. 011-26108476
Email: prabhat.kureel@gov.in

Copy to:

1. Joint Secretary(Hydro), MoP, Shram Shakti Bhawan, Rafi Marg, New Delhi-110001
2. Chief Engineer(HPA-II/HETD/PSP&PA-II), CEA
3. Chief Engineer[Design(E&NE)], CWC]
4. Director (LHIM&EPE Division), Geological Survey of India, A-11, Pushpa Bhawan, Madangir Road, New Delhi — 110062.
5. Director, CSMRS, Olf Palme Marg, Hauz khas, New Delhi-110016

(P.C.Kureel)
Secretary,CEA
Ph. 011-26108476
Email: prabhat.kureel@gov.in

Salient Features

Subansiri Lower HEP (8x250 MW=2000 MW) in Arunachal Pradesh by NHPC Ltd.

Memorandum of Changes from Concurred DPR

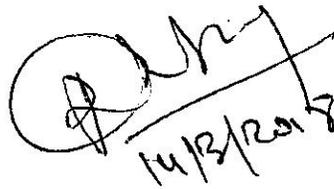
		As per Concurred DPR	As per Memorandum of Changes
1.	DIVERSION TUNNEL		
	Length	From 485m to 640m (Total 3.4 km)	From 493m to 693m (Total 4 Km)
2.	Dam		
	Height of dam above deepest foundation level	133m	125m
3.	SPILLWAY		
	CREST ELEVATION	EL 150m	EL 145m
	Number & size of Spillway Opening	9 NOs; 11.5m X 14.7m	9 NOs; 11.5m X14.0m
	Cut-off Wall	U/s cut-off wall beneath overflow & part NOF.	<ul style="list-style-type: none"> ●U/S cut-off wall under overflow & all NOF blocks. ●D/S cut-off wall in central spillway portion
4.	HEAD RACE TUNNEL		
	Length	From 225m to 390m (Total Length=2.2 km)	From 608m to 1164m. (Total Length = 7.2 Km)
5.	Surge Chamber		
(a)	U/S Surge Chamber		
	Number of Compartment & Size		<ul style="list-style-type: none"> ● 8 nos. surge chambers of size 26 m x 16 m x 62 m.
	Surge tunnels	No provision due to underground power house.	<ul style="list-style-type: none"> ● 8 Nos. Surge Tunnels ● 9.5m Dia. ● Horse Shoe Tunnel ● Total length 3545m. ● Length varying from 400m to 485m
(b)	D/S Surge Chamber Cum Draft Tube Gate Cavern		
	Size	15 m X 62.5m X 249m (Compartmented into 8 Numbers)	Not required now.

[Handwritten Signature]
14/5/2018

		As per Concurred DPR	As per Memorandum of Changes
6.	Pressure Shaft		
	Diameter	8m	9.5/8/7m
	Length	Vertical 68.25m + 48m horizontal	192m to 215m (Vertical portion part 48m) (Steel lined portion of 155m).
7.	POWER HOUSE		
	Type	Underground	Surface
	Power House Cavern	337 mx24m X 62.4m	288mX 61m X 64m
	Transformer cum MIV Cavern	327mx15m X 42.0m	-
	Bus Duct Gallery	6m X 6m x 30m	-
8.	Draft tube opening	12m X 10m including intermediate piers of 2.0 m width	3 m X 5.75m x 7.5m for each unit
9.	TAILRACE TUNNEL/CHANNEL	Tunnel	Channel
	Shape	Horse Shoe shaped	-
	Length	From 450m to 780m	35m
	Diameter	9.5m	-
	Width	-	206m
10.	SWITCHYARD		
	SIZE & LOCATION	100m X 300m at EL 190m	Pothead yard between A to B line at EL.136.00m
11.	ACCESS TUNNELS		
	Size	8m D-Shaped	9m D-Shaped
	Total Length	2422m	2161m for HRT,PS top and bottom .
	Size	5mX 7.5m, D – shaped	9.0m, D-Shaped
	Total Length	343m	1568m for Surge Tunnel
	Size	9m X 10m, D – shaped	-
	Total Length	300m	-
12.	Spillway Radial Gates		
	Crest Elevation level	EL 150 m	EL 145 m
	Opening size	11.5m x 16m	11.5m x14.0m
13.	Spillway Bulkhead Gates		
	Crest Elevation level	EL 150 m	EL 145 m
	Opening size	11.5 x 14.7 m	11.5 m x 16.34 m
	Operating head	55 m	60 m
14.	Draft tube gates		

[Handwritten Signature]
11/12/2017

		As per Concurred DPR	As per Memorandum of Changes
	No. of gates	2 Nos. / Unit	3 Nos. / Unit
	Opening size	5.0 m x 10.0m	5.77m x 7.5 m(Mid)/5.74mx7.5m(Ends)
	Hoists	1 No. Gantry Crane	24 Nos. Rope Drum Hoists
15.	Diversion Tunnel Gates		
	Gate Size	3.75m x9.5 m	3.75 m x 10.253m
16.	Pressure Shaft		
	PS-1 to PS-8	9.5m dia to 8.0 m dia travel about 36 m horizontally; then Drops vertically from EL159.5 m to EL96.0m.	9.5 m dia to 8.0 m dia travels about 13.5 m horizontally; then Drops vertically from EL139.75 m to EL114.0 m
		Bottom horizontal limb, having a length of 35 m connects to the reducer cone near MIV gallery.	Bottom horizontal limb, having a length of 35 m,, the diameter further reduces to 7.0 m. from transition after travelling horizontally about 49 m liner connects to MIV
17.	Tailrace stop log gates	One set of stop logs for opening size of 9.5m x 9.6m	-


 14/12/2017