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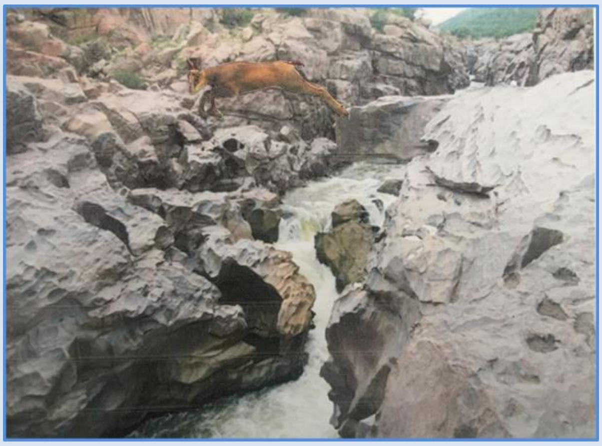

MEKEDATU BALANCING RESERVOIR CUM DRINKING WATER PROJECT

DETAILED PROJECT REPORT

VOLUME I - REPORT AND ANNEXURES

ESTIMATED COST - Rs. 9000.00 CRORES

JANUARY 2019

Managing Director

Cauvery Neeravari Nigam Limited

(A Government of Karnataka Enterprise)

Surface Water Data, Anand Rao Circle, Seshadri Rd, LakshmanPuri, Gandhi Nagar, Bengaluru, Karnataka 560001

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As per CWC/CEA guidelines

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Annexure 1 (b)	Location and depth of exploratory/ holes /drifts /pits etc	As per data based on the project report furnished by KPC which is approved by the Advisory Committee of the Government of Karnataka during 1985
Annexure 2	Material survey	As per data based on the project report furnished by KPC
Annexure 3	Gates and related hydro-mechanical equipment in detailed project reports for WRD projects	Attached
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Annexure-4	Guidelines for preparation of hydrology volume of detailed project report	Submitted as saperate Volume
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E-11	River reach in which industrial or domestic water supply is contemplated and where the quantity and quality of water is to be monitored...	NA
E-12	River reach in which navigation is to be sustaineby monitoring low flows.	NA
E-13	River reach in which water quallity (salinity) of low flows area to be monitored tor fish and wild life substance and for recreation.	NA
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A-2	Diversion projects with pondage	NA
A-3	Within the year storage projects	NA
A-4	Over the year' storage projects	NA
A-5	Complex system involving combinations of 1 to 4 above mentioned.	
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B	Classification by use of Project	
B-1	Irrigation	NA
B-2	Hydropower	Yes
B-3	Water supply and industrial use	Yes
B-4	Navigation	NA
B-5	Salinity control	NA
B-6	Water quality control	NA
B-7	Recreation, fish and wild life	NA
B-8	Flood control	NA
B-9	Drainage	NA
B-10	Surface to ground water recharge	NA
B-11	Multipurpose	-
Enclosure-D		
C	Types of Hydrologic inputs required	
C-1	For simulation studies	
C -1.1	Water inflows	Yes, Refer Chapter 5, Vol-I
C -1.2	Lake evaporation	Yes, Refer Chapter 5, Vol-I
C -1.3	Potential evapo-transpiration and rainfall	NA
C -1.4	Sediment inflows	Yes, Refer Chapter 7, Vol-I

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C -1.5	Flood inputs	Yes, Refer Chapter 5, Vol-I
C -1.6	Water•quality inputs	NA
C -1.7	Low flow inputs	NA
C -1.8	Surface to ground water recharge	NA
C -2	For studies other than simulation	NA
C -2.1	Design floods for the safety of structures	Yes
C -2.2	Design floods and flood levels for flood control works	NA
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C -2.5	Studies for determination of levels for locating structures on river banks or for location of outlets.	NA
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Abbreviation

BC Ratio	Benefit Cost Ratio
CA	Catchment Area
CBIP	Central Board of Irrigation and Power
CEA	Central Electricity Authority
CNNL	Cauvery Neeravari Nigam Limited
CPHEEO	Central Public Health and Environmental Engineering Organisation
CPM	Critical Path Method
CWC	Central Water Commission
CWDT	Cauvery Water Disputes Tribunal
DGPS	Differential Global Positioning System
DPR	Detailed Project Report
EIA & EMP	Environmental Impact Assessment and Environmental Management Plan
EL	Elevation
EMP	Environment Management Plan
FRL	Full Reservoir Level
GOI	Government of India
GOK	Government of Karnataka
GTS	Geometric Trigonometric Survey
IS	Indian Standards
KPCL	Karnataka Power Corporation Limited
KPTCL	Karnataka Power Transmission Corporation Limited
KRS	Krishna Raja Sagara
lpm	Litres per minute
lps	Litres per second
mbgl	Meters below ground level
MLD	Million litres per day
MOE&F	Ministry of Environment and Forest
MWL	Maximum water level

NA	Not Applicable
NHPC	National Hydro Power Corporation
OSHA	Occupational Safety and Health Administration
PERT	Program Evaluation and Review Technique
PWD	Public Works Department
R & R	Resettlement and Rehabilitation
REIA	Rapid Environmental Impact Assessment
SIA	Aocial Impact Assessment
TMC	Thousand Million Cubic Feet
USBR	United States Bureau of Raclamation

<u>Compliance report</u>

(Observations on DFR of Mekedatu Balancing Reservoir cum Drinking Water Project

by

Central Water Commission (CWC), New Delhi.)

The Govt. of Karnataka had submitted Detailed Feasibility report of the proposed Mekedatu Balancing Reservoir cum Drinking Water Project to CWC and CWC has accorded in principle clearance and directed the Govt. of Karnataka to proceed with preparation of the DPR subject to certain clarifications on DFR. The compliance report is as under:

<table>
<tr><th>No</th><th>Observations</th><th>Compliance</th></tr>
<tr><td colspan="3">1. Comments of cost appraisal (irrigation) – to Directorate</td></tr>
<tr><td>i)</td><td>While preparing DPR, it should be ensured that assessment of the land quantity (private, government, forest) falling in the working of Dam & allied works including dumping area and in the reservoir submergence area should be based on village-wise detailed survey up to FRL / MWL. Also, identification / survey of number of project affected families (PAFs) due to the construction of project has to be carrying out as per norms of RFCTLARR Act, 2013. The assessment of land requirements & PAFs should be in consultation with the concerned State/ Central Departments.</td><td>
<table>
<tr><th>No</th><th>Purpose</th><th>Extent (Ha)</th><th>Type of land</th></tr>
<tr><td>1</td><td>Submergence Area (FRL 440.0 m)</td><td>5160.71</td><td>Wildlife forest - 4821.66 Ha
Reserved Forest- 196.57 Ha
Revenue land- 142.48 Ha</td></tr>
<tr><td>2</td><td>Dam Seating, Intake tunnel, Underground power house and tail race tunnel</td><td>66.64</td><td>Wildlife</td></tr>
<tr><td>3</td><td>Approach road and utility corridor (13.4 km, ROW 60m)</td><td>14.60</td><td>Wildlife</td></tr>
<tr><td>4</td><td>Colony</td><td>25.64</td><td>Revenue</td></tr>
<tr><td></td><td>Grand Total</td><td>5267.59 Ha</td><td>Wildlife , Reserved and Revenue lands</td></tr>
<tr><td></td><td>Area under Wildlife</td><td>4879.02 Ha</td><td></td></tr>
<tr><td></td><td>Area under Reserved forest</td><td>198.31 Ha</td><td></td></tr>
<tr><td></td><td>Area under Revenue land</td><td>190.26 Ha</td><td></td></tr>
</table>
Required information has been furnished in the DPR which has been worked out in consultation with the concerned State Departments.</td></tr>
<tr><td>ii)</td><td>Estimate should be prepared on current Schedule of Rates / price level and Civil work /H&M/E&M quantities should be based on drawings/design approved by the competent authority.</td><td>Estimate has been prepared as per the current schedule of rate (2018-19).</td></tr>
</table>

No	Observations	Compliance
2.	**CMDD (NW & S) Directorate:**	
i)	The height of the proposed concrete dam is 99m. hence site specific seismic study for the project has to be carried out and the same to be approved from the NCSDP.	Design of the dam has been carried out in line with the IS 1893 (Part-1) – 2002. The report will be submitted to the National Committee on Seismic Design Parameters (NCSDP) for review and approval.
ii)	The hydrological studies & the Design flood of the project shall be got approved form the Hydrology Directorate of CWC.	Hydrology – Annexure 4 will be submitted to the Hydrology Directorate for review and approval.
iii)	The Geology of the project area shall be got examined by GSI and their recommendation has to be duly incorporated in the DPR.	Geology of the project area has been reviewed by GSI and all the recommendations have been incorporated.
iv)	The availability and suitability of the construction material in the close proximity of the project area shall be got approved from CSMRS.	Availability and suitability of the construction material has been certified by the Quality Control Division of the CNNL. Copy of the report will be submitted to Central Soil and Material Research Station (CSMRS) for review and approval.
v)	Flood routing studies of the project shall be submitted for further examination.	PMF studies have been carried out for the Mekedatu project with flood routed through all 15 sub-catchments. The report is included as part of Hydrology – Annexure 4.
3.	**Hydrology Directorate:**	
i)	The schematic plan of the project and position of intercepting dams may be shown in the report. The catchment plan showing catchment boundary, stream network, contours, location of the projects, G & D sites, rain gauge station, etc., may also be given in the report.	Furnished in the hydrology report – Annexure 4.
ii)	The average, maximum and minimum annual rainfall in the catchment may be given in the report.	Furnished in the Salient features of Volume I of DPR

No	Observations	Compliance
iii)	The details of utilization of data of all existing, proposed and ongoing projects, etc., at u/s and d/s of the project may be provided in the report.	The entire utilisation planned in the project upstream of Mekedatu is well within the allocated share of water by CWDT as modified by Hon'ble Supreme Court of India vide the judgement dated 16.02.2018. Downstream of Mekedatu utilization is 2 TMC (Udutore Halla project) within the State.
iv)	It is suggested that observed flow of Kollegal G & D site (CA-21082 sq km) located u/s of Mekedatu Dam may be collected to assess the 75% dependability net yield series at project site. The same may be compared with yield series assessed by Biligunglu G&D site (in SI unit).	The catchment area at Kollegal G & D site is 22,000 sq km and that at Mekedatu is 34,273 sq km. So, there is an intermediate catchment of about 12,000 sq km where a number of tributaries join the river and also several projects exists for which precise hydrological data is not available. Hence, the correlation may not give realistic simulation.
4.	**Hydro Power Aspect – The observations of HPP & I Division (CEA) are as under:**	
i)	The proposed project is a multi-purpose project, envisaging construction of a 99m high Concrete Gravity dam with live storage of 1595 MCM between FRL 440 m and MDDL 395m. the installed Capacity of the project is 400MW, which consist of 3 units of 120 MW each and 1 unit of 40MW with an annual energy generation of 624.78 MU. The smaller unit of MW is proposed to utilize the environmental flows of 2.5 TMC per month during the months of utilize the environmental flows of 2.5 TMC per month during the months of February to May every year. No Irrigation or Flood control benefits have been envisaged for the project. Also, the total project cost is estimated at Rs. 5912.00 crores, which results in a tariff of Rs. 4.00 / KW hr. the total construction period proposed for the project is 48 months form the zero date.	Noted.This project has been conceived as a "Balancing Reservoir cum Drinking Water Project" with main objectives being releasing the mandated quantum of water to Tamil Nadu on a monthly basis (in a normal year) as per CWDT Award further modified by the Hon'ble Supreme Court of India vide its dated 16.02.2018 and to provide drinking water to Bangalore Metropolitian Region. Power generation is envisaged from the releases to the downstream

No	Observations	Compliance
ii)	As per the procedure for accord of concurrence of Hydro – Electric Project having likely cost of more than Rs. 1000 Crs. S&I/DPR preparation is to be carried out following consultation Process with the appraising agencies like CEA, CWE, GSI and CSMRS etc. the developers is required to submit the relevant chapters for examination to the concerned Directories/Divisions / Organizations of CEA, CWC, GSI and CSMRS under intimation to HPP &I Division, CEA, HPP&I Division shall hold the consultation meeting at the submission of relevant documents/chapters to Concerned Appraising agencies. In addition, nine clearance are to be obtained prior to submission of the DPR to CEA for its concurrence. However, the received proposal is a Multipurpose project in which only component needs to be reviewed in CEA and DPR of the project is to be concurred by the Technical Advisory Committee of MoWR.	Noted. Submissions will be made accordingly for review and approval.
5.	**HCD (NW & S) Directorate:**	
i)	Various alternatives have to be explored and tried before finalizing the present layout being adopted in the project.	Yes. All the alternates have been explored and the best layout has been selected.Refer Volume I of DPR
ii)	All Geological investigations may be carried out as per MoWR, RD & GR "Guidelines for Preparation of Detailed Project Report of Irrigation and Multipurpose Project, 2010 & and Further 2017.	Noted and investigations has been carried out in line with the guidelines. Any other suggested investigations if any required, the same will be carried out as pre- construction activities.
iii)	All Geological tests such as bore holes, drift, etc., shall be conducted, as per relevant IS Codes, before	Noted and investigations has been carried out in line with the guidelines except drift which will be carried out during pre-construction stage.

No	Observations	Compliance
	Finalization and fixing of hydropower components.	
iv)	Length of Main Access Tunnel to power house appears to be too long. To reduce the length alternative may be explored.	This has been reworked and the optimum alignment has been adopted. The length of the main access tunnel has been revised to 833.00 m.
v)	Surge shaft size as shown in page no. 119 is not matching.	This has been rectified.
vi)	Input file for transient analysis for tail race surge shaft as mentioned at Appendix-15.3 of volume 2 of the Report may be submitted for examination.	Submitted in volume II of the DPR vide Appendix 15.3
vii)	Head loss taken in the water conductor system is 3m which appears to be on lower side. Detailed calculation as per relevant IS code may be included in feasibility Report.	Head loss has been reworked as per IS Code and detailed calculation has been appended vide Appendix 15.2
viii)	Emergency gate along with service gate provision shall be there for maintenance purpose. In some drawings (EIT-1230X-WRE-XX-STR-A020 (1/2)(2/2), EIT-123X-WRE-XX-STR-A021(1/2)(2/2) Emergency gate is shown but in report and other relevant drawings provision of emergency gate has been omitted.	The power sluice service gate with hydraulic hoist is now provided. Emergency gate is not proposed in view of the very short water conductor system, but main inlet valve is proposed for each of the units in the machine hall. For River sluices both service and emergency gates have been provided. In case of spillway gates, two sets of stop log gates in elements have been provided. Moving gantry crane is provided for the operation of stop log gates.
x)	Inadequate spacing between power house and transformer hall cavern, transformer hall and surge shaft caverns have been shown in the drawings. Placing the two caverns close together may give rise to unfavourable stress conditions in pillar between the cavern depending upon rock mass strength.	Since the pillar width is approximately equal to height of larger of the two caverns, the zones of overstress are of limited extent and the core of the pillar has strength/stress ratio in excess of 2 (RMR/Q =80/19.8). This means that the stress field surrounding the two caverns are almost independent of one another. The extent of overstress zones suggest that a relatively modest amount of the rock support would be adequate to stabilise the rock mass surrounding the cavern.
xi)	Draft tube shall be less protruding in surge chamber. If	The original design concept has been retained, as adopted in several other projects.

No	Observations	Compliance
	we consider 7.5m extension of draft tube in surge chamber it may be required to accommodate loss of area due to draft tube extension. Draft tube gate provided inside the surge chamber may be shifted upstream.	
6.	**FE & SA Directorate**	
i)	Since the height of the dam is more than 30m and it falls in Seismic Zone-II of the Seismic Zonation map of India (IS:1893 (part-I)-2002), the site specific seismic studies for determination of design earthquake parameters shall be carried out in accordance with National Committee on Seismic Design Parameters (NCSDP) guidelines and report to be submitted to the NCSDP for approval. The "Guidelines for preparation and submission of site specific study report of river valley project to NCSDP" may be downloaded from CWC official website http://www.cwc.gov.in.	The required coefficients for the design of the major dam in terms of earthquake and other parameters have been considered as per the latest and relevant IS codes [IS 1893 (Part-1) – 2002]. The required seismic studies will be carried out as pre-construction activity for validating the coefficients considered in the design and if need be suitable modifications will be carried out as approved by NCSDP.
ii)	Further as far as geotechnical investigation are concerned, the project authorities shall get clearances from GSI (Geological Survey of India) / Agency accredited by GSI separately as indicated in the CWC's guidelines for submission, Appraisal and Acceptance of Irrigation and Multipurpose Project, 2017.	The geological studies has been reviewed and approved by the GSI.
Observations by Tamil Nadu – Annexure 2 -Chief Secretary to Government of Tamil Nadu		
i)	Justification for the Mekedatu project	Copy of the DPR attached which is self-explanatory.

CERTIFICATES

Appendix - A

Certificate on Preparation of DPR

This is to certify that Detailed Project Report (DPR) of Mekedatu Balancing Reservoir cum Drinking Water Project, Karnataka has been prepared in a consultative mode with the specialized directorates of CWC i.e. Hydrology, Irrigation Planning, Inter-State Matters and Project Planning from concerned unit under Design & Research Wing.

(signature with seal)

Chief Engineer,**CNNL**
Irrigation (South), Mysore
Govt. of Karnataka.

Counter signed by

Hydrology
(Signature, Name with seal)

Irrigation Planning
(Signature, Name with seal)

Inter-State Matters
(Signature, Name with seal)

Project Planning
(Signature, Name with seal)

Appendix - B

Certificate on Geological exploration

This is to certify that complete Geological exploration for the Mekedatu Balancing Reservoir cum Drinking Water project, located in the State of Karnataka required for the DPR stage has been carried out by Geological Survey of India during the period 1996 in the area of Mekedatu project site, Karnataka. Copy of the report is attached.

Authorised signatory of GST/Agency accredited by GSI with seal.

**The list of agencies accredited by GSI will be communicated separately.*

Appendix – C

Certificate on rock/soil mechanic tests

This is to certify that the required rock/soil mechanic tests have been carried out from the rock/soil samples collected through Geological exploration for the proposed Mekedatu Balancing Reservoir cum Drinking Water project, located in the State of Karnataka in the project area of Kanakapura Taluk, Ramanagara District.

(signature with seal)

Director,
Central Soil and Material Research Station,
Hauzkhas,
New Delhi

(or)

Authorised signatory of agency accredited by CSMRS with seal

**The list of agencies accredited by CSMRS will be communicated separately.*

Appendix - D

Certificate on suitability of available construction material

This is to certify that quarry area and suitability of available construction material both qualitatively and quantitatively within economical reach has been assessed for the project parameters at DPR stage for the proposed_Mekedatu Balancing Reservoir cum Drinking Water project, located in the State of Karnataka during Year 2018-19 in the project area of Kanakapura Taluka Ramanagara District Copy of the report is attached.

Executive Engineer, Manchanbele Project Division CNNL,Ramanagara	Executive Engineer QC Division. CNNL Mysuru	Superintending Engineer, KRSM & MIP Circle, CNNL, Mandya

Office of The Assistant Executive Engineer, No. 1 Q.C Sub division, CNNL, Ramanagara

GRADATION TESTS OF COARSE AGGREGATE FOR CONCRETE (40 mm & d/s)

Name of work: Mekedatu Balancing Resrvoir cum drinking water project

Date of test : 14.01.2019

Description	Sieve size in mm	Requirement as per IS 383:2016, Table 7 (% passing)	Percentage of passing as per test			Remarks
			1	2	3	
For Graded aggregate of 40mm & d/s.The aggregate of sizes 40mm, & d/s, 20mm and d/s and 10mm and d/s are mixed in the trial proportions of 55:15:30 and are tested for their grading / size suitability for concrete work.	80mm	100	100	100	100	The grading test on the combined aggregate conforms to the requirement. Note : Adopt the following percentage combination for coarse aggregate: **40mm & d/s : 55%** **20mm & d/s : 15%** **10mm & d/s : 30%** to achieve the required gradation for concrete.
	40mm	90-100	98	97	98	
	20mm	30-70	53	51	55	
	10mm	10-35	21	20	22	
	4.75mm	0-5	2	2	3	

Test conducted by: Er M N Kantharaju, AE

Copy submitted to

1. Executive Engineer, MP division, Ramanagara
2. Executive Engineer, Q C division, Mysore for Kind information.
3. Assistant Executive Engineer, dam sub division, Arobele for kind action.

Assistant Engineer

Assistant Executive Engineer
No.1 QC sub division, Ramanagara

Office of The Assistant Executive Engineer, No. 1 Q.C Sub division, CNNL, Ramanagara

GRADATION TESTS OF COARSE AGGREGATE FOR CONCRETE (20 mm & d/s)

Name of work : Mekedatu Balancing Resrvoir cum drinking water project

Date of test : 14.01.2019

Description	Sieve size in mm	Requirement as per IS 383:2016, Table 7 (% passing)	Percentage of passing as per test			Remarks
			1	2	3	
For Graded aggregate of 20mm & d/s.The aggregate of sizes 20mm and d/s and 10mm and d/s are mixed in the trial proportions of 45 : 55 and are tested for their grading / size suitability for concrete work.	40mm	100	100	100	100	The grading test on the combined aggregate conforms to the requirement. Note : Adopt the following percentage combination for coarse aggregate: **20mm & d/s : 45%** **10mm & d/s : 55%** to achieve the required gradation for concrete.
	20mm	90-100	93	92	93	
	10mm	25-55	41	39	43	
	4.75mm	0-10	4	5	4	

Test conducted by: Er M N Kantharaju, AE

Copy submitted to
1. Executive Engineer, MP division, Ramanagara
2. Executive Engineer, Q C division, Mysore for Kind information.
3. Assistant Executive Engineer, dam sub division, Arobele for kind action.

Assistant Engineer

Assistant Executive Engineer
No.1 QC sub division, Ramanagara

Office of The Assistant Executive Engineer, No. 1 Q.C Sub division, CNNL, Ramanagara

TESTS OF FINE AGGREGATE FOR CONCRETE

Name of work : Mekedatu Balancing Resrvoir cum drinking water project

Date of test : 14.01.2019

Description	GRADATION Percentage of passing as per Table 9 & Table 2 of IS 383 : 2016							Materials finer than 75µ sieve (as per Table 2 of IS 383:2016)	Other deleterious constituents (as per Table 2 of IS 383:2016)	Remarks
	10mm	4.75mm	2.36mm	1.18mm	600µ	300µ	150µ			
Zone I	100	90-100	60-95	30-70	15-34	5--20	0-20	Max 3% for Uncrushed & Max 15% for Crushed stone sand	Not to exceed 2%	The Crushed stone sand Conforms to Zone-II as per IS:383-2016
Zone II	100	90-100	75-100	55-90	35-59	8--30	0-20			
Zone III	100	90-100	85-100	75-100	60-79	12--40	0-20			
Zone IV	100	95-100	95-100	90-100	80-100	15--50	0-20			
Gradation test on representative sample of Crushed stone sand	100	97.30	86.28	76.94	47.66	22.35	12.98	7.59	Nil	

Test conducted by: Er M N Kantharaju, AE

Copy submitted to

1. Executive Engineer, MP division, Ramanagara
2. Executive Engineer, Q C division, Mysore for Kind information.
3. Assistant Executive Engineer, dam sub division, Arobele for kind action.

Assistant Engineer

Assistant Executive Engineer
No.1 QC sub division, Ramanagara

Appendix - E

Certificate on Ground Water aspect

This is to certify that the Mekedatu Balancing Reservoir cum Drinking Water project, located in the State of Karnataka is envisaged as a balancing reservoir to ensure releases as per the CWDT award further modified by the Hon'ble Supreme Court of India along with supply of drinking water to Bengaluru Metropolitian Region without irrigation component and as such command area is not a part of the project. However, on implementation the storage in the reservoir will definitely have an impact on the groundwater table in the surrounding areas.

(signature with seal)

Member(SML),

Central Ground Water Board,

West Block-2, R.K.Puram, New Delhi

Appendix –G(1)

Certificate on submission of site specific seismic design parameters

This is to certify that site specific seismic design parameters in accordance with the Guidelines for preparation and submission of site specific seismic study report of river valley project has been submitted by Project Authority for the Mekedatu Balancing Reservoir cum Drinking Water project, located in the State of Karnataka. Study report of the river valley project has been submitted as per **Appendix – G(2).**

(signature with seal)

Chief Engineer,**CNNL**

Irrigation (South), Mysore

Govt. of Karnataka.

Counter signed by

Director,

FE&SA Directorate & Member Secretary, NCSDP, Central Water Commission,

New Delhi

Appendix – G(2)

PROFORMA FOR SUBMISSION OF STUDY REPORT TO NCSDP

The study report should be compiled in a single dossier as per *proforma* given below.

The *proforma*, duly filled and signed, should be furnished as a check-list in the beginning of the study report.

No.	Description	Compliance(Yes/ No) w.r.t. Guidelines & reasons For Non- compliance
1	Project Details	Yes
(a)	Name of the Project	Mekedatu Balancing Reservoir cum Drinking Water Project
(b)	Name of the River over which the project is proposed	River Cauvery
(c)	Location of the Project: *State, District, Longitude & Latitude and Topo-sheet no. of each of the Project component (e.g. Dam/Barrage /Power House etc.)for which design seismic coefficient is required. Information to be given in tabular format.*	Karnataka, Ramanagara and Chamarajanagar Districts Longitude 77°26' 25" E Latitude 12°16' 20" N 57H/03, 57H/04, 57H/07, 57H/08, 57H/11, 57H/12. (Scale: 1:50,000)
(e)	Type of Project: *Multipurpose or irrigation Storage (area/volume of reservoir) or Run of the River Scheme or Hydro Power Project(Surface/subsurface, installed Capacity, number of units etc.*	Balancing Reservoir cum Drinking Water Project
(f)	*Details of the other projects in the vicinity(within 100 km):* *(Refer Annexure-E)* *Name of project, type of hydraulic structures, and seismic parameters (expected PGA for MCE) for projects constructed/ under construction.*	-
(g)	**Present Status of Investigation:** ***DPR submitted/approved; Salient comments/observations on DPR for ground exploration, relevant to Seismic design; status on environment clearance; preconstruction/ construction stage etc.***	DPR now submitted. For details refer DPR
(h)	Nature of foundation Material: *Nature of foundation material (including geotechnical properties of rock / soil etc. below different segments of dam and other project components.*	Refer DPR
(i)	Name and address of the Project Authority and Consultants/Advisors: *Complete postal address with telephone /fax/e-mail of the Project Authority and Consultants / Advisor engaged by the project Authority for various types of inputs [geological , geotechnical, seism0tectonics, seismic design etc] shall be given.*	-

No.	Description	Compliance(Yes/ No) w.r.t. Guidelines & reasons For Non- compliance
2	**Regional Geological and Seismo - Tectonic Evaluation** (*Refer Section 3.0 of the guidelines for details)*	
(a)	Tectonic Map:	-
(b)	Seismo – tectonic section:	
(c)	Interpretation of regional tectonic mechanism and other details:	
(d)	Earthquake catalogue:	
(e)	Micro earthquake investigation:	
3	**Local Geologic Setting** *(Refer Section 3.0 of the guidelines for details)*	
(a)	Geological map:	
(b)	Surface & subsurface configuration of major faults:	
(c)	Additional inputs on subsurface configuration of major faults:	
4	**Evaluation of site specific seismic parameters**	
(a)	Methodology of the study: *The adopted study methodology, confirming to item 4 of the guidelines, should be briefly described. Any deviation from the recommended approach should be pointed out with adequate justification.*	
(b)	Evaluated site specific seismic parameters: *The study should furnish the identified MCE (deterministic); recommended response vertical seismic coefficients along with computed natural period of the dam; estimated duration of shaking; and acceleration time histories for both horizontal and vertical motions.*	
5	**Recommendations on design approach** *(Refer Section 5.0 of the guidelines for details)*	
6	**Submission of study report for NCSDP approval** *(Refer Section 6.0 of the guidelines for details)*	

Date:

Signature & Seal of authorized representative of Project Authority

Appendix –H

Certificate on status of action taken for Statutory Clearances

This is to certify that necessary actions have been taken for obtaining Statutory clearances for the Mekedatu Balancing Reservoir cum Drinking Water project located in the State of Karnataka and status of the action taken is as follows:

a. Environment Clearance from MoEF&CC :

i. EIA in process
ii. EMP in process
iii. Others in process

b. Forest Clearance from MoEF&CC :

In process

c. Clearance in respect of R&R of Tribal population from MoTA:

In process

Signed by

(Signature, Name with seal)
Principal Secretary, Water Resources Department,
Govt. of Karnataka

Appendix –I

Certificate on mode of construction

This is to certify that the Mekedatu Balancing Reservoir cum Drinking Water project located in the State of Karnataka is going to be constructed through contract / Department and special team has been planned for timely construction of project as per the MoWR, RD&GR “Guidelines for preparation of Detailed Project Reports of irrigation and multipurpose projects. The constitution of the special team is as follows:

No.	Designation of officers of the team
	Will be confirmed

Signed by

(Signature, Name with seal)
Principal Secretary, Water Resources Department,
Govt. of Karnataka

<u>Appendix – J</u>

Sample Letter of Clearance of Major / Medium Irrigation / Multi-purpose Projects by the CDO of the State Govt.

To

The Chief Engineer,
Project appraisal Organization,
Central Water Commission Sewa
Bhavan, R.K. Puram, New Delhi –
110066

Subject: Clearance of providing DPR of the Mekedatu Balancing Reservoir cum Drinking Water project Multipurpose Project.

(1) The above project has been examined in the Central Design Organization with reference to the Checklist as per the latest guidelines for preparation of DPR of Ministry of Water Resources, RD & GR (2010) and it is found that:

(i) All necessary surveys and investigations for planning of the project and establishing its techno-economic feasibility have been carried out as per the aforementioned guidelines.

(ii) 10%/5000 ha. of the command area of the project (whichever is minimum) has been investigated in full details in three patches representing terrain conditions in the command for estimation of the conveyance system upto the last farm gates **– Not applicable.**

(iii) 100% of Main Canal and 10% of the remaining Canal structures (Branch canals, Distributaries, Minors etc.) have been investigated in full detail **– Not applicable.**

(iv) Detailed Hydrological, geological, construction material investigations, have been carried out for all major structures i.e. dams, weirs, main canal, branch canal up-to distributaries carrying a discharge of 10 cumecs.

(v) Soil survey of the command has been carried out in detail as per IS 5510- 1969 **– Not applicable.**

(vi) Necessary designs for the various components of the project has been done in accordance with the guidelines and relevant Indian Standards for Planning & Design/Safety aspects including design flood estimation etc., of the project which are enclosed. List of Codes is enclosed.

(vii) Necessary studies for utilization of ground water have been done with special regard to problem of water logging and suitable provisions have been made for conjunctive use of ground water & drainage arrangements **– Not applicable.**

(viii) The cropping pattern has been adopted in consultation with the State Agriculture Department and are based on soil surveys of the command keeping in view the national policy in respect of encouraging crops for producing oil seeds and pulses. Availability of water as per Inter-State agreements, awards and consent of co-basin States are also considered **– Not applicable.**

(ix) The cost estimates and economic evaluations are carried out as per guidelines issued by the Central Water Commission. No existing command of existing ground water, water bodies or minor irrigation schemes has been taken as beneficial command of the proposed project.

(2) The project has also been examined by the State level Project appraisal / Technical Advisory Committee comprising representative of Irrigation, Agriculture, Fisheries, Forests, Soil Conservation, Ground Water, Revenue and Finance Dept. and State level Environmental Committee etc. and techno-economic feasibility of the project has been established.

(3) The project is recommended for acceptance by Central Water Commission and Ministry of Water Resources, River Development & Ganga Rejuvenation.

Chief Engineer,**CNNL**
Irrigation (South), Mysore
Govt. of Karnataka.

Counter signed by

Principal Secretary, Water Resources Department, Govt. of Karnataka

Appendix –K

Certificate on Survey and Investigation

This is to certify that the Mekedatu Balancing Reservoir cum Drinking Water project located in the State of Karnataka for which 100% survey has been carried out. Copy of the report is attached.

Signed by

(Signature, Name with seal)
Principal Secretary, Water Resources Department,
Govt. of Karnataka

Appendix – L

Certificate on Cadastral Survey

This is to certify that proper Cadastral Survey has been carried out for all the property coming under submergence, for reservoir and for the Mekedatu Balancing Reservoir cum Drinking Water project located in the State of Karnataka. The list of properties coming under submergence are as follows:

No.	Name of Properties	
1	**Land in ha (including Roads Bridges Colony etc)** *Forest land:*	5077.33 Ha
	Agriculture land:	-
	Revenue land:	190.26 Ha
	Others:	0 Ha
	Total	**5267.59 Ha**
2	**Houses and Buildings (in Nos.)**	About 500
3	**Other structures such as road bridges, Railway bridges etc. (in Nos.)**	-
4	**Others**	-

Signed by

(Signature, Name with seal)
Principal Secretary, Water Resources Department,
Govt. of Karnataka

Appendix –M

Certificate on sharing of information to co-basin States

This is to certify that copy of DPR of the Mekedatu Balancing Reservoir cum Drinking Water project located in the State of Karnataka_has been sent to the Principal Secretaries of all other co-basin States for their views vide letter no.________________ dated (copy enclosed). Receipt for the same by the co-basin States enclosed. Views furnished by the co-basin States also enclosed herewith.

Signed by

(Signature, Name with seal)
Principal Secretary, Water Resources Department,
Govt. of Karnataka

SECTION – 1 CHECKLIST

SECTION - 1
CHECKLIST
(As per CWC Guidelines 2010- Modified circular 2017)

No.	Particulars	Details
I.	**GENERAL DATA**	
1)	Name of the project	MEKEDATU BALANCING RESERVOIR CUM DRINKING WATER PROJECT
2)	**Location**	
a)	State(s)	Karnataka
b)	District(s)	Ramanagara and Chamarajanagar
c)	Taluka (s) / Tehsil (s)	Kanakapura and Kollegal
d)	Longitude/Latitude	Longitude 77° 26´ 25″ E and Latitude 12° 16´ 20″ N
e)	Survey of India Topographical Map reference No.	57 H/03, 04, 07, 08,11 & 12
f)	Earthquake Zone number	Zone II
g)	Complete address for correspondence along with pin code /e-rnail	**The Managing Director,** Cauvery Neeravari Nigam Limited, Surface Water Data Center Building 3rd and 4th floor, Ananda Rao Circle, Bangalore-560009 E-mail : cnnbantech@yahoo.co.in
3)	**Category of the project**	
a)	Irrigation/Multipurpose	Drinking water and Power Project
b)	Storage/diversion	Storage [Balancing Reservoir cum drinking water]
II.	**PLANNING**	
4)	Has the Master plan for overall development of the river basin been prepared and stages of basin development discussed?	Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to.
5)	Have the alternative proposals (including set of smaller developments vis-a-vis a single large development) been studied and their merits and demerits discussed?	Merits and Demerits of alternative proposals are discussed in the Report, Vol-I Chapter 1, para 1.9
6)	Does the scheme fit in the overall development of the river basin and has its priority in the overall development of the basin been discussed?	Discussed in the Report, Vol-I,Chapter 1, para 1.12

No.	Particulars	Details
7)	Have the other Departments concerned with the development been informed?	Yes, Discussed in the Report, Vol-I,Chapter 1, para 1.13
8)	Is the present scheme proposed to be executed in stages? If so, are various stages of execution and development discussed in the report?	Single Stage
9)	Are the effects of the scheme on the riparian rights & existing Upstream and downstream projects etc. discussed?	Yes, Discussed in the Report, Vol-I,Chapter 3, para 3.4 on Inter State Aspects
10)	Has the provision for municipal and industrial water supply been made?	To the extent of 4.75 TMC allocation towards providing drinking water supply to Bengaluru Metropolitan region, its surrounding areas etc.
III.	**INTERSTATE AND INTERNATIONAL ASPECTS**	
11)	Are there any International/Interstate issues involved? If so have these issues been identified and present status of agreement or tribunal decision indicated specially in respect of	
a)	Sharing of water	As per CWDT Award and further modified as per the Judgement of the Hon'ble Supreme Court of India on 16/02/2018
b)	Sharing of cost	NA - As project is solely taken up by Karnataka
c)	Sharing of benefits (irrigation, flood control. Power etc.)	Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. Hence not applicable.
d)	Acceptance of the submergence by the upstream state(s)	NA - As submergence is only in Karnataka
e)	Acceptance by the upstream state(s) of compensation of land coming under submergence	NA - As submergence is only in Karnataka which is the implementing state
f)	Settlement of oustees	Provision has been made for Rehabilitation and Resettlement of oustees coming under submergence area of the balancing Reservoir as per the latest Land Acquisition Act which is in vogue.
g)	Any other	Nil
NOTE:-If there is no agreement, state the present position against each of the above item		
IV.	**SURVEYS**	
12)	Have the detailed topographical surveys been carried out for the following items and maps prepared as per prescribed scales	

No.	Particulars	Details
a)	River surveys	Survey has been carried out. The project site falls under the forest land including the upstream areas (part). CNNL is in the process of obtaining the approval from the forest authority to validate and to carry out further survey and Investigation if required
b)	Reservoir surveys	Survey has been carried out. The project site falls under the forest land including the upstream areas (part). CNNL is in the process of obtaining the approval from the forest authority to validate and to carry out further survey and Investigation if required
c)	Head work surveys (dam(s), dyke(s), barrage(s).weir(s) etc. and auxiliary components)	Survey has been carried out. The project site falls under the forest land including the upstream areas (part). CNNL is in the process of obtaining the approval from the forest authority to validate and to carry out further survey and Investigation if required
d)	Plant and Colonies sites	Survey has been carried out. The project site falls under the forest land including the upstream areas (part). CNNL is in the process of obtaining the approval from the forest authority to validate and to carry out further survey and Investigation if required
e)	Canal(s),branch canal(s) and water distribution system	NA – Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
f)	Major canal structures	NA – Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
g)	Power house, switch-yard, surge shafts, tailrace	Survey has been carried out. The project site falls under the forest land including the upstream areas (part). CNNL is in the

No.	Particulars	Details
		process of obtaining the approval from the forest authority to validate and to carry out further survey and Investigation if required
h)	Tunnel(s), adit(s),penstocks etc.	Survey has been carried out.. The project site falls under the forest land including the upstream areas (part). CNNL is in the process of obtaining the approval from the forest authority to validate and to carry out further survey and Investigation if required
i)	Surveys (detailed and sample) of areas of the command for OFD and Drainage work	NA – Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
j)	Soil surveys	Survey has been carried out. The project site falls under the forest land including the upstream areas (part). CNNL is in the process of obtaining the approval from the forest authority to validate and to carry out further survey and Investigation if required
k)	Surveys for soil conservation	The project site falls under the forest land including the upstream areas (part). CNNL is in the process of obtaining the approval from the forest authority consequent to the approval further survey will be carried out.
l)	Any other surveys i.e. archeological right of way. communication etc.	The project site falls under the forest land including the upstream areas (part). CNNL is in the process of obtaining the approval from the forest authority consequent to the approval further survey will be carried out.
V.	**GEOLOGICAL INVESTIGATIONS**	
13)	Have the geological surveys for the following items been carried out and report on geology of the following appended?	
a)	Region as a whole	Yes, Refer Chapter 4 , para 4.3
b)	Reservoir	Yes, Refer Chapter 4 , para 4.3
c)	Head work and energy dissipation area	Yes, Refer Chapter 4 , para 4.3
d)	Power house and appurtenances	Yes, Refer Chapter 4 , para 4.3
e)	Intakes and regulators	Yes, Refer Chapter 4 , para 4.3
f)	Major canal structures	NA – Present project is envisaged to be developed in single stage to ensure releases to Tamil

No.	Particulars	Details
		Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
g)	Tunnel(s),Pen stock(s),hill(s)etc.	Yes, Refer Chapter 4 , para 4.3
h)	Communication routes	NA – As Navigation is not envisaged in the project development
i)	Any other	Nil
VI.	**SEISMIC INVESTIGATIONS**	
14)	Has the seismicity of the region been studied and co-efficient of vertical horizontal acceleration for the various structures discussed?	Yes, Refer Chapter 4 , para 4.3.2
15)	Has the approval of the Standing Committee for recommending design of seismic coefficients for River Valley Project been obtained?	No, Consequent to the approval of the project before implementation, approval regarding the design of seismic coefficients will be obtained from the standing committee for river valley projects
16)	Is there possibility of liquefaction of foundations? If so whether liquefaction studies been carried out?	N/A, The Concrete Gravity dam is founded on Hard rock
VII.	**FOUNDATION INVESTIGATIONS**	
17)	Have the detailed foundation investigations (including in-situ tests and laboratory tests) for the following structures been carried out and detailed report(s) appended?	
a)	Earth and rock fill dam(s)	NA – Concrete gravity dam is proposed.
b)	Masonry/concrete dam(s)	Yes, Concrete gravity dam is proposed. Investigations have been carried out. The project site falls under the forest land including the upstream areas (part). CNNL is in the process of obtaining the approval from the forest authority to validate and to carry out further survey and Investigation if required
c)	Barrage(s) / Weir(s) / head regulators) etc.	NA
d)	Canal(s) & Canal Structures	NA
e)	Power house (t),tunnel (s), transformer caverns), Desilting chamber(s), surge tank(s) / shaft(s), intake(s)	Yes, Investigations have been carried out. The project site falls under the forest land including the upstream areas (part). CNNL is in the process of obtaining the approval from the forest authority to validate and to carry out further survey and Investigation if required
f)	Pump House(s)	NA
g)	Any other	Nil
18)	Are there any Special features affecting the	No

No.	Particulars	Details
	designs?	
VIII.	**CONSTRUCTION MATERIAL SURVEYS**	
19)	Have the surveys and laboratory tests for the· following Construction materials been carried out and report(s) appended?	
a)	Soils for impervious, semi-pervious and pervious zones of earth and rock-fill dam(s)	NA - As a concrete Gravity dam is proposed.
b)	Sand	Yes, Refer Chapter 4 , para 4.5.2
c)	Rock and coarse aggregates	Yes, Refer Chapter 4 , para 4.5.3
d)	Bricks and tiles	NA
e)	Pozzolona	NA
f)	Cement and lime stone	Yes, Refer Chapter 4 , para 4.5.6
g)	Steel	Yes, Refer Chapter 4 , para 4.5.7
h)	Any other	Nil
20)	Have the sources for each of the above material been identified and need etc. indicated?	Yes, Refer Quarry map,Vol III - Drawings
21)	Have the proposals for procurement of scarce materials been indicated?	NA
IX.	**HYDROLOGICAL AND METEOROLOGICAL INVESTIGATIONS**	
22)	(a) Have the hydrological and meteorological investigations been carried out and status of following data discussed in report?	Yes
	i. Rainfall	Yes, Refer Chapter 4 , para 4.6.1.1
	ii. Temperature	Yes, Refer Chapter 4 , para 4.6.1.2
	iii. Sunshine	-
	iv. Gauge & Discharge	Yes, Refer Chapter 4 , para 4.6.2
	v. Sediment	Yes, Refer Chapter 4 , para 4.6.3
	vi. Water quality	-
	vii. Evaporation	Yes, Refer Chapter 4 , para 4.6.1.6
	(b) Has the above data been collected & appended?	Appended in the report as **Appendix 3- Vol II**
X.	**HYDROLOGY**	
23)	Is the Hydrology dealt with in detail in a separate volume? Have its brief details been included in this Report?	Yes, Hydrology study is carried out and dealt in Chapter 5 – Vol I.
24)	Have an index map and bar chart showing locations of various hydro-metric, climatic and rainfall stations existing / ongoing / planned water resources projects and the data availability at those stations been attached?	Index Map showing the location of the proposed reservoir appended in Vol – III - Drawings
25)	Have required detail note about project-specific-hydro-meteorological data observatories been attached.	Yes, Refer **Appendix 3 – Vol II**
26)	Have required detail in case of Himalayan rivers, if project being planned in upper reaches the satellite imageries of project catchment especially	NA –As the project is planned in Deccan plateau, a non Himalayan area.

No.	Particulars	Details
	one during snow melt period (March-May) and one during monsoon (June-September) period been attached?	
27)	Are detail notes about quality, Consistency. Processing and gap filling of the data included.	Yes, Refer Appendix 7 , Vol II
28)	**Have hydrological studies been carried out for the following:**	
a)	To establish the availability of water for the benefits envisaged?	As per CWDT Award. Refer Vol I , Chapter 5 , para 5.1.6 and further modified by the Hon'ble Supreme Court of India vide its Judgement dated 16/02/2018
b)	To determine design flood for the various structures (spillway ,weir ,barrage etc.)	Yes. Refer Vol I , Chapter 5 , para 5.1.8.
c)	Sediments storage	Yes. Refer Vol I , Chapter 8 , para 8.2
d)	Design flood for diversion during construction	Yes.
e)	Tail water rating curve	Yes. Refer Vol I , Chapter 5 , para 5.1.13
f)	Evaporation rates from reservoirs/concerned area	Yes. Refer Vol I , Chapter 5 , para 5.1.7
g)	Command area rainfall	NA – The present proposal doesn't envisage irrigation component
29)	Has the Ground Water Potential (existing use and additional availability) been indicated?	No
30)	Have the studies regarding reservoir sedimentation been carried out and revised elevation-area capacity curves been used in the simulation studies (Working Table)?	Yes, Refer Vol I, Chapter 8, para 8.2
31)	Have the ecological requirements of water such as low flow augmentation and water quality control etc. and water requirement for domestic, industrial use and power generation (thermal, Hydel, nuclear) been considered and included in the Project Report and incorporated in the simulation studies?	Yes, Refer Vol I, Chapter 5, para 5.1.11
32)	Have the details of the simulation studies. (Working Tables) and conclusions arrived, from the various alternatives explaining the factors and assumptions been included and discussed?	Yes, Refer Vol I, Chapter 5, para 5.1.11.
33)	Has the number of failures for different aspects been indicated?	Yes, Refer Appendix 8 – Working Tables
34)	Have the likely desirable and,undesirable changes in the hydrologic regime due to-.the project been brought out in the report?	Mekedatu project is a balancing reservoir to regulate flow of water hence no hydrologic regime changes are expected.
35)	Is the criteria adopted for selection of the construction diversion flood discussed?	No
36)	Has the basis for determining the storage capacity been discussed?	Yes, Refer Vol I, Chapter 5, para 5.1.3
37)	Have integrated working tables (for more than	Working tables for the present project is

No.	Particulars	Details
	one reservoir in the system) been prepared?	prepared.
38)	Has carry over storage been provided? If so. Whether studies for most economic carry over storage been done?	Carry over storage has not been provided in the proposed scheme.
39)	Have the flood routing studies been carried out?	Refer Vol I, Chapter 5
40)	Have the back water studies been carried out?	Yes, Refer Vol I, Chapter 5, para 5.1.14
XI.	**LAND ACQUISITION AND RESETTLEMENT OF OUSTEES**	
41)	Have the type and quantum of land proposed to be acquired in the submerged area project area, area coming under canals and distribution system, area required for rehabilitation of the oustees been detailed?	Yes, Refer Vol I, Chapter 8, para 8.8
42)	Is the basis for provision for land compensation indicated?	Yes, Refer Vol I, Chapter 8, para 8.8
43)	Have the rehabilitation measures, amenities and facilities to be provided to the Project Affected Persons been discussed and whether their provisions included in the report? Are these in accordance State's policy/project, specific policy/draft national policy for rehabilitation and resettlement	Yes, Refer Vol I, Chapter 8, para 8.8.3
44)	Are the basis of land acquisition of the submerged area upto FRL/MWL etc. discussed?	Yes, Refer Vol I, Chapter 8.
XII.	**DESIGNS**	
45)	Does the state have established a Central Design Organization and State level multi-disciplinary /Advisory Committee and whether its composition has been indicated in the report?	Yes, The project is examined by the State level project appraisal committee comprising of experts in irrigation and other departments and techno economic feasibility has been established.
46)	Has the selection of final location of the head works and, appurtenances, in preference to the other sites investigated been discussed?	Yes. Refer Vol –I,Chapter 1, para 1.9
47)	Have the layout of the project viz location of head work workshop sheds; offices, Colonies. etc. been finalized and discussed?	Yes
48)	Has the layout of the various major components of the head works been discussed in the, light-of site features, geology, foundation characteristics?	Yes, Refer Vol –I,Chapter 4, para 4.3
49)	Have the detailed designs been prepared for the following components & got vetted by CDO?	Detailed designs have been prepared in accordance with the guidelines and relevant Indian Standards which has been examined by the State level project appraisal committee comprising of experts in irrigation and other departments and techno economic feasibility has been established

No.	Particulars	Details
a)	Earth or rock fill dam. Masonry or concrete dam; spillway ,barrage, weir. etc. and appurtenances.	Yes, Refer Vol –I, Chapter 7, para 7.2
b)	Energy dissipation arrangements, training walls etc.	Yes, Refer Vol –I, Chapter 7, para 7.2
c)	Openings through dams- galleries head regulators, penstocks other outlets, sluices etc.	Yes, Refer Vol –I, Chapter 7, para 7.2 and 7.3
d)	Regulators	NA
e)	Canal and water conductor system	NA
f)	Canal structures	NA
g)	Pump house, Intake structures	Power Intake 3 Nos. in the Dam Blocks
h)	Power House, tunnels, surge shaft	Yes, Refer Vol –I, Chapter 7, para 7.3
i)	Instrumentation	Yes, Refer Vol –I, Chapter 7, para 7.4
j)	Power evacuation arrangement	Yes, Refer Vol –I, Chapter 13, para 13.8.1.20
k)	Design of Hydro Mechanical equipment's	Yes, Refer Annexure 3
50)	Have the salient features of the above components ·and the assumptions made in the design of above components of the project been indicated and their basis discussed?	Yes,
51)	Have any model studies been carried out for location of the-dam, spillway and other appurtenances & checking the design profile. of the spillway. Energy dissipation arrangements. Location of outlets/regulators etc.?	Shall be conducted after approval of the proposal and before taking up the construction.
52)	Has the final alignment of canal(s) , and branch canal(s) been discussed in the light of various alignments studied?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. No irrigation component is envisaged.
a)	Does the canal design provide for meeting requirement to rush irrigation?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. No irrigation component is envisaged.
b)	Have any intermediate storages and tail tanks been considered to reduce the canal capacities?	NA - Present project is envisaged to be developed in single stage to ensure releases

No.	Particulars	Details
		to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. No irrigation component is envisaged.
53)	Are the canals and distribution system being lined and If so what is the minimum capacity of the channel proposed to be lined?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. No irrigation component is envisaged.
54)	Is the location of canal structure on main and branch canals fixed after detailed surveys of the final alignments?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region, its surrounding areas etc in Cauvery Basin" besides generating power by utilizing the level difference out of the releases effected to. No irrigation component is envisaged.
55)	Are the regulation arrangements of the. off taking channel both. near and away from the cross regulators discussed?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. No irrigation component is envisaged.
56)	Are sufficient escapes including terminal escapes provided on the main/branch canal distributaries/minors?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme

No.	Particulars	Details
		Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. No irrigation component is envisaged.
57)	Have the basis for adopting water way for the cross drainage works been discussed?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. No irrigation component is envisaged.
58)	Have the proposals for rating the canal section by providing standing wave flumes. rating of the falls, broad crested weirs. V -notches etc. been discussed for the canal and distribution system?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. No irrigation component is envisaged.
59)	Have any model studies for major canal structure(s) been carried out and if so are the results discussed and incorporated in the design?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. No irrigation component is envisaged.
XIII.	**IRRIGATION AND COMMAND AREA DEVELOPMENT**	
60)	Have the conveyance and field irrigation efficiencies for paddy and upland crops during kharif, rabi etc. been indicated, discussed and justified?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing

No.	Particulars	Details
		storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. No irrigation component is envisaged.
61)	Have the 10-daily/monthly crop water requirements at the canal head been worked out?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. No irrigation component is envisaged.
62)	Are there any proposals for introducing Warabandi and if so have these proposals been discussed in the report and sample calculations for a typical distributary / minor / sub- minor furnished?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. No irrigation component is envisaged.
63)	Has the present position of irrigation in the command through existing canals, tanks, and lift schemes. wells etc. been brought out·in the report?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. No irrigation component is envisaged.
64)	Are the particulars of all irrigation projects (including minors schemes) existing / proposed in the command been indicated?	–Yes. However, present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing

No.	Particulars	Details
		the level difference out of the releases effected to.
65)	Are there any potential areas, where ground water is available? If so, has the quantity & quality of the ground water been indicated?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
66)	Has the quantum of available ground water been assessed and plan for its conjunctive use with surface water been prepared and incorporated in the report?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
67)	Have the semi-detailed soil surveys been carried out for the entire command? If not the extent of area surveyed may be indicated.	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. No irrigation component is envisaged.
68)	Have soil and land irrigability classifications brought out in the report?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. No irrigation component is envisaged.
69)	Is the method used for determining the crop water requirements discussed?	NA -Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT

No.	Particulars	Details
		award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. No irrigation component is envisaged.
70)	Has the pre-project cropping pattern and the proposed cropping pattern along with justification been furnished?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. No irrigation component is envisaged.
71)	Has the proposed cropping pattern been certified by Centre/State Agricultural: Authorities giving the statement of having considered the soil characteristics and land irrigability characteristics of the command area in-deciding the percentage of the command area falling under respective crops as suggested in DPR.	NA -Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region difference out of the releases effected to. No irrigation component is envisaged.
72)	Whether drinking water needs of the population projected for the 25-30 years after construction of the project on enroute and that in the command of the project considered.	Yes, The municipal limit of the Bangalore City has increased to nearly 8005 sq.km and the areas falling upto the north bank of Cauvery river is dependent on Cauvery water for their drinking needs. The population of the belt as per 2011 census is projected upto 2044.
73)	Whether the proposed G.W utilization is certified by CGWB and a statement furnished.	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
74)	Are the areas and percentages of the CCA that	NA - Present project is envisaged to be

No.	Particulars	Details
	will be irrigated during kharif, rabi, two seasonal, summer and perennial been indicated?	developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. No irrigation component is envisaged.
75)	Is justification furnished for irrigating perennials and summer crops from the reservoir?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. No irrigation component is envisaged.
76)	Have the monthly reservoir operation studies been carried out at least for 20 years and summary on annual basis attached?	Summary on Annual Basis attached
77)	Have the number of blocks selected for detailed surveys for On Farm Development (OFD) works including drainage and total area covered by such blocks been indicated?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. No irrigation component is envisaged.
78)	Have the existing locations of the Trial cum Demonstration Farm, input centers (seeds, fertilizer and insecticides) in .the command been indicated and proposal to strengthen the same discussed?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
79)	Have the arrangements for financing the OFD works and proposals, if any, .for strengthening,	NA - Present project is envisaged to be developed in single stage to ensure releases

No.	Particulars	Details
	the same been discussed?	to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
80)	Have the agencies responsible for execution of OFD Works been identified and simultaneous planning of execution of OFD works along with engineering works discussed?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
81)	Has-the year wise phasing of irrigation development as a result of the project been discussed?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. No irrigation component is envisaged.
82)	Is the existing communication system telephone. wireless and roads within command are a sufficient to meet the requirement after full development to irrigation? If not, have the new proposals been planned and discussed?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. No irrigation component is envisaged.
83)	Is the adequacy of the marketing centers in the Command Area and new proposals to meet the requirements after full development of irrigation been discussed?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan

No.	Particulars	Details
		Region" besides generating power by utilizing the level difference out of the releases effected to. No irrigation component is envisaged.
84)	Is there any stabilization of existing irrigation proposed?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. No irrigation component is envisaged.
XIV.	**FLOOD CONTROL AND DRAINAGE**	
85)	Have the various flood control components of the multipurpose project been indicated?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
86)	Have the damage areas in pre-project & post project situations been identified and flood intensities worked out at each of the damage center(s) which gets affected?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
87)	**Have the following flood aspects been discussed?**	
a)	Flood cushion in the reservoir.	Provision has been made for flood cushion
b)	Maximum moderated flood outflows over the spillway etc. and its frequency	The spillway has been designed to discharge PMF as per the approved CWC parameters Refer Vol I, Chapter 5 , para 5.1.8
c)	Existing and proposed safe carrying capacities of the channel below the dam after construction of flood embankment, channel improvement, river diversion etc.	The river valley downstream of the dam is well defined with very high hills on either side and the bed is predominantly hard rock. The chances of flood overflanking immediately downstream is remote.
d)	Synchronized moderated peak floods due to	The spillway has been designed to discharge

No.	Particulars	Details
	releaser(s) from the dam upstream and un-intercepted catchment up to the damage centers.	PMF as per the approved CWC parameters which takes into cognizance of the flood releases from upstream dam and un-intercepted catchment
e)	Average annual expenditure incurred on flood relief works.	Expenses due to flood relief work is not envisaged since such a scenario has not been encountered in the Cauvery basin in Karnataka till date.
f)	Area and population affected/likely to be affected before/after the project.	Only population in some of the hamlets may require rehabilitation and resettlement. Refer Vol I, Chapter 1 , para 1.6
g)	Estimated saving in annual loss of life, property, cattle, crops etc. (evaluated in terms of money) due to flood control.	Mekedatu balancing reservoir project is located just 5 km upstream of Interstate border and meant for regulating releases.
88)	**Have the following drainage aspects of command area been discussed?**	
a)	Existing Surface and sub-surface drainage network and problems of the drainage congestion, water logging, alkalinity/salinity if any.	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
b)	Studies on sub soil water table (pre-monsoon, post monsoon etc.).	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
c)	Maximum intensity of 1, 2. and 3 day rainfall.	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
d)	Deficiencies in farm drains.	NA - Present project is envisaged to be

No.	Particulars	Details
		developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
e)	Deficiencies in existing natural drains	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
f)	Proposal for improvement of drainage water logging /alkalinity/salinity of the area along with justification thereof.	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
g)	Identification of the area in Command which will get benefited due to execution of drainage net-work and benefits thereof in terms of relief from crop damage, increased yields etc.	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
XV.	**NAVIGATION**	
89)	Is the present scheme for remodeling of the existing facilities and/ or extension of the navigable reach or establishing new navigable reach?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan

No.	Particulars	Details
		Region" besides generating power by utilizing the level difference out of the releases effected to
90)	Is the existing inland transport system being fully utilised? If not, have the bottlenecks in its full utilisation been identified and discussed?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
91)	Have the surveys for goods and passenger traffic been carried out and discussed?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
92)	Is the extent of modification required in the existing system discussed and justified?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
93)	Do design for the canal section and structures take into account the navigation requirements?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
94)	Have the proposals to develop the new scheme and phases of development in the different reaches been discussed?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme

No.	Particulars	Details
		Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
95)	If the area is being served by inland water transport, have the following been discussed:	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
a)	The existing toll rates and registration fees for the crafts (size-wise)	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
b)	Proposals for revision of tollage rates and fees, if any.	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
c)	Concurrence of the competent authorities for revision of rates and fees.	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
d)	Proposal to subsidies the tariff, tollage, craft	NA - Present project is envisaged to be

No.	Particulars	Details
	registration fee, passenger fare etc. to attract traffic.	developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
96)	Has the State Inland Water Authority been consulted while finalising the scheme and its view point discussed?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
97)	Has economic justification and viability of the, navigation component of the multipurpose project been discussed?	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
XVI.	**POWER**	
98)	**Have the following points been discussed**	
a)	Availability of the power generating capacity in the state as well as in the region from different sources.	Yes, Refer Vol I, Chapter 13 , para 13.1.1
b)	Total energy available and peaking capacity of the system, in the state as well as in the region from different sources.	Yes, Refer Vol I, Chapter 13 , para 13.1.3
c)	Integrated operation of the system and present status of utilization in the state as well as in the region.	Yes, Refer Vol I, Chapter 13 , para 13.1.1
d)	Surpluses and shortfalls in the system in the state as well as in the region.	Yes, Refer Vol I, Chapter 13 , para 13.1.1
e)	Future plans of power development from different sources in the State/region.	Yes, Refer Vol I, Chapter 13 , para 13.1.1
f)	Fitment of the scheme in planning of power development of the state /region.	Yes, Refer Vol I, Chapter 13 , para 13.1.1

No.	Particulars	Details
g)	Energy generated from the project Firm power, seasonal power and total power.	Yes, Refer Vol I, Chapter 13 , para 13.1.1
h)	Proposal for transmission lines connecting to the existing system / grid.	Yes, Refer Vol I, Chapter 13 , para 13.7
i)	Project. Cost. Per kWh installed and per kwh generated at bus bar as compared to the different hydro-electric: thermal generation and gas projects and different sources.in the State as well as.in the region to justify the power component of the project.	Yes, Refer Vol I, Chapter 13 , para 13.1.4
j)	Whether the proposed addition to the transmission system has been shown-on a geographical map Whether options considered for the proposed addition have been discussed with statement of justification for the selected option after carrying out supporting studies covering load flow studies , short circuit studies (three phase and single phase) and stability studies.	No, This will be worked out consequent to the approval of the project.
k)	*Whether sufficient surplus of Peak power is available for pumping of water from lower to upper reservoir.	N/A. - This arrangement is not envisaged in the present project
l)	*Actual off peak energy requirement of proposed scheme	N/A. - This arrangement is not envisaged in the present project
m)	*Cost of peak-and off peak energy	N/A. - This arrangement is not envisaged in the present project
	for pumped storage schemes only	
XVII.	**CONSTRUCTION PROGRAMME & PLANT AND, MANPOWER PLANNING**	
99)	Are the .major components of work proposed to be done departmentally or through contractor?	The construction works are proposed to be executed through Tendering process.
100)	Have the various alternative construction programme been studied and proper justification furnished for the final programing adopted?	Yes, for 4 yrs.
101)	Has the proposed Construction programme been prepared and synchronized for timely completion of each of the major component of work including Command Area Development?	Yes, refer Chapter 15. Command area development is not applicable.
102)	**Have the year wise quantities of the following materials of construction been worked out for various components of the project.**	
a)	Excavation separately in -soft and hard strata	Yes, Detailed project WBS has been worked out considering the overall project schedule.
b)	Earth work in filling-impervious, semi-pervious and pervious	Yes, Detailed project WBS has been worked out considering the overall project schedule.
c)	Rock fill-for dam,toe, riprap etc.	NA
d)	Stone for masonry	Yes, Detailed project WBS has been worked out considering the overall project schedule.
e)	Coarse aggregate for concrete	Yes, Detailed project WBS has been worked

No.	Particulars	Details
		out considering the overall project schedule.
f)	Sand-for filter, masonry/ concrete. '	Yes, Detailed project WBS has been worked out considering the overall project schedule.
g)	Gravel-for filter.	Yes, Detailed project WBS has been worked out considering the overall project schedule.
h)	Steel of various sizes and type	Yes, Detailed project WBS has been worked out considering the overall project schedule.
i)	Cement-normal, quick/slow setting with or without Pozzolona, special types	Yes, Detailed project WBS has been worked out considering the overall project schedule.
j)	Lime-surkhi-Pozzolona	NA.
k)	Scarce material-special steel	Yes, Detailed project WBS has been worked out considering the overall project schedule.
l)	Other material-fuel, electricity, explosive etc.	Yes, Detailed project WBS has been worked out considering the overall project schedule.
103)	Have the year wise quantities to be executed by machine labour for each of the major component been worked out for each of the above material?	Yes, Detailed project WBS has been worked out considering the overall project schedule.
104)	Have the labour intensive items of the various major components of the project been identified and the quantities of such items worked out?	Yes, Detailed project WBS has been worked out considering the overall project schedule.
105)	Have PERT chart or CPM diagrams for construction programme of various components been made and included in report? Has organizational setup and frequency for project monitoring been indicated in the report?	Yes, Detailed project WBS has been worked out considering the overall project schedule.
XVIII.	**FOREIGN EXCHANGE**	
106)	Have the details of the plant and machinery, spares, instruments and scares material to be imported\ worked out ?	NA
107)	Has the phasing of imports and source(s) of imports been discussed item wise?	NA
108)	Are the imports to be affected under foreign grants/credits or internal resources of the country?	NA
109)	Is the scheme covered under State sector or Central sector?	Covered under State Sector
XIX.	**FINANCIAL RESOURCES**	
110)	Has the Concurrence of the State Finance department been obtained?	Yes, The project has been approved by the State Level competant authority.
111)	Is the scheme included in the Five Year/Annual Plan? If not what is the present position regarding its inclusion in the plan?	The project will be included in the annual plan for the budget before taking up the construction activity.
112)	Whether the scheme has already been started? If so, is the present stage of construction indicated?	Feasibility Report had been reviewed by CWC and CEA. The GoK has been directed to go ahead with preparation of the DPR .
113)	Have the year wise requirement of funds been indicated?	Yes 1st year – Rs. 1200.00 Crores

No.	Particulars	Details
		2nd year – Rs. 3000.00 Crores 3rd year – Rs. 3000.00 Crores 4th year – Rs. 1800.00 Crores **Total - Rs. 9000.00 Crores**
114)	Is the scheme covered or proposed to be covered under any foreign assistance/aid agreement?	The scheme is not proposed to be covered under any foreign /aid agreement
XX.	**ESTIMATE**	
115)	Is the separate volume of estimate attached as appendix?	Yes, Refer **Vol -II**
116)	Is the year to which the rates adopted in the estimate relates to indicated?	The estimates are prepared based on SR of 2018-19 of WRD and 2016-17 of KPCL
117)	Have the analysis of rates for various major items of the work for the major components of the project been furnished and with basis of analysis described?	Yes, Refer Vol -II
118)	**Are the provision for the following items made on the basis of sample survey and sub estimates**	
a)	Distributaries:,minor and sub-minors	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. . No irrigation component is envisaged.
b)	Watercourses	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. . No irrigation component is envisaged.
c)	Drainage	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan

No.	Particulars	Details
		Region" besides generating power by utilizing the level difference out of the releases effected to. . No irrigation component is envisaged.
d)	CAD works	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. . No irrigation component is envisaged.
XXI.	**REVENUE**	
119)	**Are the basis for the following sources of revenues furnished?**	
a)	Betterment levy and proposal for its recovery	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. . No irrigation component is envisaged.
b)	Irrigation cess	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. . No irrigation component is envisaged.

No.	Particulars	Details
c)	Flood protection cess	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. . No irrigation component is envisaged.
d)	Crop wise water rates	Not applicable as the present scheme do not envisage any irrigation component
e)	Sale of water for Village / City / Industrial / Power / Water supply	Yes, Refer Chapter 20
f)	Miscellaneous	-
120)	Have these rates been compared with the existing rates at the other projects in the State/region?	Yes, rates have been adopted as per the prevailing rates approved by GoK which is in vouge
121)	In case the rates are being enhanced, has the concurrence of the concerned department(s) been obtained?	NA
122)	Have the Organisational set up for the collection of revenue been indicated?	Yes, refer Chapter 15.
XXII.	**B.C.RATIO**	
123)	**Are the allocated cost for the following components of the multipurpose project worked out and basis there in furnished?**	
a)	Irrigation	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to. . No irrigation component is envisaged.
b)	Power	–Yes. Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases

No.	Particulars	Details
		effected to.
c)	Flood Control	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
d)	Navigation	NA - Present project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award further modified by Hon'ble Supreme Court of India on 16/02/2018 and "Providing storage backing to meet drinking water requirement of Bangalore Metropolitan Region" besides generating power by utilizing the level difference out of the releases effected to
e)	Water supply	Yes, Refer Chapter 21
f)	Any other	NA
124)	Have the various departments of the State/Centre agreed to the sharing of the above allocated cost?	This is a power/water supply/regulation reservoir. Sharing of the cost between the concerned departments in the State will be worked out
125)	Have the crop wise benefits been worked out for irrigated and un irrigated crops being grown before project in consultation with the agriculture department and statement furnished?	NA. . No irrigation component is envisaged.
126)	Have the crop wise benefits been worked out for proposed cropping pattern after the introduction of irrigation in consultation with the agriculture department and statement furnished?	NA. No irrigation component is envisaged.
127)	Is the B.C. Ratio of Irrigation Projects acceptable or otherwise justified?	NA. No irrigation component is envisaged.
128)	Is the B.C.Ratio for Flood Control Projects acceptable or otherwise justified?	NA-
129)	Is the B.C.Ratio for power component of the project acceptable or otherwise justified?	Yes , Refer Chapter 21
130)	Have the financial and economic return statements been furnished keeping in view the phasing of development?	Yes , Refer Chapter 21
131)	Are the benefits other than those considered in the B.C. Ratio and financial return statement been identified?	Yes , Refer Chapter 21

No.	Particulars	Details
132)	Is the benefit from Gallper land, if proposed, based on lease rates admissible and statement from concerned Central/State authorities furnished?	NA
133)	Are the benefits from fisheries, horticulture, if proposed, based on lease rates admissible and statement from concerned Central/State authorities furnished	No benefits considered at present
XXIII.	**ECOLOGICAL ASPECTS**	
134)	**(a) Is the area likely to have any of the following environmental and ecological problems due to the altered surface water pattern? If yes, whether preventive measures have been discussed?**	
	Excessive sedimentation of the reservoir and the upper reaches of the river and its tributaries tailing into reservoir	
	i. Water logging, salinity/alkalinity	No effect. Refer Chapter 17
	ii. Quality of surface and ground water	No effect. Refer Chapter 17
	iii. Ground water recharge	Yes
	iv. Health hazards-water borne diseases,	No effect. Refer Chapter 17
	v. industrial pollution etc.	No effect. Refer Chapter 17
	vi. Submergence of important minerals deposits	No effect. Refer Chapter 17
	vii. Submergence of monuments/archeological sites	No effect. Refer Chapter 17
	viii. Fish culture and aquatic life	No effect. Refer Chapter 17
	ix. Plant life (flora)	No effect. Refer Chapter 17
	x. Wild Life	No effect. Refer Chapter 17
	xi. Migratory birds	No effect. Refer Chapter 17
	xii. National parks and sanctuaries	No effect. Refer Chapter 17
	xiii. Seismicity due to filling of reservoir	No effect. Refer Chapter 17
	xiv. Likely changes in the regime of the river	No change is expected in the regime of the river
	xv. Any other	NA
	(b) Have the environmental and forest clearances from MOE&F been obtained? If not what is status thereof?	The proposals are under preparation
XXIV.	**COLONIES AND BUILDINGS**	
135)	Has the planning of the colony/building been done keeping in view the ultimate use for optimum utilisation of investment?	Planning is being done for Rehabilitation and Resettlement of ousters coming under submergence of the proposed reservoir.Refer Vol –I, Chapter 8, para 8.8
136)	Has an estimate of the extent of higher cost involved been made and details discussed?	NA
137)	Are the permanent buildings being constructed required for maintenance of the project only?	Yes
138)	Can the buildings other than required for maintenance of the project being constructed be	Yes

No.	Particulars	Details
	put to some other use after the completion of the project by the department or any other agencies?	
139)	Have the interested agencies been consulted for planning of the buildings to suit their requirements later on?	Yes
140)	Have the proposals for disposal of temporary buildings been discussed?	NA
XXV.	**PUBLIC PARTICIPATION AND COOPERATION**	
141)	**Are the possibilities of these been discussed in:**	
a)	Planning	Yes, Refer Vol –I, Chapter 17
b)	Construction	Yes, Refer Vol –I, Chapter 17
c)	Improved agricultural practices	NA
d)	Any other	NA
142)	Have-public debates about utility of projects been held and the response thereof outlined in the Report?	In process
XXVI.	**SOIL CONSERVATION**	
143)	Is the need for soil conservation measures in the catchment-of the project discussed?	-

SECTION – 2 SALIENT FEATURES

SECTION - 2
SALIENT FEATURES

<table>
<tr><th>No.</th><th colspan="2">Particulars</th><th colspan="3">Details</th></tr>
<tr><td>1</td><td colspan="2">Name of the Project</td><td colspan="3">MEKEDATU BALANCING RESERVOIR CUM DRINKING WATER PROJECT</td></tr>
<tr><td>2</td><td colspan="2">Type of Project
(Irrigation or Multipurpose)</td><td colspan="3">Balancing reservoir cum Drinking water Project</td></tr>
<tr><td>3</td><td colspan="2">Location</td><td colspan="3">Longitude 77°26' 25" E
Latitude 12°16' 20" N</td></tr>
<tr><td rowspan="2">3.1</td><td rowspan="2">River Basin</td><td>a) Name</td><td colspan="3">Cauvery Basin</td></tr>
<tr><td>b) Located in
(i) State(s)
(ii)Countries(if international river)</td><td colspan="3">
Karnataka
India</td></tr>
<tr><td>3.2</td><td colspan="2">River /Tributary</td><td colspan="3">Cauvery River</td></tr>
<tr><td rowspan="5">3.3</td><td colspan="2">State(s)/District(s) Taluk(s) or Tehsils in which the following are Located.</td><td>State</td><td>District(s)</td><td>Taluka(s)</td></tr>
<tr><td colspan="2">a) Reservoir</td><td>Karnataka</td><td>Mandya, Ramanagara & Chamarajanagar</td><td>Malavalli, Kanakapura & Kollegal</td></tr>
<tr><td colspan="2">b) Headwork</td><td>Karnataka</td><td>Mandya, Ramanagara & Chamarajanagar</td><td>Malavalli, Kanakapura & Kollegal</td></tr>
<tr><td colspan="2">c) Command Area</td><td>Nil</td><td>Nil</td><td>Nil</td></tr>
<tr><td colspan="2">d) Power House</td><td>Karnataka</td><td>Chamarajanagar</td><td>Kollegal</td></tr>
<tr><td>3.4</td><td colspan="2">Name of the village near the Headwork</td><td colspan="3">Muguru and Mekedatu village of Kanakapura and Kollegal Taluks, Ramanagara & Chamarajanagar Districts</td></tr>
<tr><td rowspan="3">3.5</td><td rowspan="3">Location of Head Works</td><td>a) Longitude</td><td colspan="3">77°26'25" N</td></tr>
<tr><td>b) Latitude</td><td colspan="3">12°16'20" E</td></tr>
<tr><td>c) Lies in Earthquake Zone Number.</td><td colspan="3">Zone No-II</td></tr>
<tr><td rowspan="3">3.6</td><td colspan="2">Project area Reference to</td><td colspan="3"></td></tr>
<tr><td colspan="2">a) Degree Sheets</td><td colspan="3">57H/03, 57H/04, 57H/07, 57H/08, 57H/11, 57H/12. (Scale: 1:50,000)</td></tr>
<tr><td colspan="2">b) Index Plan</td><td colspan="3">Enclosed</td></tr>
<tr><td rowspan="5">3.7</td><td colspan="2">Access to the Project</td><td colspan="2">Name</td><td>Distance from project site</td></tr>
<tr><td colspan="2">a) Airport</td><td colspan="2">Bengaluru International Airport</td><td>133 km</td></tr>
<tr><td colspan="2">b) Rail head</td><td colspan="2">Ramanagara</td><td>66 km</td></tr>
<tr><td colspan="2">c) Road head</td><td colspan="3">NH-209, 36 km from Kanakapura (Ramanagar District)</td></tr>
<tr><td colspan="2">e) Sea port</td><td colspan="2">Mangaluru (Sea port)</td><td>370 km</td></tr>
<tr><td>3.8</td><td colspan="2">Rail/Road transportation limit of</td><td colspan="2"></td><td></td></tr>
</table>

No.	Particulars		Details	
	a) Weights (T)		--	---
	b) Dimensions (LxBxH)		--	---
4	**International/Interstate aspects of the Project**			
	a) Catchment area of the Basin (Cauvery Basin)		81,155 Sq.km	
	b) Catchment area in the State		Karnataka - 34,273 Sq.km	
	c) Submergence due to project			
	(i) In the State		**5267.59**	
	No	**Purpose**	**Extent (Ha)**	**Type of land**
	1	Submergence Area (FRL 440.0 m)	5060.71	Wildlife forest - **4821.66 Ha** Reserved Forest- **196.57 Ha** Revenue land- **142.48** Ha
	2	Dam Seating, Intake tunnel, Underground power house and tail race tunnel	66.64	Wildlife
	3	Approach road and utility corridor (13.4 km, ROW 60m)	14.60	Wildlife
	4	Colony	25.64	Revenue
		Grand Total	**5267.59 Ha**	Wildlife , Reserved and Revenue lands
		Area under Wildlife	4879.02 Ha	
		Area under Reserved forest	198.31 Ha	
		Area under Revenue land	190.26 Ha	
	(ii) In other States		Nil	
	d) Water allocation for the state		Allocation to Karnataka in a normal year is 284.75 TMC (as per CWDT Award further modified by the Judgement of Hon'ble Supreme Court of India 0n 16/02/2018) which includes 17.64 TMC out of balance water	
	e)Water allocation for the other states		Allocations to the States in a normal year as per CWDT Award and further modified as per the Judgement of Hon'ble Supreme Court of India on 16/02/2018 are: Tamil Nadu – 418.25 TMC inclusive of 10 TMC for environmental flows and 4 TMC inevitable escapages into the Sea Karnataka – 284.75 TMC Kerala - 30 TMC Puducherry - 7 TMC	
	f) Committed utilization		270 TMC as per CWDT Award. Additional allocation of 14.75 TMC to be planned for utilization totaling to 284.75 TMC	
	g) Proposed annual utilisation by the project			
	(i) Irrigation		Nil	

No.	Particulars	Details	
	Khariff	Nil	
	Rabi		
	Hot weather		
	Total		
	(ii) Water supply	4.75 TMC (comprising of supply of drinking water to Bengaluru Metropolitan Region, its surroundings and etc in the Cauvery Basin)	
	(iii) Hydel (evaporation losses)	Covered at para 5.1.11	
	(iv) Thermal Power	Nil	
	(v) Industrial	Nil	
	h) Minimum agreed/proposed flow in the river for maintaining ecology	As per CWDT Award & further modified by the Hon'ble Supreme court of India as per its judgement on 16/02/2018, 10 TMC is to be made available at Biligundlu being the environmental flows from February to May of every year.	
5	**Estimated Life of Project (years)**	**100 Years**	
6	**Irrigation(Ha.)**	**By Flow**	**By lift**
	a) Gross Command Area (GCA)	NA	NA
	b) Culturable Command Area (CCA)	NA	NA
	c) Area under Irrigation (ICA)	NA	NA
	i) Kharif	NA	NA
	ii) Rabi	NA	NA
	iii) Hot Weather	NA	NA
	iv) Two Seasonal	NA	NA
	v) Perennial	NA	NA
	vi) Gross Irrigated Area (GIA)**	NA	NA
	iv) Intensity of Irrigation (GIA/CCA) x100	NA	NA
	v) District Benefited	NA	NA
	** Irrigated Area under Khariff, Rabi, Two seasonal, Hot weather and Perennial shall be indicated		
	d) Cost per hectare of gross irrigated area	NA	NA
	e) Cost per 1000 cum of gross storage (TMC)	NA	NA
	f) Cost per 1000 cum of water delivered at the canal head/outlet (TMC)	NA	NA
	g) Water utilization	NA	NA
7	**Flood Control**	NA	
8	**Navigation**	NA	
9	**Water Supply**	Utilize the proposed reservoir as storage backing to meet requirement of water supply to Bangalore Metropolitan Region, its surrounding areas etc in the Cauvery basin, Karnataka as per the Hon'ble Supreme Court of India vide	

No.	Particulars	Details	
		its judgement on 16/02/2018 (4.75 TMC). As per the CPHEEO Guidelines, any new project proposed to provide drinking water (DWS) supply shall be designed (to meet the requirement) taking into consideration a population projection of minimum 30 years. Accordingly, the population of Bengaluru Metropolitan Region has ben nprojected upto 2044 and the requirement worked out.Eventhough, the allocation is 4.75 TMC (as per the Census of 2011) as awarded by Hon'ble Sipreme Court of india, the requirement as arrived at (projecting upto 2044) forms the basis for fixing the storage of the reservoir.	
9.1	Domestic		
	a) Names of the towns / villages served	Bengaluru Metropolitan Region etc in the cauvery Basin of Karnataka	
	b) Size of population served	85,20,435 as per 2011 census considering 73.47% of BMRDA area falling within Cauvery basin.	
	c) Quantum of water made available (TMC)	Utilize the proposed reservoir as storage backing to meet requirement of water supply to Bangalore Metropolitan Region, its surrounding areas etc in the Cauvery basin within the allocated share as per the Hon'ble Supreme Court of India vide its judgement on 16/02/2018 (4.75 TMC). As per the CPHEEO Guidelines, any new project proposed to provide drinking water (DWS) supply shall be designed (to meet the requirement) taking into consideration a population projection of minimum 30 years. Accordingly, the population of Bengaluru Metropolitan Region has been projected upto 2044 and the requirement worked out. The total requirement of drinking water will be about 63 TMC. Eventhough, the allocation is 4.75 TMC (as per the Census of 2011) as awarded by Hon'ble Sipreme Court of india, the requirement as arrived at (projecting upto 2044) forms the basis for fixing the storage of the reservoir.	
9.2	Industrial Location(s)	NA	
	a) Name (s) (Location(s))	NA	
	b) Quantum of water made available (Cum.)	NA	
10	**Project Performance**	**Period of simulation**	**No. of failures**
	a) Irrigation	NA	NA
	b) Power	29 years	Out of the 29 years, power generation will be less than the average in 12 years
	c) Flood control	NA	NA
	d) Water Supply	29 years	15 years
	e) Navigation	NA	NA

No.	Particulars	Details	
11	**Hydrology**		
11.1	Catchment		
11.1.1	Catchment Area at Headwork site(Sq.Km)		
	a) Gross	34,273 Km^2 (At Mekedatu)	
	b) Intercepted	23, 913 Sq.Km	
	i) By existing Projects		
	Harangi Dam	419.60 Km^2	
	KRS	10619 Km^2	
	Kabini	2141.90 Km^2	
	ii) By ongoing Projects		
	Hemavathi Dam	2810 Km^2	
	iii) By contemplated Projects	----	
	c) Unintercepted	10,360 Sq.Km	
11.1.2	Catchment area classification according to mode of precipitation		
	a) Rainfed	34,273 Sq km	
	b) Snow	Nil	
11.2	Precipitation		
11.2.1	Catchments		

District	Rainfall (weighted mm) Annual / Monsoon (June-Oct)			
	Average	**Maximum**	**Minimum**	**Co-efficient of variation**
Bangalore Rural	833 / 579	1332 / 997	489 / 280	0.286
Bangalore Urban	957 / 666	1351 / 1078	533 / 312	0.229
Chamarajnagar	742 / 415	1198 / 743	239 / 131	0.339
Chickjmangalur	2024 / 1713	2639 / 2498	1417 / 1144	0.182
Hassan	1242 / 944	1518 / 1297	918 / 605	0.161
Kodagu	2748 / 2330	3760 / 3606	2001 / 1264	0.194
Mandya	709 / 444	1212 / 809	407 / 221	0.305
Mysore	758 / 485	1037 / 749	417 / 277	0.216
Tumkur	722 / 501	1030 / 764	415 / 250	0.271
Ramanagara	695 / 465	996 / 626	448 / 258	0.275

Source: India Water Portal (IMD) 2004-2010, Directorate Economics and Statistics, Bangalore (2011-2016)

Snowfall (mm) Annual - NA

No.		Cropping Season			
11.2.2	Command				
		Annual (mm)	Khariff (Jun –Oct) mm	Rabi (Nov- Feb) mm	Hot (Mar-May) mm
	a) Average	NA	NA	NA	NA

No.	Particulars		Details		
	b) 80% dependable	NA	NA	NA	NA
	c) ET_0 (mm)	NA	NA	NA	NA
11.3	Annual yield calculated at the proposed site (Mcum.)				
	Yield at Mettur Yield between Biligundlu & Mettur Yield at Biligundlu Yield between Proposed Mekedatu site & Biligundlu Hence Yield at Mekedatu Project site		508 TMC (14387 M cum) 25 TMC (708 M cum) 483 TMC(13679 M cum) 2 TMC(56.64 M cum) 481 TMC(1359 M cum)		
11.4	Climatic Data(Command)		Moderate tending to hot		
11.4.1	Name of station(s) and period of records				

	No.	Names	Periods of records	
			From	To
	1.	Bangalore	1971	2000

No.	Particulars	Details			
11.4.2	Data (average of all stations in command area)				
			Normal	Max	Min
		a) Air Temperature (°C)	28	29.4	19
		b) Humidity (%)	60	80	51
		c) Wind (km/hr)	5.2	8.9	4.8
		d)Water temperature (°C)	26.5	27.1	16

No.	Particulars	Details
11.5	Seismic coefficients	
	a)Horizontal b)Vertical	The project falls under Zone II as per IS 1893 and corresponds to basic seismic coefficient α_h = 0.02. with the importance factor of I = 3.0 , the α_h = 0.06. Vertical component is half of this i.e, α_v = 0.03
11.6	Utilisation within the State (TMC)	As per CWDT Award and further modified by the Hon'ble Supreme Court of India vide its judgement on 16/02/2018, the share of Karnataka is 284.75 TMC
11.6.1	Water availability(States share in case of interstate River)	284.75 TMC to Karnataka out of 740 TMC (As per CWDT award and further modified by the Hon'ble Supreme Court of India vide its judgement on 16/02/2018)
11.6.2	Committed Utilisation(Mcum)	
	a) Up stream projects (completed & ongoing)	GoK has already committed for utilizing 270 TMC as per the CWDT Award. Additional allocation of 14.75 TMC made by the Hon'ble Supreme court has to be planned. Out of this additional allocation, 4.75 TMC is proposed to be utilized for drinking water purposes of Bangalore Metropolitian Region for this project.
	b) Downstream projects	Nil
11.6.3	Proposed utilization by the project	
	a)Irrigation	NA
	i)Khariff	NA
	ii) Rabi	NA

No.	Particulars	Details	
	iii) Hot weather	NA	
	iv)Perinneals	NA	
	Total	NA	
	b) Water supply & other purpose	4.75 TMC for Water supply to Bengaluru Metropolitan Region, its surrounding areas etc in Cauvery Basin.	
11.7	Flood near the Head Work site	(22650 Cumecs) 8.00 Lakhs Cusecs (PMF)	
11.7.1	Historical period of record		
11.7.2	Observed period of record	Location 1 (Chunchanakatte on Cauvery) from 21/07/1998 to 31/05/2016	Location 2 (T. Narasipura on Kabini) from 01/02./1971 to 31/05/2016
	Maximum water level	756.44 m	641.22 m
	Maximum discharge	1456 cumecs	2325 Cumecs
	Year of occurrence / Date	2008 / 14th August	1979 / 4th August
11.7.3	Estimated Flood in cum/sec		
	a) 50 years return period	6357 cumecs	
	b) 100 years return period	7192 cumecs	
	c) 1000 years return period	9950 cumecs	
	d) Standard Project flood	Not considered	
	e)Probable Maximum flood	(22650 Cumecs) 8.00 Lakhs Cusecs	
11.7.4	Design flood in cum/sec		
	a) Dam	(19054 Cumecs) 6.73 Lakhs Cusecs at FRL (22650 Cumecs) 8.00 Lakhs Cusecs at MWL	
	b) Weir / Barrage	NA	
	c) Construction Diversion	NA	
	d) Flood Control works	NA	
11.7.5	River flows(minimum observed)		
	a) Water level (El.Mts)	---	
	b) Discharge (cumecs)	2.4 cumecs (On 29.03.2004)	
	c)Months of nil flow, if any	Nil	
12	**Reservoir**		
12.1	Water levels (EL.m)		
	a) Maximum Water level (MWL)	441.20 m	
	b) Full Reservoir level (FRL)	440.00 m	
	c) Minimum Draw Down Level (MDDL)	395.00 m	
	d) Outlet levels	359.00 m	
	i) Irrigation	Nil	
	ii) Power	379.75m	
	iii) Others (Please Specify)	359.00m (River sluice)	
	e) Dead Storage Level	395.00m	
12.2	Free Board (m)	3.576 m	
12.3	Wave height (m)	2.630 m	
12.4	Live Storage (M.cum)	59.46 TMC (1683.90 MCM)	
12.5	Capacity (M.cum)		

<table>
<tr><th>No.</th><th>Particulars</th><th colspan="2">Details</th></tr>
<tr><td></td><td>a) Maximum Water Level</td><td colspan="2"></td></tr>
<tr><td></td><td>b) Full Reservoir Level</td><td colspan="2">67.16 TMC (1901.97 MCM)</td></tr>
<tr><td></td><td>c) Minimum Draw Down Level</td><td colspan="2">7.7 TMC (218.06 MCM)</td></tr>
<tr><td></td><td>d) Dead Storage Level</td><td colspan="2">7.7 TMC (218.06 MCM)</td></tr>
<tr><td>12.6</td><td>Flood absorption capacity (M.cum)</td><td colspan="2"></td></tr>
<tr><td></td><td>a) Below FRL</td><td colspan="2">NA. (Flood absorption not considered)</td></tr>
<tr><td></td><td>b) Between FRL & MWL</td><td colspan="2">About 69 MCM, PMF passes at EL 441.20 m</td></tr>
<tr><td>12.7</td><td>Sedimentation (M.cum) and levels after</td><td colspan="2"></td></tr>
<tr><td></td><td>Total Sediment</td><td>50 years</td><td>100 years</td></tr>
<tr><td></td><td>b) Above MDDL</td><td>Nil</td><td>Nil</td></tr>
<tr><td></td><td>c) Below MDDL</td><td>89.70 Mcum</td><td>179.40 Mcum</td></tr>
<tr><td></td><td>d) Encroachment on Live Storage</td><td>Nil</td><td>Nil</td></tr>
<tr><td></td><td>b)New zero elevation</td><td>RL 370.48 m</td><td>RL 375.76</td></tr>
<tr><td>12.8</td><td>Average Monthly evaporation losses from reservoir(Mcum)</td><td colspan="2">The value of evaporation considered is that of KRS as per actual measurement. The same has been considered for the proposed project with FRL for Reservoir.

<table><tr><th>Month</th><th>Evaporation value</th></tr><tr><td>June</td><td>4.199</td></tr><tr><td>July</td><td>3.212</td></tr><tr><td>August</td><td>3.195</td></tr><tr><td>September</td><td>3.293</td></tr><tr><td>October</td><td>4.048</td></tr><tr><td>November</td><td>3.319</td></tr><tr><td>December</td><td>3.187</td></tr><tr><td>January</td><td>3.122</td></tr><tr><td>February</td><td>3.048</td></tr><tr><td>March</td><td>3.408</td></tr><tr><td>April</td><td>4.885</td></tr><tr><td>May</td><td>5.120</td></tr></table></td></tr>
<tr><td>12.9</td><td>Seepage in the reservoir</td><td colspan="2">NA</td></tr>
<tr><td>13</td><td colspan="3">Submergence</td></tr>
<tr><td>13.1</td><td colspan="3">Land and Property Submerged-Included in Table 1.6 of DPR</td></tr>
<tr><td>13.2</td><td>Submergence ratio (with reference to CCA)</td><td colspan="2">Irrigation is not envisaged and as such CCA Is not a part of the proposal</td></tr>
<tr><td>13.3</td><td>Number of families /persons affected</td><td colspan="2"></td></tr>
<tr><td rowspan="5"></td><td>a) Total</td><td colspan="2" rowspan="5">Detailed studies are under progress and the required details will be furnished.
The details form a part of the Detailed Project report which will contain the Chapters on EIA, EMP including R & R.</td></tr>
<tr><td>b) Scheduled castes</td></tr>
<tr><td>c) Scheduled tribe</td></tr>
<tr><td>d) Other backward castes</td></tr>
<tr><td>e) General</td></tr>
<tr><td>14</td><td colspan="3">Head Works</td></tr>
</table>

No.	Particulars		Details	
14.1	Dam		Concrete Gravity Dam (Length 734.5 m)	
14.1.1	Embankment Dam			
	(a)	Type of Dam	NA	
	(b)	Length of Dam at Top	NA	
	(c)	Top Width	NA	
	(d)	Maximum Height above GL	NA	
	(e)	Dyke(s)	NA	
	(f)	Type of cut off and maximum depth	NA	
14.1.2	Masonry and Concrete Dam (Non-over flow section)			
			Left side	**Right Side**
	(a)	Type of Dam	Concrete	Concrete
	(b)	EL of top	445.00 m	445.00 m
	(c)	EL of deepest foundation	352.00 m	352.00 m
	(d)	Length at top	179.50 m	218.00 m
	(e)	Length at River bed		
	(f)	Width at top	7.5 m	7.5 m
	(g)	Width at deepest bed level	90.8 m	90.8 m
	(h)	Maximum height above deepest foundation level	95.0 m	95.0 m
14.1.3	Spillway (over flow section)			
(a)	Type of spillway (Ogee/chute/side channel/tunnel/syphon/any other type		Ogee	
(b)	Full Reservoir level		440.00 m	
(c)	Maximum Water Level		441.20 m	
(d)	Length		337.0 m	
(e)	Maximum height above the deepest foundation		99.00 m	
(f)	Crest level		428.00 m	
(g)	Number of gates		18	
(h)	Type of gates		Radial	
(i)	Size of Gate		15 x 12 m	
(j)	Maximum Discharge Capacity			
	(i)FRL		(19054 Cumecs) 6.73 Lakhs Cusecs at FRL	
	(ii)MWL		(22650 Cumecs) 8 Lakhs Cusecs at MWL	
(k)	Flood lift			
(l)	Tail water level			
	(i)Maximum		369.60 m	
	(ii)Minimum		352.50 m	
(m)	Type of energy dissipation arrangements		Flip bucket	
(n)	Type of hoisting arrangement and its capacity		Rope drum Hoist (140 T)	

No.	Particulars	Details
14.1.4	River sluice(s), Irrigation/Power outlets	River sluice
(a)	Purpose	To meet downstream releases in line with CWDT Award modified by Hon'ble Supreme Court of India
(b)	Number	3
(c)	Size(m)	3.0 x 3.0 m
(d)	Sill level	359.00 m
(e)	Discharge capacity at (m^3/s)	
	(i)Full reservoir level	762.4 m^3/sec at EL 440.00 m
	(i)Minimum draw down level	502.3 m^3/sec at EL 395.00 m
(f)	Number of gates	3
(g)	Type of gates	Vertical lift
(h)	Size of gate	3.0 x 3.0 m
(i)	Type of hoist arrangement and its capacity	Hydraulic hoist 700 T capacity
14.2	Barrage	-
14.3	Weir	-
14.4	Head Regulator	-
15	**Canal system**	**NA**
16	**Cropping pattern**	**NA**
17	**Power**	
17.1	Type –Conventional/Pumped storage	Conventional Storage
17.2	Installed capacity (MW)	3×120 MW + 1×40 MW=400 MW
17.3	Load Factor	18.56% (Annual)
17.4	Annual Energy	90% Dependable Energy
	(a)Firm	169.13 MU
	(b)Seasonal	481.15 MU
	(c)Total	650.28 MU
17.5	Off peak requirement for pumping	--
17.6	Cost per kW installed	--
17.7	Cost per kW at the bus bar	--
17.8	Head Race Channel /Tunnel	
	(a)Length(m)	Not applicable. Since water conductor system consists of short Horizontal limbs and Vertical pressure shafts. Details are furnished in 15.13
	(b)Shape	
	(c)Size(m)	
	(d)Rock type reach-wise-RMR/Q values	
	(e)Rock cover reach-wise	
	(f)Free/Pressure flow	
	(g)Lining type-PCC/RCC/Steel	
	(h)Reach-wise Design Internal & external pressure	
	(i)Thickness of lining (m)	

No.	Particulars	Details
	(j)Design Discharge (m^3/s)	
	(k)Invert level at (El-m)	
	(l)Gate-No. Type & size	
17.9	Balancing Reservoir	
	(a) Capacity(Mcum)	1901.97 MCM (67.16 TMC)
	(b) FRL (EL-m)	EL.440 m
	(c) Max. Reservoir Level	EL.441.20 m
	(d) Min. Drawdown Level	EL.395 m
	(e) Live Storage	59.46 TMC (1683.90 MCM)
	(f) Balancing period	
17.10	Forebay	
	a) Size of forebay	Reservoir acts as a forebay
	b) Sill level of Forebay	
	c) FRL	
	d) Maximum reservoir level	
	e) MDDL	
	f) Duration of storage	
	g) Number of off-takes	
	h) Size of off-takes	
	i) Invert level at off-take(El-m)	
	j) Capacity of each off-take (cumecs)	
	k) Escape arrangement • Location • Length • Discharge capacity (cumecs)	
17.11	Intakes	
	(a) Upper intake (i) Type & size of intake	Semicircular type,2 nos,6.5m Radius, one of 7.5 m Radius.
	(ii) Energy profile with details of transition	Elliptical profile, as per IS guidelines.
	(iii) Stability of the slope/cut around intake	Stable cut slopes in rock
	(iv) Design velocity through trash rack and bellmouth	0.5m/sec
	(v) Submergence of the entry below water level	Submergence below water level is 12 m above the bellmouth top
	(vi) Intake gates-Number. Type. Size	1 service gate for each penstock Vertical lift wheeled gates. Size: 2nos.of 5.6m x 5.6m,1 of 6.5m x 6.5m. operating by Hydraulic hoist.
	(vii) Details of anti-vortex arrangements	Capacities for 6.5 m dia,160 T / for 5.6 dia, 150T.
	(viii) Type of hoisting arrangement and its	

No.	Particulars	Details
	capacity	
	(b) Lower Intake (for pumped storage scheme) (i) Type & Size of intake (ii) Entry profile with details of transition (iii) stability of the slope/cuts around intake (iv) Design velocity through trash rack and bellmouth (v) Submergence of the entry below water level (vi) Intake gates-Number. Type. Size Details of anti-vortex arrangements	NA
17.12	Surge tank /Shaft	
	(a) Nos. & Location (HRT/TRT or both)	1No on TRT side
	(b) Type height & size	45m (H) & 22m(W) × 775m
	(c) Orifice-size & position (or any other relevant details)	Surge chamber cavern D/S Power House
	(d) Top level	EL.328.50 m
	(e) Bottom level	El. 281.50 m
	(f) Steady state level	El. 302.5 m
	(g) Capacity	-
	(h) Lower expansion Chamber-Size and location	No
	(i) Upper expansion Chamber-Size and location	No
	(j) Max. Surge Level (El-m)	El.315 m
	(k) Min. Surge level (El-m)	El.292.5 m
	(l) Size of gates and capacity of hoists	No gates
17.13	Penstocks/pressure shafts:	
	(a) Number, diameter, & length	2no. 5.6 m Ø circular+1No. 6.5 m Ø, L=285m before bifurcation
	(b) Inclination	Vertical & Horizontal
	(c) Liner type	Steel
	(d) Grade of steel	ASTM 517F
	(e) Reachwise rock cover	73.5m for Horizontal Portion
	(f) Reachwise rock properties-RMR/Q	80/19.8
	(g) Reachwise rock participation factor –computed & adopted	50%

No.	Particulars	Details	
	(h) Reachwise liner thickness	1st Reach=16mm,2nd Reach=20mm,3rd Reach=25 mm	
	(i) Necessity for heat treatment if any	Yes	
	(j) Bifurcation / trifurcation	Bifurcation	
	(k) Gate Number: Type & Capacity	2no. 5.6m×5.6m+1no. 6.5m×6.5m	Hydraulic Hoist
	(l) Size of gate and capacity of hoists.	2no. 150 T, 1no. 160 T	
17.14	Power House	Underground	
`	(a) Type (Surface or Under Ground)	(Included in the geology chapter|)	
	(b) Orientation		
	(c) Rock types encountered-RMR/Q Value	Granite- 80/19.8	
	(d) Major wedge formations, if any		
	(e) Rock ledge dimension between cavities	40m Between PH & TC	
	(f) Maximum head(m)	138 m	
	(g) Minimum head(m)	90 m	
	(h) Average head(m)	103 m	
	(i) Head loss in water conductor system	3 m	
	(j) Design head(m)	120 m	
	(k) Dimensions (m)	139(L)×22m(W) × 42m	
	(l) Unit Capacity	3×120MW+1×40MW	
	(m) Installed capacity (MW)	400 MW	
	(n) Type of turbine	Vertical Francis	
	(o) Type of generator	SYNCHRONOUS	
	(p) Type of power house crane	EOT, 2×225MT capacity	
	(q) Number and size of draft tube gates/bulk head capacity of hoists	3 No. 8m×8m+1No. 6m×6m, 150 T/ 100 T Rope drum hoist	
17.15	Switch Yard (a) Type (b) Voltage level (c) No. of incoming and outgoing bays	 GIS - Overground 220 kV 4 Outgoing Bays	
17.16	Transformer Cavern (a) Dimension (b) Orientation (c) Rock type encountered – RMR/Q Values (d) Major wedge formations, if any (e) Rock ledge-dimension	16m(W) x 78m(L) Parallel to Power House cavern. Granite Hard rock- 80/19.8 40 m Between PH & TC	

No.	Particulars	Details
	between cavities	
17.17	Tail Race Channel	
	(a) Shape & Size	Rectangular Shape 35 (L) x 45 (B)
	(b) Length	35m
	(c) Recovery Slope	
	(d) Side Slope	1:5
	(e) Max. Tail Water Level (El-m)	EL:305m
	(f) Min. Tail Water Level (El-m) (g) Average tail water level (El-m)	EL:302m
	(h) Tail water level corresponding to one unit discharge.	EL:303.3m
	(i) Tail water level corresponding to max flood condition / one in thousand year flood.	EL:315.0m
	(j) HFL of recipient river channel at outfall	EL:315.0m
	(k) Draft tube gate – Number, Type, Siz	Covered under 17.14
17.18	Tail Race Tunnel	
	(a) Number Shape & Size	Horse Shoe, 2 No. & 9.5 m Diameters
	(b) Length	2150m
	(c) Reach wise Rock cover	Ranges between 65 m to 155 m
	(d) Reach wise Rock properties-RMR/Q	80/19.80
	(e) Type of lining	Concrete lining
	(f) Max. Tail Water Level	EL:305 m
	(g) Min. Tail Water Level	EL:302 m
	(h) Avg. Tail Water Level	---
	(i) Tail water level corresponding to one unit discharge	EL.303.30 m
	(j) Tail water level corresponding to Max. flood condition / one in thousand year flood	EL. 315.0 m
	(k) HFL Of recipient river channel at outfall	EL. 315.0 m
	(l) TRT gate number, type, size	2 no. rope drum hoist 130 T capacity for gate of size 9.5 m × 9.5 m.

No.	Particulars	Details		
18	**Construction facilities**			
19	**Cost**			
19.1	Cost of the Project (Rs. Lakhs)	**Rs. 900000.00 Lakhs**		
	Allocated cost			
	a) Irrigation	Not envisaged in the present project		
	b) Power	-		
	c) Flood control	Not envisaged in the present project		
	d) Navigation	Not envisaged in the present project		
	e) Water supply & others	-		
20	**Benefits / Revenue**			
20.1	Benefits			
	Item	**Benefits (Annual)**		
		Qty	Unit Price (Rs.)	Value in Rs. Lakhs
	a) Food Production (tonne)			
	b) Power(kwh)	650.28 MU	4.00	260112.00
	c) Flood Protection(ha)		---	---
	d) Navigation (tonnage)		---	---
	e) Water supply	1401.30 MCum	100	140130.00
	Population served (projected to 2044)	366.00 Lakhs		
	f) Any other (fisheries)	----	----	---
	Total	**---**	**---**	**400242.00**
20.2	Revenue			
	Item	Revenue		
		Qty	Rate	Amount in lakhs
	a) Betterment levy	----	----	---
	b) Water Rates	Shall be as per applicable charges		
	c) Irrigation Cess	----	----	---
	d) Pisiculture rights action	----	----	---
	e) Power rates	Shall be as per applicable charges		
	f) Navigation	----	----	---
	(i)Cargo rates	----	----	---
	(ii)Regd Charges	----	----	---
	(iii)Passenger Tax	----	----	---
	(iv) others			
	g) Others	**---**	**---**	
	Total			
21	**Benefit Cost Ratio**			
	(a) B.C.Ratio	1.67 (Based on the NPV)		
	(b) Financial Internal Rate of Return (FIRR)	15.69%		

PLATE – I INDEX MAP

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

General

The Detailed Project Report of Mekedatu Balancing Reservoir cum Drinking Water Project comprises of three volumes titled as under;

- **Volume I -** Report and Annexures (Annexure 4 – Hydrology attached as separate booklet) including compliance to observations of Central Water Commission and Chief Secretary, Tamil Nadu on Detailed Feasibility Report submitted earlier.
- **Volume II** - Appendices (Designs and Cost Estimates). Appendix 4 A –Bore log details attached as separate booklet.
- **Volume III** - Drawings.

In the initial part, the particulars covered include;

- Document Control,
- Contents of the Report,
- List of Annexures enclosed as per CWC Guidelines,
- **Section-1**: Checklist (As per CWC Guidelines 2010),
- **Section-2**: Salient Features
- **Section-3**: Report

A brief summary of the particulars of the topics covered in different chapters of the DPR Volume I, are presented hereunder;

1. Chapter 1: Introduction

Karnataka State having a geographic area of 1.91,976 Sq. km. happens to be the 8th largest state with a population of 6,11, 95,297 as per 2011 census. The interstate river Cauvery is a major east flowing river and is the only perennial source of water available to provide drinking water to Bengaluru Metropolitan Region. The project site is accessible by road from Bengaluru, and Ramanagar via Kanakapura, nearest rail head is Ramanagara, nearest airport is Bengaluru and sea-port is Mangalore.

The objectives of Mekedatu Balancing Reservoir Cum Drinking Water Project include;

i. Utilizing additional 4.75 TMC of water to provide drinking water facility to Bengaluru Metropolitan Region, its adjoining area etc by way of proposing a scheme to tap water from the foreshore of the intended Mekedatu Balancing Reservoir cum Drinking water project.

ii. To regulate the required quantum of water to Tamil Nadu on a monthly basis (in a normal year) as per the CWDT award, as modified by the Hon'ble Supreme Court of India vide its Judgement dated 16.02.2018. It is further proposed to store the flood waters otherwise escaping to sea as it happened in the monsoon of 2018.

iii. Harnessing nearly 400 MW (650.28 MU of renewable energy annually @90 % dependable year) of renewable energy annually by utilizing the fall in the natural bed profile of the Cauvery River upto the State border from the monthly releases effected to (in a normal year) as per the modified award (by the Hon'ble Supreme Court of India vide its Judgement dated 16.02.2018.)

The major components of Mekedatu Balancing Reservoir Cum Drinking Water Project as planned include;

i. Construction of Concrete Gravity dam at Mekedatu referred to as Mekedatu site with FRL at RL 440.00 metres having a Gross Storage Capacity of 67.16 TMC (1901.97 MCM).

ii. Dam will have a central spillway with radial gates to effectively discharge the design flood with suitable energy dissipating arrangement (Flip bucket) on the downstream side.

iii. Intake structure with water conducting system consisting of required number of penstocks, pressure shafts which will be embedded partly in the body of the dam and the rock mass to feed the water continuously to the generating units.

iv. Underground power house with three caverns is proposed downstream of the dam with an installed capacity of 400 MW with necessary transformers, substation and auxiliaries to evacuate the power generated.

v. Construction of Jackwell cum pump house on the foreshore of the reservoir to lift the required quantum of water along with raising main and Delivery chamber at the identified location to plan for further transportation and distribution.

The possibility of developing power from Mekedatu project has been under examination since 1948, when Kollegal territory was a part of Madras Presidency. However this project was not taken up for investigation till the reorganization of the States in the year 1956. After 1956, initially this project was investigated by the

Hydro-Electric Project Investigation Department of GoM and then on by the Karnataka Power Corporation Limited (KPCL) from the year 1986 onwards. KPCL prepared a report titled "Mekedatu Hydroelectric Project – Project Report" in July 1996. However, the further consideration of the same got stalled at that time, directing Govt. of Karnataka to wait for the Award of the Hon'ble Cauvery Water Disputes Tribunal (CWDT)

2. Chapter 2: Physical Features

The Mekedatu Balancing Reservoir Cum Drinking Water Project is located at Latitude 12º 16' 20'" N Longitude 77º 26' 25'" E in Muguru and Mekedatu villages, Kanakapura and Kollegal Taluks of Ramanagara and Chamarajanagar Districts. The river Cauvery flows over a, length of 800 km up to the sea and has a total catchment area of 81,155 Sq. km. It has its main tributaries as Harangi, Hemavathi, Shimsha, Arkavavathi, Lakshmanathirta, Kabini and Suvarnavatti in the State of Karnataka and Bhavani, Noyyal and Amaravathy in Tamilnadu. The western side of catchment receives south-west monsoon rainfall between June and Sept. of each year and the eastern catchment receives north-east monsoon rainfall between Oct. and Dec. of each year, and the non-monsoon period rainfall is not significant. The climate in the catchment basin remains dry except for monsoon moths, and the temperature ranges between 19.5°C and 33.7°C and the mean daily minimum temperature varies between 9.1°C and 25.2°C. The plate showing the Index Map of the project is enclosed.

3. Chapter 3: Interstate Aspects

River Cauvery is an interstate river, originating in Karnataka State traversing through Tamil Nadu before draining into Bay of Bengal. The catchment area (totaling to 81,155 Sq. km. up to confluence to sea) lies in the States of Karnataka, Kerala, Tamil Nadu and Puduchery and the respective areas are 34,273 sq.km, 2,866 sq.km., 43,868 sq.km., and 148 sq.km. The lengths of the river in Karnataka State, common Boundary and Tamil Nadu State respectively are 320 km., 64 km., and 357 km.

The yield of river Cauvery was studied by The Cauvery Fact Finding Committee (CFFC) constituted in 1972, which estimated the annual yield of the Cauvery basin at 740 TMC, 670 TMC, and 623 TMC at 50%, 75% and 90% dependability. The subject of sharing of the waters was adjudicated by the Hon'ble Cauvery Water Disputes Tribunal (CWDT). CWDT passed the Award which was notified by the Centre on 19.02.2013. The riparian States approached the Supreme Court through their appeals against the award of the CWDT. The Hon'ble Suprenme Court of India, after hearing the petition of the States, adjudicated on sharing of waters

(Civil Appeal No. 2453 0f 2007) and delivered its judgment on16.02.2018. As per this judgment, the award has been modified as under;

- The total quantum of water to be made available by the Karnataka state to Tamil Nadu at Biligundlu in a normal year is 177.25 TMC (167.25 TMC + 10 TMC for environmental flows) annually.
- The volume of water allocated to Karnataka on account of drinking water is 6.5 TMC in lieu of 1.75 TMC awarded by the CWDT Tribunal. Thus, 4.75 TMC of water has been allocated additionally for drinking water use of Bengaluru Metropolitan Region.
- The volume of water allocated to Karnataka additionally is 14.75 TMC in all, i.e. 10 TMC (on account of availability of ground water in Tamil Nadu) + 4.75 TMC (for drinking and domestic purposes including such need for the whole city of Bengaluru Metropolitan Region).

Thus the final allocation of shares in view of this determination for a normal year would be as under;

No	Share of the waters	Quantity in TMC
1.	**Karnataka**	**284.75 TMC (270 + 14.75)**
2.	Tamil Nadu	404.25 TMC (419 - 14.75)
3.	Kerala	30.00
4.	UT of Puduchery	7.00
5.	Environmental Protection	10.00
6.	Inevitable escapages into the Sea	4.00
	Total	**740.00**

4. Chapter 4: Surveys and Investigations

This chapter presents various studies and investigations conducted for preparation of the DPR covering topography of the river, reservoir, project complex, regional and project specific geology- geotechnical features and seismicity, hydrological and meteorological and sediment data as required for planning, and design of the project, including the sources of construction materials required for the construction of the project.

The geology of the project area reveals exposures of pink/grey granite gneisses as major types of rock formations that are often massive, fine to medium grained, but cut irregularly by close joints and fracture zones.

5. Chapter 5: Hydrology (Working tables, performance tables, flow tables)

This chapter presents the particulars of hydro-meteorological data collected for studies and investigations carried out for preparation of the DPR in the area of hydrology for establishment of area-elevation-capacity curves for the reservoir, tail water rating curve, back-water profile curves for the reservoir area, water availability, water demands for various utilizations and compliances and the estimation of design flood. The detailed working tables have been prepared considering the inflows into the four Karnataka reservoirs, Mekedatu reservoir and the flows at Biligundlu. The PMF has been arrived at for the said project and the the design flood for the design of spillway is 22650 cumecs (8.0 lakh cusecs).

6. Chapter 6: Hydro Geology

The hydro-geological set up, ground water availability, prospects of ground water development, quality of ground water, identification of zones with raising and declining water tables in different upstream districts i.e. (Ramanagaram and Chamarajanagar) are presented in this section.

7. Chapter 7: Design Features and criteria for river valley structures

For the finalization of the location of the concrete gravity dam, three alternative locations were examined. This chapter describes all the civil design aspects and the underlying considerations of different structures.

The Mekedatu Balancing Reservoir Cum Drinking Water Project is conceived to fulfill the objectives stated in an earlier para, and envisages construction of the following major structures;

i. A 99 m height 734.5 m long concrete gravity dam comprising over-flow spillway blocks with flip bucket to provide sky-jump type energy dissipation arrangement, non-over flow blocks and power blocks housing the power intakes.

ii. A water conductor system comprising a vertical pressure shaft with short upper / lower horizontal limbs.

iii. A three cavern underground power house complex equipped with 400 MW (1 x40 MW + 3 x 120 MW) capacity hydro-power generator units along with all the associated ancillary structures such as surface switch-yard, and tunnels / galleries for access, ventilation, tail race etc.

8. Chapter 8: Reservoir

The reservoir created due to the proposed Mekedatu dam has a gross storage of 67.16 TMC, involves the submergence of an area 5267.59 Ha, and stretches up to 30 km upstream of the dam. The design wave height with the maximum fetch at 4.70 km at the FRL works out at 2.705 m and the freeboard provided is 3.576 m. The reservoir is expected to pose no rim stability problems. The dead storage is 7.7 TMC. The accumulation of sedimentation over fifty years is estimated to be at around 8970 Ha-m.

No	Purpose	Extent (Ha)	Type of land
1	Submergence Area (FRL 440.0 m)	5160.71	Wildlife forest - **4281.66 Ha** Reserved Forest- **196.57 Ha** Revenue land- **142.48** Ha
2	Dam Seating, Intake tunnel, Underground power house and tail race tunnel	66.64	Wildlife
3	Approach road and utility corridor (13.4 km, ROW 60m)	14.60	Wildlife
4	Colony	25.64	Revenue
	Grand Total	**5267.59 Ha**	Wildlife , Reserved and Revenue lands
	Area under Wildlife	4879.02 Ha	
	Area under Reserved forest	198.31 Ha	
	Area under Revenue land	190.26 Ha	

9. Chapter 9: Irrigation Planning

The Mekedatu Balancing Reservoir Cum Drinking Water Project is conceived for the purpose to act as a balancing reservoir and augment the drinking water supply to the Bengaluru Metropolitan Region with incidental power generation from the releases to be affected to Tamil Nadu. ***This project does not envisage any irrigation component.***

10. Chapter 10: Command Area

The Mekedatu Balancing Reservoir Cum Drinking Water Project is conceived for the purpose to act as a balancing reservoir and augment the drinking water supply to the Bengaluru Metropolitan Region with incidental power generation from the releases to be affected to Tamil Nadu. ***This project does not envisage any irrigation component. Hence command area development is not a part of the scheme.***

11. Chapter 11: Flood Control

Flood control is not a part of present proposal.

12. Chapter 12: Drainage

The Mekedatu Balancing Reservoir Cum Drinking Water Project is conceived for the purpose to act as a balancing reservoir and augment the drinking water supply to the Bengaluru Metropolitan Region with incidental power generation from the releases to be affected to Tamil Nadu. This does not form a part of this report.

13. Chapter 13: Power

This project proposal primarily developed as being one to act as a balancing reservoir to facilitate obligatory releases to Tamil Nadu State and for fulfillment of drinking water needs of the Bengaluru Metropolitan Region. Power generation is proposed by utilizing the downstream releases and the available natural head drop between the water level in the reservoir level and that at the tail race exit. Accordingly, powerhouse generation capacity and the unit sizes are worked out (i.e. at 1 x 40 MW + 3 x 120 MW) to facilitate beneficial utilization of both lean period and monsoon period releases. ***The annual energy generation potential harnessed is placed at 650.28 MU at 90% dependable year.***

14. Chapter 14: Navigation

The Mekedatu Balancing Reservoir Cum Drinking Water Project is conceived for the purpose to act as a balancing reservoir and augment the drinking water supply to the Bengaluru Metropolitan Region with incidental power generation from the releases to be affected to Tamil Nadu. This does not form a part of this report.

15. Chapter 15: Construction Methodology, Schedule, Manpower and Plant planning

The envisaged completion time for the execution of the project works from the date award of works (by which time all the pre-construction works is expected to get completed and the site would be a state of fitness to start the major construction works) is 4 years. It is proposed to have three shifts working over the whole year.

The construction methodology for the dam is based on stage-wise diversion of the river and high rate of placement of concrete with modern placement technique based on Rotec/ Creter crane and belt conveyer system. The geological set-up to be encountered at different works sites is projected to comprise sound rock formations, and is expected not to pose any serious problems.

The planning for the execution of the underground works is also based on deployment of modern fleet of construction machinery and systematic sequence of working to achieve a speedy and safe execution of works.

The detailed construction sequence, year wise projected progress, the planned construction machinery fleet for the plant and machinery and the man power are presented in this chapter.

16. Chapter 16: Foreign exchange element

No foreign exchange element is envisaged in this project. However, as a part of the project procurement if there are any specialized instruments, components, equipments etc. the same shall be addressed on case to case basis.

17. Chapter 17: Environment, Ecology and Forest aspects of the project

The environment, ecology and forest aspects of the project including flora & fauna, aquatic ecology, water quality and socio-economic characteristics as well as construction stage disturbances / dislocations and the related environment management plan and mitigation measures have been discussed in detail in this chapter.

18. Chapter 18: Estimate

The details of the particulars of breakdowns of estimated costs as per the format of Central Water Commission (CWC) are furnished.. Out of the total estimated cost of the proposed project development placed as at **Rs. 9000.00 Crores (**as per the current schedule of rates SoR-2018-19) for all the considered heads (including indirect costs), the principal heads under which the expenditures is expected to be incurred are as under;

No.	Particulars	Total Rupees in Lakhs
1	A- Preliminary	5025.00
2	B- Land	192643.00
3	C- Works	253520.00
4	D- Regulators	12500.00
5	E- Falls(for canals only)	NIL
6	F- Cross Drainage works(for canals only)	
7	G- Bridges (for canals only)	
8	H- Escapes	
9	I- Navigation works	NIL
10	J- Power plants civil works	64640.00
11	K- Buildings	4540.00
12	L-for canals only	NIL
	a) Earth work	
	b) Lining	
	c) Service roads	
13	M-Plantation	125.00
14	N- Tank and Reservoir	NIL

No.	Particulars	Total Rupees in Lakhs
15	O- Miscellaneous	72.00
16	P- Maintanance	
	1% of cost of I - works less(A+B+M+O+Q+X+Y)	4881.60
17	Q- Special T and P	35.00
18	R- Communication	43304.00
19	S- Power plant and Electrical system	109656.00
20	T- Water supply works(LS)	NIL
21	U- Distributaries,Minors & sub minors	NIL
22	V- Water courses and Field channels	NIL
23	W- Drainage	NIL
24	X- Environment and ecology	156890.00
25	Y- Loss on stock & Unforeseen	
	0.25% of I works less (A+B+M+O+Q+X+P)	1220.40
	Total cost of I works	**849052.00**
II	Establishment (5% of cost of I works less B - Land)	32820.45
III	Tools & Plants (1% of I works including B)	NIL
IV	**Suspense**	NIL
V	**Receipts and recoveries on capital account**	
	a) Recoveries on account of K-building 15 % salvage value of building cost.	NIL
	b) Recoveries towards resale transfer of special T & P @ 75 % of machinery & 20% of cost of vehicle	NIL
	Total Direct charges	**881872.45**
	INDIRECT CHARGES	
	a) Capitalised value of abatement of land revenue(5% of B-Lands)	9632.15
	b)Audit and Account charges (1% of cost of I works)	8490.52
	Total Indirect charges	**18122.67**
	TOTAL DIRECT AND INDIRECT CHARGES	**899995.12 Lakhs**
	Rounding off	**4.88 Lakhs**
	Total cost of the project	**900000.00 Lakhs**
		9000.00 Crores

19. Chapter 19: Financial resources

The GoK has kept an allocation of Rs 25 Crores to meet the immediate expenditures in respect of initial activities (including preparation of Detailed Project Report) to be performed in respect of the project. The requirement of funds on annual basis for the execution of the main project works (after completion of all the pre-construction works and related activities) for the envisaged completion period of the project of 4 years from the date of award of contracts.

No	Particulars	Amount in Crores
1.	First year	1200.00
2.	Second year	3000.00
3.	Third year	3000.00
4.	Fourth year	1800.00
	Total	**9000.00**

The present proposal has been envisaged by GoK to meet the basic requirement of common populace such as drinking water and energy. Hence, necessary allocation will be made in the budget for speedy implementation of the project. However, in view of the substantial cost involved in implementation of the project including the land acquisition and environmental and ecological mitigation measures demanding huge provisions, GoK may look for extension of financial support by way of allocations from GoI or funding agencies. Soon after accord of clearances and approval from different departments/ ministries, necessary specific allocations will be planned for ensuring the speedy development of the project.

20. Chapter 20: Revenue

The total cost of development of the project as worked out has been estimated at **Rs. 9000.00 Crores**.

Annual benefits will be worked out in terms of meeting the Drinking water and Power Supply.

The rate of operation and maintenance per TMC of potential (inclusive of establishment) considered usually is 0.5 % to 1.50 % of the works portion. In the present proposal, the same is considered at 1% of cost of I - works less (A+B+M+O+Q+X+Y). Refer Cost abstract for heads.

For working out the annualized costs, the following is adopted;

- The Capital recovery of civil works is taken as 1% depreciation plus 10% interest (With the existing economic condition 8% interest should be sufficient. However 10% is used as a convention).

- The capital recovery of hydro mechanical components is again considered as depreciation as per norms mentioned above plus 10% interest on capital cost.
- Taxes being only transferred payment are deleted for the cost in calculating economic indices.

The profitability analysis is based on the annualized cost and benefit and following assumptions;.

- Full "Free market" conditions are assumed. This means that all the labour and material costs of both inputs and outputs are at their opportunity cost and so no shadow pricing is done.
- Profitability index is used in BC ratio, which is defined as the ratio of annual benefit to annual cost.
- While implementing the Mekedatu Project, the following facts are to be considered in the profitability analysis.
    - ➢ Construction of Dam with Sluice and Power house along with appurtenant structures
    - ➢ Acquisition of 5252.40 Ha which includes 4996.00 Ha of land going to be submerged.
    - ➢ The R & R component involved with land acquisition and resettlement of villages.

21. Chapter 21: Benefit Cost Ratio, Financial Return and Internal Rate of Return

Mekedatu Balancing Reservoir cum Drinking Water project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award as modified by Hon'ble Supreme Court of India and meet the drinking water requirement besides generating Hydro power from releases.

The revenue from the project is contemplated in terms of cost towards drinking water supply to municipalities and through sale of the power as under;.

No	Particulars	Unit	Quantity	Rate in Rs Lakhs	Amount / Revenue in Lakhs per annum
1	Water supply charges	MCum	1401.30	100	140130.00
2	Energy charges	MU	650.28	40	260112.00

The financial feasibility of the project as examined through the financial indicators such as NPV, FIRR and B/C ratio. For a project to be feasible, the NPV value at the defined discount rate should be '0' or greater than '0'. The Internal Rate of Return should be more than the lending rates of financial institutions which are normally in the range of 10 to 12%. The Benefit Cost Ratio shall be more than 1.0 at the predefined discounted rate.

These ratios worked out for a total duration of 50 years including 4 years construction period and the analysis has resulted in following:

1. NPV at 10% discount rate is Rs. 450334.50 lakhs **which is positive.**
2. Financial Internal Rate of Return (FIRR) is 15.69% which is **greater than 12.0%**
3. B/C ratio is **1.67** which is **greater than 1.0.**

22. Chapter 22: Future Utilization of facilities created (buildings)

Most of the facilities such as buildings, accessibility, communication network, treatment plants (STP & WTP) and other infrastructures will be located above the FRL and the same will be retained after carrying out minimum repairs and maintenance and utilized during O & M.

REPORT

Chapter 1 Introduction

1.1 Aim(s) of the project and descriptionof works

Karnataka State having a geographical area of 1,91,976 sq.km happens to be the eighth largest State in India with a population of 6,10,95,297 as per 2011 census. Karnataka is blessed with major perennial/non-perennial rivers such as Krishna and Cauvery besides 13 West flowing rivers , but still faces severe drought and drinking water scarcity frequently, besides facing acute power shortage. As per the data published in the public domain, Karnataka happens to be second state in India i.e. next to Rajasthan in terms of drought area.

Bangalore Metropolitan Region and areas falling under Cauvery Basin are facing acute drinking water shortage (with these areas having grown substantially in the past few years) due to increase in population. As per the CWDT award, it was indicated that only 33 % of the Bangalore City falls under the Cauvery Basin. However, due to expansion of Bangalore under the name Bruhat Bangalore Mahanagara Palike and further as Bengaluru Metropolitan Area and Bengaluru Metropolitan Regional Development Authority, additional areas in the Cauvery Basin have been amalgamated. Refer table below for details

Table 1.1:Revised area of Bangalore Metropolitian Region and percentage falling under Cauvery Basin

No	Particulars	Area falling under Cauvery Basin (Sq Km)	Year	Percentage falling under Cauvery Basin
1	As per original erstwhile Bengaluru City Corporation	136.40	Prior to 1990	**33**
2	As per revised Bengaluru Mahanagara Palike	239.89	1990	**36**
3	As per Bruhat Bengaluru Mahanagara Palike	543.92	1996	**47**
4	As per Bengaluru Metropolitan Regional Development Authority	5882.00	2007	**73.47**

It could be seen that originally, the extent of area falling under Cauvery Basin was only 33 % (also as per CWDT Award). As per the latest amalgamation of areas under Bengaluru Metropolitan Regional Development Authority, the extent of area falling under Cauvery Basin has increased to 73.47 %. The **Fig. 1.1** and **Fig. 1.2** shows Area of Bengaluru during erstwhile Bengaluru City Corporation (BCC), Bengaluru Mahanagara Palike (BMP), Bruhat Bengaluru Mahanagara Palike (BBMP) and Bengaluru Metropolitan Region Development Authority (BMRDA).

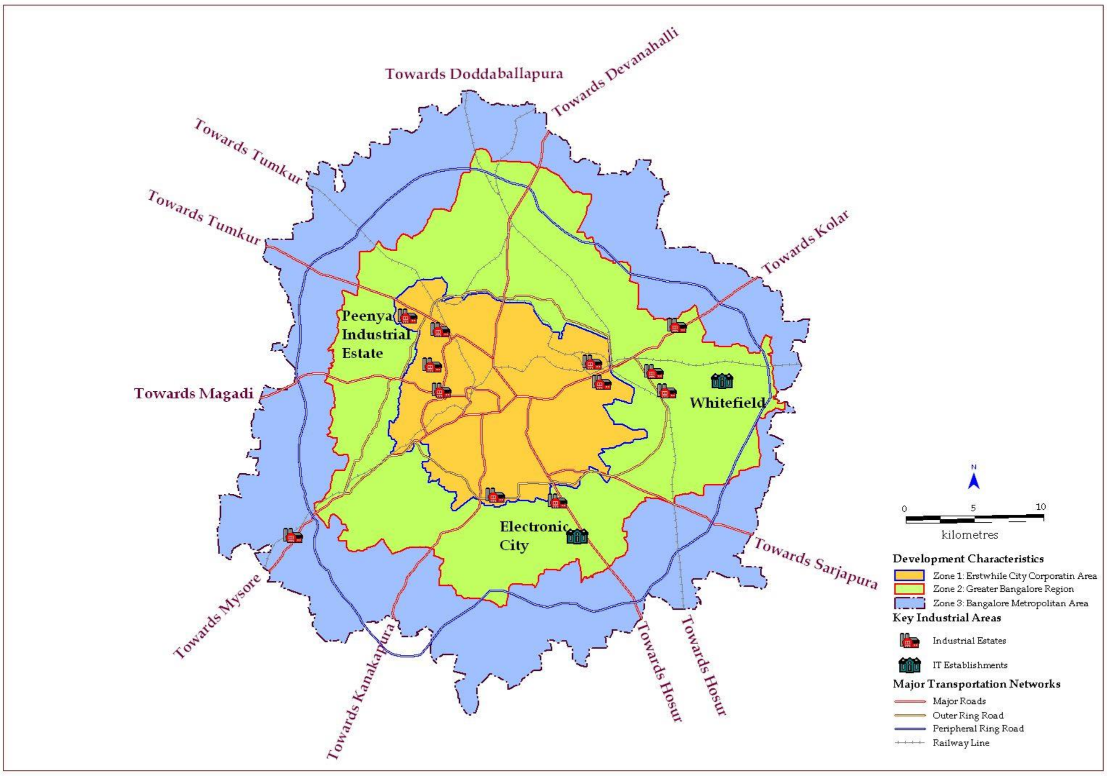


Fig. 1.1 Map showing areas of Bengaluru City Corporation (BCC), Bengaluru Mahanagara Palike (BMP), Bruhat Bengaluru Mahanagara Palike (BBMP)

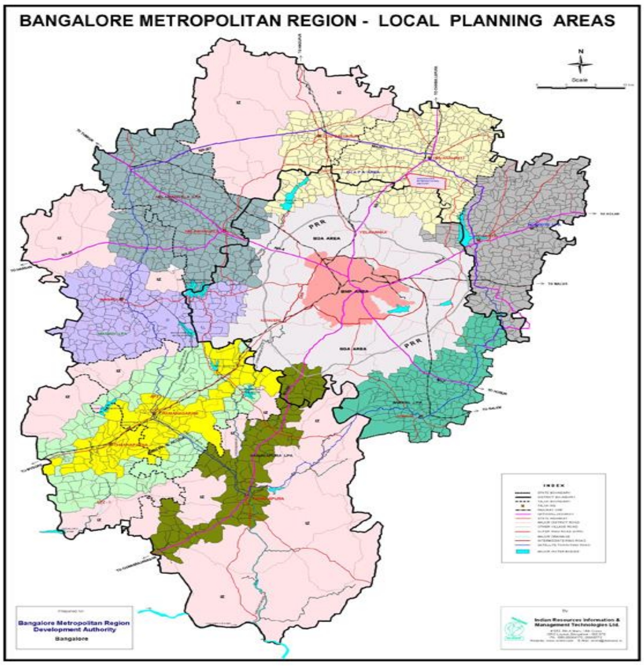


Fig. 1.2. Map showing area of Bengaluru Metropolitan Region Development Authority (BMRDA)

It is evident from the above Table and Figure that Bengaluru Metropolitan Region has expanded exponentially besides being acknowledged globally as one of the fastest growing cities attracting investments from across the Globe. This fact has also been acknowledged by the Hon'ble Supreme Court in its judgement dated 16/02/2018 which states thus:

"We are inclined to think so as the perception of a basin State inheres in it a degree of flexibility in approach in a unique fact situation to justify a warrantable flexibility and departure from such rigoristic approach. We are disposed to think so, for the city of Bengaluru, as an evident phenomenon, has burgeoned over the years and has grown today into a progressively sophisticated, sprawling, vibrant and a much aspired seat of intellectual excellence particularly in information technology and commercial flourish. It has transformed into a nerve centre of contemporaneous significance and its population is daily on the rise, thus registering an ever enhancing demand for all civic amenities. Having regard to its exclusive attributes, it is incomparable in many ways not only to other urban areas in the State, but also beyond. The requirements of its dependent population as a whole for drinking and other domestic purposes, therefore, cannot justifiably, in the prevailing circumstances, be truncated to their prejudice only for consideration of its physical location in the context of the river basin, We think so since the city of Bengaluru cannot be segregated having an extricable composition and integrated whole for the purposes of the requiremets of its inhabitants, more particularly when the same relates to allocation of water for domestic purposes to meet their daily errands. ***It will be inconceivable to have an artificial boundary and deny the population the primary need of drinking water. We hold so in the special features of the case keeping in view the global status the city has attained and further appreciating the doctrine of equitable proportionality on the bedrock of pressing human needs."***

In view of the above increase in the area and subsequent increase in the population (whose drinking water needs are to be met with), present supply is not sufficient to cater to this increased drinking water requirement. Drinking water requirement is a right under the Constitution and gets prime importance over other users as per the National Water policy. Hence it has become necessary to augment the supply through implementation of a new project /s and one such project envisaged is Mekedatu Balancing Reservoir cum Drinking Water project which can serve the purpose. Further, as per CPHEEO guidelines, any new project envisaged to supply drinking water shall be designed considering the population projected upto a minimum of 30 years. Hence this aspect has been considered while fixing the storage of the reservoir.

Cauvery is the only perennial source of water available and any project or proposal to provide drinking water can only be from this source.

GoK having realized the need for basic and fundamental rights of its people in the region to be provided with safe and potable drinking water had made an appeal to the Hon'ble Supreme Court of India requesting for additional allocation over and above the allocation as per the CWDT award (Civil Appeal No. 2453 of 2007).

Hon'ble Supreme Court after hearing the pleas made by the State and also the pleas of other Riparian States, pronounced its landmark judgement on 16/02/2018 which states thus:

- ***Karnataka has been allocated an additional quantum of 14.75 TMC of water and the total allocation will now be 284.75 TMC. This includes 4.75 TMC of water exclusively for Bengaluru Metropolitan Region.***
- ***Karnataka has to release a total quantum of 177.25 TMC of water to Tamil Nadu (in a normal year) at the contact point on the Inter-state border, i.e., at Biligundlu which is inclusive of 10 TMC towards Environmental flow at 2.5 TMC every month from February to May.***

As per Point No. 11 of Judgement, - Final Water Allocation amongst States and further under Point No 12. – Monthly Schedule for delivery of water at Inter State Contact points, Sub point No 289, Page 333 & continued in Page 334,

the Supreme court states thus:

"It was also made clear that in case the yield was less in a distress year, the allocated shares would be proportionately reduced amongst the States involved by the Regulatory Authority. Having regard to the fact that the irrigation season starts form 1st of June and the normal date of onset of South West monsoon in Kerala is of the same date so much so that any delay in the advent of monsoon would affect the inflows and consequently dislocate the schedule of releases from Krishnaraja Sagara & Kabini Reservoirs, the Tribunal felt it to be advisable that at the end of May each year, as much storage as was possible during a good year should be consciously conserved as that would help in adhering to the schedule of monthly deliveries".

As a measure to conserve water, provide drinking water to Bangalore Metropolitan Region, its surrounding areas etc in Cauvery basin including addressing energy shortage, GoK is planning to build a balancing reservoir across River Cauvery near Mekedatu due to the fact that beyond KRS and Kabini Dams, there are no structures which can be utilized for providing / augmenting drinking water to these areas.

Further, construction of Mekedatu Balancing Reservoir cum Drinking Water project would help in utilizing the available drop from the construction of dam and the natural bed slope of the river from the project site to nearby State border to generate power from the releases to be made to Tamil Nadu on a monthly basis (in a normal year). This project, on successful implementation will enable ensuring that the downstream commitment of allowing 177.25 TMC (which includes 10 TMC towards environmental flow) to Tamil Nadu is met with along with drinking water needs of the Bangalore Metropolitian Region and surrounding areas including generation of power from the monthly releases effected to as per the CWDT Award further modified by the Hon'ble Supreme court of India vide its Judgement dated 16/02/2018.

The proposed balancing reservoir site upstream of Mekedatu has been earlier called as 'C ' site by Karnataka Power Corporation Limited (KPTCL) which had identified about 3 sites namely, 'A' site, 'B' site and 'C ' site for locating Hydropower Project, However, after analyzing various parameters and as per the directions of the Government, they had decided to consider locating the said project at 'C' site. CNNL, on its part has also decided to consider the same location for siting headworks for the proposed balancing reservoir. From hereon, the site will be called as Mekdatu site and the the project will be referred to as Mekedatu Balancing Reservoir cum Drinking Water Project.

The Mekedatu project site is situated at 12° 16´ 20˝ N Latitude and 77° 26´ 25˝ E Longitude.

1.1.1 Objectives

The proposed project is envisaged to address the following Objectives: The objectives of the project are

- ✓ Utilizing additional 4.75 TMC of water to provide drinking water facility to Bengaluru Metropolitan Region, its adjoining area etc by way of proposing a scheme to tap water from the foreshore of the intended Mekedatu Balancing Reservoir cum Drinking water project.
- ✓ To regulate the required quantum of water to Tamil Nadu on a monthly basis (in a normal year) as per the CWDT award, as modified by the Hon'ble Supreme Court of India vide its Judgement dated 16.02.2018. It is further proposed to store the flood waters otherwise escaping to sea as it happened in the monsoon of 2018.
- ✓ Harnessing nearly 400 MW (650.28 MU of renewable energy annually @90 % dependable year) of renewable energy annually by utilizing the fall in the natural bed profile of the Cauvery River upto the State border from the monthly releases effected to (in a normal year) as per the modified award (by the Hon'ble Supreme Court of India vide its Judgement dated 16.02.2018.)

1.1.2 Description of works

- Construction of Concrete Gravity dam at Mekedatu referred to as Mekedatu site with FRL at RL 440.00 metres having a Gross Storage Capacity of 67.16 TMC (1901.97 MCM).
- Dam will have a central spillway with radial gates to effectively discharge the design flood with suitable energy dissipating arrangement (Flip bucket) on the downstream side.
- Intake structure with water conducting system consisting of required number of penstocks, pressure shafts which will be embedded partly in the body of the dam and the rock mass to feed the water continuously to the generating units.
- Underground power house with three caverns is proposed downstream of the dam with an installed capacity of 400 MW with necessary transformers, substation and auxiliaries to evacuate the power generated.
- Construction of Jackwell cum pump house on the foreshore of the reservoir to lift the required quantum of drinking water along with raising main and Delivery chamber at the identified location to plan for further transportation and distribution.

The extent of submergence of the land on the upstream of the Dam with the proposed FRL at RL 440.00 m is 4996.00 Ha.

1.2 Location of project area

The proposed project is located at Latitude 12° 16´ 20˝ N and Longitude 77° 26´ 25˝ E in Muguru and Mekedatu villages, Kanakapura and Kollegal taluks of Ramanagara and Chamarajanagar Districts, Karnataka State. The dam site is located about 2.0 km downstream of confluence of Arkavathy with Cauvery river called 'Sangama'. While the left flank of the dam falls under Ramanagara District, the right flank falls under Chamarajanagar District. The centerline of the Cauvery river forms the administrative boundary between the two Districts. Detailed location of the project is shown in **Fig. 1.3**.

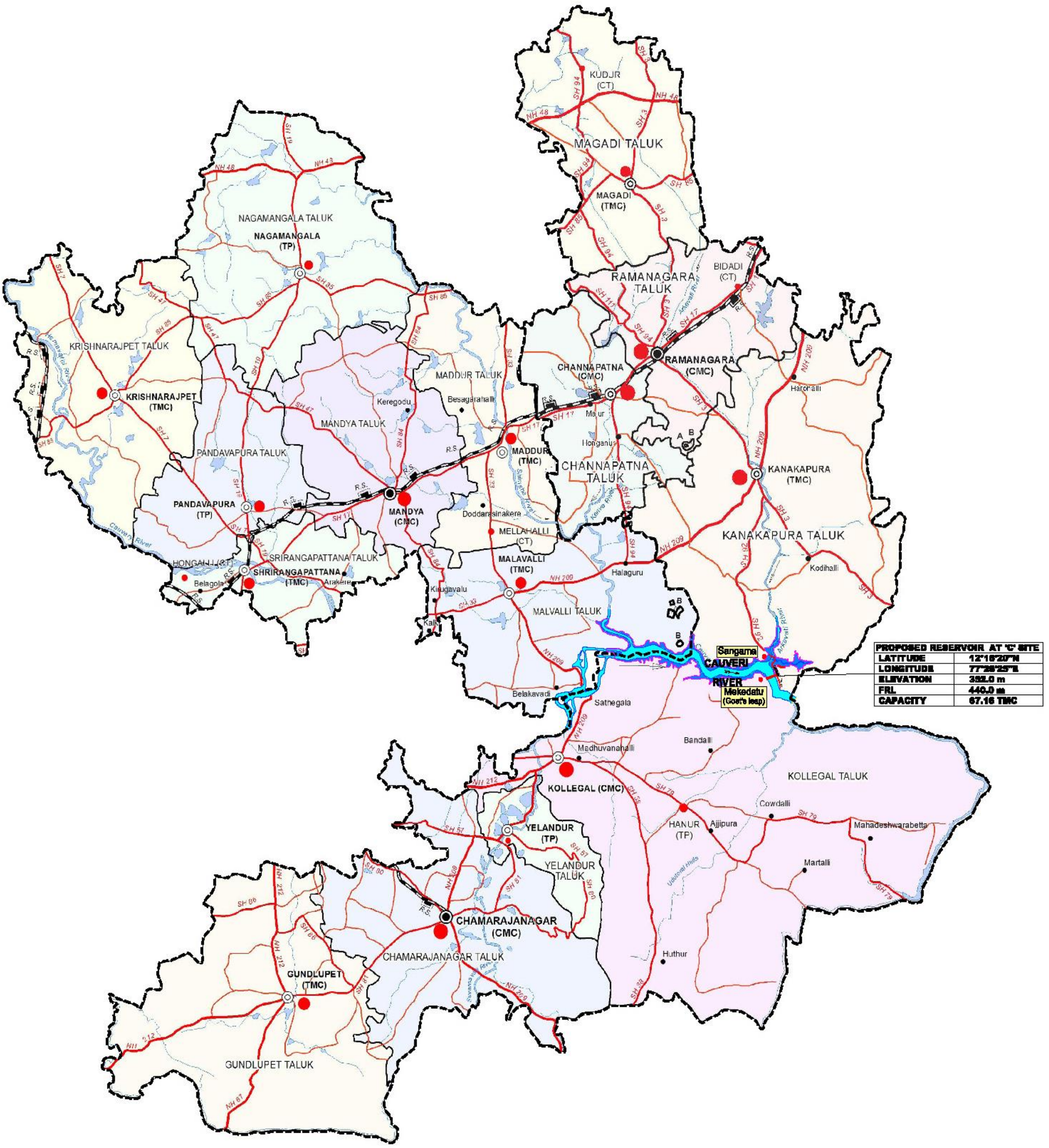


Fig. 1.3: Location map of the project

The toposheet mosaic of the project area is shown in **Fig. 1.4**

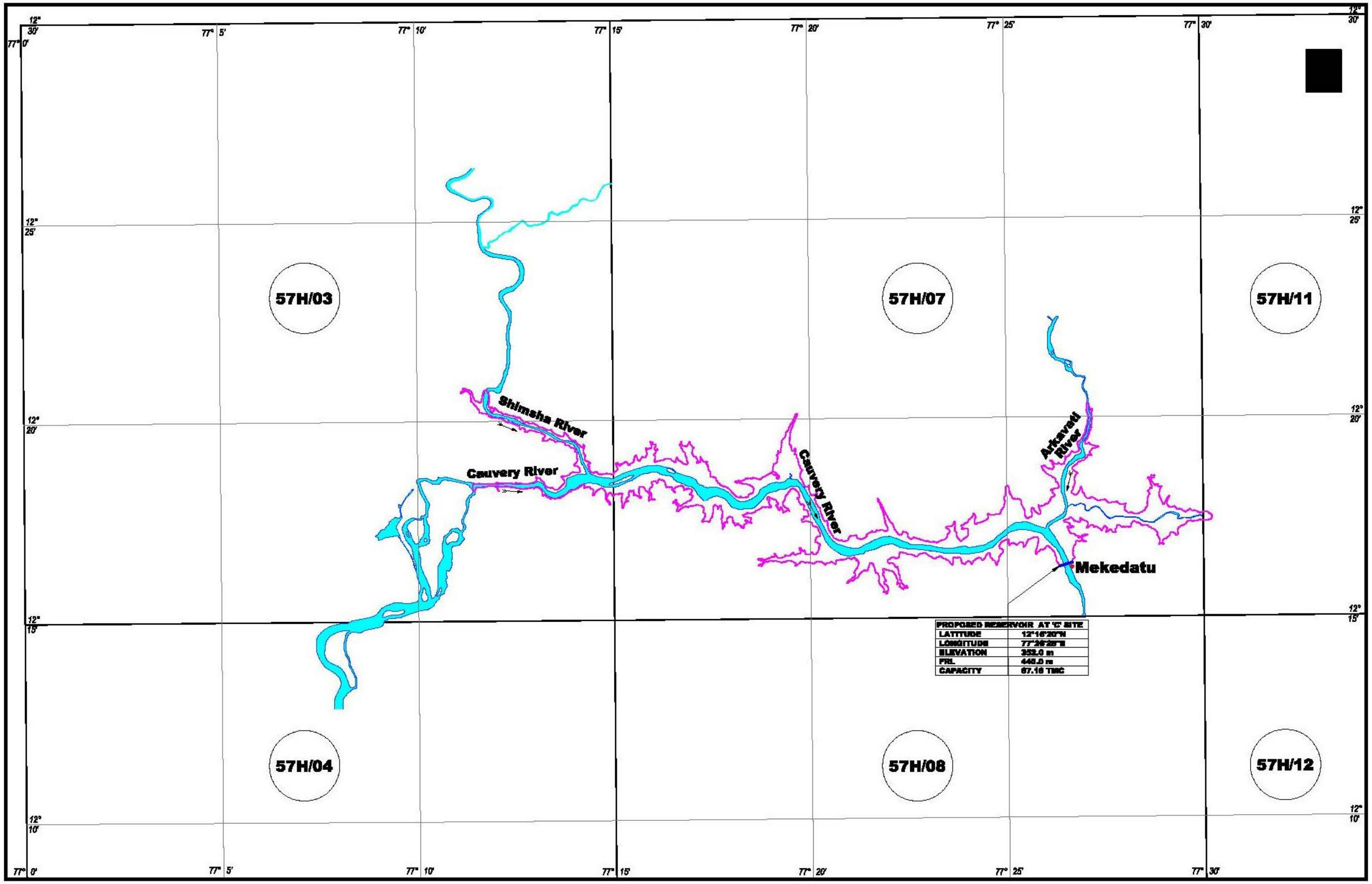


Fig. 1.4: Toposheet reference of the project

1.3 Accessibility

1.3.1 By Road

Mekedatu dam site is well connected from Bangalore and District headquarters Ramanagar via Kanakapura.

a. Connectivity from Bangalore (Left flank)

Mekedatu dam site can be accessed from Bangalore by NH 209 upto Kanakapura covering a distance of 63 Km and thereafter through SH 3 for a length of 2 km and through SH 92 upto Arkavathy river crossing covering a length of 31 Km. From Arkavathy river crossing, the dam site has to be accessed by cart track for a length of 3.0 km which leads to left flank of the Mekedatu dam site. The dam site is located 97 Km south of Bangalore.

b. Connectivity from Ramanagara (Left flank)

Mekedatu dam site can be accessed from Ramanagara by SH 3 via Kanakapura covering a distance of 30 Km and thereafter through SH 3 for a length of 2 Km and thereafter through SH 92 upto Arkavathy river crossing covering a length of 31 km. From Arkavathy river crossing, the dam site has to be accessed by cart track for a length of 3.0 km which leads to left flank of the Mekedatu dam site. The dam site is located 66 km south east of Ramanagara.

c. Connectivity from Chamarajanagar (Right flank)

Connectivity to the right flank is limited in view of hilly terrain and forest. There are no well established roads except for tracks which are maintained by forest authorities.

Hence in terms of connectivity Mekedatu dam site is well connected to the left flank.

1.3.2 By Rail

The nearest Railway Station is Ramanagara between Bangalore and Mysore and is located approximately 66 Km north west of Mekedatu dam site.

1.3.3 By Air

Bengaluru International Airport (Kempegowda International Airport) which is located 125 km North of the dam site is the nearest Airport .

1.3.4 Port connectivity

New Mangalore Port will be the nearest sea port and is located 370 km via Puttur-Sakleshpura-Hassan-Yediyur-Kunigal-Magadi-Ramanagar-Kanakpura, northwest of Mekedatu dam site.

For details regarding connectivity and major towns, refer Index map **EIT-1328X-WRE-XX-IND-A001**.

1.4 General Climatic conditions

Karnataka State witnesses three types of climates. The State has a dynamic and erratic weather that changes from place to place within its territory. Due to its varying geographic and physio-graphic conditions, Karnataka experiences climatic variations that range from arid to semi-arid in the plateau region, sub-humid to humid tropical in the Western Ghats and humid tropical monsoon in the coastal plains.

More than 75 percent of the entire geographical area of Karnataka, including interior Karnataka, witnesses arid or semi-arid climate. Karnataka has about 15 percent of the total semi-arid or 3 percent of the total arid areas identified in India.

Due to the climatic difference, Karnataka is divided into three meteorological regions:

Coastal Karnataka: This region stretches over the districts of Udupi, Uttara Kannada and Dakshina Kannada. The entire coastal belt and the adjoining areas have tropical monsoon. The area receives heavy rainfall. The average annual rainfall in Coastal Karnataka is about 3456 mm, which is much more than the rainfall received in the other parts of the State.

North Interior Karnataka: This region extends over the districts of Bagalkot, Belgaum, Bijapur, Bidar, Bellary, Dharwad, Haveri, Gadag, Gulbarga, Koppal and Raichur. This area is an arid zone. North Interior Karnataka receives the least amount of rainfall in the State where the average annual rainfall is just 731 mm.

South Interior Karnataka: This region spreads over the districts of Bangalore Rural, Bangalore Urban, Chitradurga, Chamrajnagar, Chikmagalur, Hassan, Kodagu, Kolar, Mysore, Shimoga and Tumkur. This zone experiences semi-arid type of climate. South Interior Karnataka receives an annual average of 1286 mm rainfall.

1.4.1 Climatic conditions of the Project area

The Cauvey basin lies in South Interior Karnataka. The year may broadly be classified into four seasons. The dry season is from January to February, followed by hot weather from March to May. The SW monsoon season is from June to September and the NE monsoon period is from October to December.

The normal rainfall in the project area is 854 mm and varies from 822 mm at Kanakapura to 868 mm at Magadi. December to March represents very low rainfall months. The major part of rainfall occurs in nearly 49 rainy days. The rainfall during pre-monsoon period has a normal of 345 mm (35%),SW monsoon period has

363 mm (37%) and the NE monsoon period has 263 mm (27%) rainfall. It is observed that there is not much variation in the distribution of rainfall during pre monsoon, SW monsoon and NE monsoon periods of the year.

1.4.1.1 Ramanagar District

The year may broadly be classified into four seasons. The dry season is from January to February, followed by hot weather from March to May. The SW monsoon season is from June to September and the NE monsoon period from October to December.

The amount of rainfall is being measured at the rain guage stations located in the district. A study of the rainfall data from 2001 to 2010 of various rain gauge stations has shown that the amount of rainfall is relatively uniform through out the district. The normal annual rainfall of the district is 854 mm and varies from 822 mm at Kanakapura to 868 mm at Magadi. December to March represents very low rainfall months. The major part of rainfall occurs in nearly 49 rainy days. The rainfall during pre-monsoon period has a normal of 345 mm (35%),SW monsoon period has 363 mm (37%) and the NE monsoon period has 263 mm (27%) rainfall. It is observed that there is not much variation in the distribution of rainfall during pre-monsoon, SW monsoon and NE monsoon periods. During the year 2011, the district received an average rainfall of 970 mm. However it varies from a lowest 800 mm at Kanakapura to a highest 1130 mm at Magadi station.

The temperature starts rising from January to peak in April, the hottest month with a maximum temperature of 34°C. Thereafter it declines during the monsoon period. December is the coldest month with the temperature dipping down to 16°C.

The humidity is lowest during the dry season and highest during the monsoon period with an average value of about 49% and 86% respectively.

The winds are predominantly from south west during the summer monsoon and from north east during the winter monsoon.

The annual potential Evapotranspiration is 1531 mm with monthly rates of more than 100 mm throughout the year and the maximum is 166 mm in the month of March.

1.4.1.2 Chamarajanagar (C.R.Nagar) District

The climate of C.R.Nagar district is quite moderate through out the year with fairly hot summer and cold winter. March to May are summer months, where mean maximum temperatures ranges from 32.6°C to 34°C. June to September is the southwest monsoon period, October and November is the post monsoon retreating monsoon season with clear bright weather and during December to February weather remains dry. The skies are cloudy or overcast during southwest monsoon. During October and November some of the depressions and cyclonic storms originates in Bay of Bengal, and passes through the district, causing wide spread heavy rains and high winds.

The mean maximum temperature in the district is 34°C. and the mean minimum temperature is 16.4°C. during January month. Relative humidity ranges from 69 to 85% in the morning and in the evening it ranges from 21% to 70%. The wind speed ranges from 8.4 to 14.1 kmph. The potential evopotranspiration in the district ranged from 106mm to 165mm/year.

C.R.Nagar district receives rainfall from southwest monsoon from June to September and northeast monsoon from October to December. Overall on an average, there are 67 normal rainy days, with a minimum in Yalandur taluk for 63 days, maximum in Gundlupet taluk for 73 rainy days. As per the last three decades (1970-2000) rainfall analysis, the precipitation during southwest monsoon accounts for 61.17% of the total amount of rainfall and the northeast monsoon accounts for 31.88%. September is the wettest month in the year. Annual rainfall for the last three decades are; Chamarajanagar- 799.3 mm, Gundlupet-785.5 mm, Kollegal-768.1 mm and in Yalandur-894.1 mm. Average annual rainfall in the district is 811.75mm. The analysis of the last ten year rainfall data (1997-2006) shows that the highest annual rainfall occurred in C.R.Nagar taluk with 731.80mm and the lowest at Gundlupet with 586.1mm. Deficiency in rainfall is observed in the four taluks for the last ten years except during the years 2000, 2004, and 2005 where excess rainfall in the range of 3% to 40% was observed.

1.5 General description of Topography, Physiography and Geologyof the basin

1.5.1 Topography

The Cauvery Catchment basin is bounded on the north by the ridges separating it from Krishna and Pennar basins, and the basin area is covered by the streams between Palar and Cauvery on the south and by the Eastern Ghats on the east and by Western Ghats on the west. The upper reach of the basin is covered with hill ranges of the Western Ghats and the basins area is broad and open with gently undulating country. In the north – west and south, there are a number of hill ranges which have steep slopes. The maximum length of Cauvery basin from west to east is 540 km in Karnataka. The maximum width from north to south is 255 km.

1.5.2 Physiography

The Southern Karnataka Plateau covers the districts of Bangalore urban , Bangalore Rural, Hassan, Kodagu, Kolar, Mandya, Mysore and Tumkur. This region largely covers the area of the Cauvery river basin lying in Karnataka. It is bounded by the 600 metre contour and is characterised by a higher degree of slope in the west and south (enclosed by the ranges of Western Ghats). The northern part is an interrupted but clearly identifiable high plateau.

In the east, the valleys of the Cauvery and its tributaries open out to form undulating plains. The general elevation of the region varies from 600 m to 900 m. However, elevations of 1,500 m to 1,750 m are found in the Biligirirangan hills of Mysore district and the Brahmagiri range of Kodagu district.

1.5.3 Geology

The region comprise of rocks belonging to Charnockite group, Sargur group, Peninsular gneissic complex (PGC), Closepet granite, and basic and younger intrusives. Charnockite group is represented by Charnockite. Sargur group comprises of ultra mafic rocks, amphibolite, banded magnetite quartzite, occurring as small bands, and lenses within the migmatite and gneisses. The PGC includes granites, gneisses and migmatite and occur to the east and west of Closepet granite. Transformation of PGC into Charnokite is reported locally in the district. The Closepet granite occurs as intrusive bodies trending nearly N-S within the gneisses over a distance of 50 km and for a width of 15-20 km. The Closepet granite contains enclaves of migmatite, gneisses, quartzite and amphibolites and is reported to be of variable composition. The basic intrusives are represented by dolerite, gabbro, occasionally norite and pyroxenite. The dolerite is dominant among the basic dykes. There are three major lineaments in the district trending NNW-SSE direction. These lineaments range in length from 45 km to 70 km. Interpretation of this data revealed the presence of deep seated fault tending NNW-SSE, which cuts across the Closepet granites.

1.6 Population

1.6.1 Affected

On implementation of the Project and construction of the balancing reservoir, it is expected that due to submergence, some villages are likely to be affected. Besides population of few hamlets may get submerged. Hence evacuation or relocation of such hamlets is anticipated. However,mostly dry, cultivation field and forest land will be submerged. Scattered development along the river course developed by private enterpreners such as fishing camps, places of worship, weekend resorts may require relocation. Consequent to the approval of the DPR, a comprehensive survey of the submergence area will be carried out in order to identify facilities which are likely to be submerged and requires relocation including extent of compensation payable etc.

1.7 Natural Resources

The region traversed by the Cauvery river and its tributaries in Karnataka cannot be individually described as it is a part of the South Deccan Plateau which has varied biological richness in terms of diversity. It comprises of the Western Ghat region in the initial reaches followed by South Deccan Plateau Dry Deciduous Forests. The Natural Resources of the two regions are enumerated hereunder:

The climate of region is quite moderate through out the year with fairly hot summer and cold winter. The district has a forest cover of half of total area i.e., 2,75,610 hectares with rich forest products like sandal wood and also has wild animals, Temperatures being 32˚C (Max.) and 10˚C (Min.), Average Rainfall is 951 mm and Major River being Suvarnavati. Agriculture is the backbone of the economy with the net sown area being 1.75 lakh hectares. The area falls under southern dry zone. The major crops grown are the cereals with an area of 92,261 ha where jower, maize, and ragi are the major cereals, the commercial crops with an area 76,763 ha in which sugarcane and cotton are the major crops and pulses with an area of 39699 ha and lastly oilseeds with an area of 33069 ha in which sunflower is major cash crop. This district is also endowed with rich mineral resources, both metallic and nonmetallic minerals. It has vast reserves of black granite.

As it is having a large percentage of forest cover known for tourist attraction to visit around, such as Survarnavathi Reservoir, Kanakagiri hill, Thriembakapura, Huguligana murudi •BR Hills Wildlife Sanctuary (Yelandur Taluka), Sri Male Mahadeshwara Hills (Kollegal Taluka), Bandipura National Park (Gundlupet Taluka), Barachukki (Kollegal Taluk), Himavad Gopalaswamy Hills (Gundlupet Taluka) and South Deccan Plateau Dry Deciduous Forests.

Although not exceptionally outstanding for biological richness or endemism by itself, the South Deccan Plateau Dry Deciduous Forests ecoregion is contiguous with the moist deciduous forests that lie along the foothills of the southern extent of the Western Ghats Mountains. Two of India's most important elephant conservation areas, the Nilgiris-Eastern Ghats and the Anamalais-Nelliampathis, and two of the most important TCUs extend across three ecoregions: the South Western Ghats Montane Rain Forests, South Western Ghats Moist Deciduous Forests, and South Deccan Plateau Dry Deciduous Forests. Together, these three ecoregions provide an important, contiguous habitat landscape for conservation of Asia's largest terrestrial herbivore and predator.

The ecoregion represents a large area of tall, tropical dry forests in the southern Deccan Plateau, on the leeward side of the Western Ghats Mountain Range. It extends across the southern Indian states of Karnataka and Tamil Nadu. The ecoregion's links to the ancient, southern circumpolar continent, Gondwanaland, are evident in the biotic links to Africa and Madagascar.

The ecoregion's vegetation is highly influenced by climate. The tall Western Ghats Mountain Range intercepts the moisture from the southwest monsoon; therefore, the eastern slopes and the Deccan Plateau receive very little rainfall; annual rainfall ranges from 900 to 1,500 millimeters (mm). The undulating hillsides have very shallow soils.

The dry deciduous forests of this ecoregion are flanked by the moist deciduous forests along the lower elevations and foothills of the Western Ghats to the west and by thorn scrub to the east. Therefore, this ecoregion probably represents a transition zone between the moisture western vegetation and the drier vegetation to the east.

Champion and Seth, classified these forests as Southern Dry Mixed Deciduous Forests, where teak (*Tectona grandis*) is not conspicuous. Thorny plants become more common in areas where grazing pressure is high.

Structurally, these dry forests have a three-level forest, with an upper canopy at 15-25 meters (m), an understory at 10-15 meters, and undergrowth at 3-5 meters. Lianas drape the trees in denser, mature forests. The vegetation is characterized by *Boswellia serrata*, *Anogeissus latifolia*, *Acacia catechu*,*Terminalia tomentosa*, *Terminalia paniculata*, *Terminalia belirica*, *Chloroxylon swietenia*, *Albizzia amara*, *Cassia fistula*, *Hardwickia binata*, *Dalbergia latifolia*, *Sterospermum personatum*, *Pterocarpus marsupium*, *Diospyros montana*, and *Shorea talura*, among others. One of the important species of this forest, sandalwood (*Santalum album*), has been selectively removed from most of the forests in this ecoregion.

1.7.1 Biodiversity Features

Although not high in endemism or diversity, the ecoregion harbors several important populations of India's large threatened vertebrates whose populations are fast declining throughout their ranges because of habitat loss and hunting pressure. For instance, the elephant population that ranges from the Nilgiri Hills to the Eastern Ghats, estimated at more than 6,000 animals, is considered to be the largest single elephant population in India. A second important population ranges along the Anaimalai and Nelliampathi Hills.

The ecoregion's mammal fauna includes seventy-five species. One, the critically endangered Salim Ali fruit bat, is a near-endemic species. Other threatened mammals include the Asian elephant (Elephas maximus), wild dog (Cuon alpinus), sloth bear (Melursus ursinus), chousingha (Tetracerus quadricornis), gaur (Bos gaurus), and grizzled giant squirrel (Ratufa macruora).

Two species in this ecoregion, the Indian bustard (Ardeotis nigriceps) and lesser florican (Eupodotis indica), are globally threatened and warrant conservation attention.

1.8 Land Use and Socio Economic aspects

1.8.1 Land use

Geographically, Ramanagara District is about 412.78 sq.km out of which forest area is 69,946 ha, Cultivated area is about 1,75,539 ha. The District with major part sloping towards south and south east forming Pediplain interspersed with hills all along the western part with the elevation in the range of 996 m and 1467 m mostly is in the granitic terrain. The Pediplain form major part of the district underlain by gneisses and granites with the highest pediplain in the range of 850 m to 950 m amsl. Rocky upland pediplain and plateau constitute erosional topography. Major part of pediplain constitutes low relief area having matured dissected rolling topography with erosional landscape covered by layers of red soil of varied thickness. Major parts of the pediplain are dissected by streamlets flowing in southerly direction. An alluvial valley with low relief of 600 m – 650 m is located in Kanva plain. This district geomorphology majorly consists of Rocky uplands, Plateaus, and Flat topped hills. Cauvery basin is one of the main water source flowing within the district.

As shown in **Fig. 1.5** to **Fig. 1.11**, the project site is surrounded partly by rocky boulders with pockets of water flow. At Shivanasamudram, the Cauvery River branches off into two parts and falls through a height of 91 m. in a series of falls and rapids. The falls at this point is utilized for power generation in the upstream of this project site. The power station at Shivanasamudram was built as early as 1902. The two branches of the river join after the falls and flows through a narrow gorge which is the present project site known as "Mekedatu" and continues its journey and forms the boundary between Karnataka and Tamil Nadu States for a distance of 64 km. The project site photos are shown below.

Fig. 1.5: Birds eye view – Central line of Dam towards upstream

Fig. 1.6: Exposed sheet Rocks along the flanks and River bed – Dam Central line

	
Fig. 1.7: Borehole location along the Dam central line	**Fig. 1.8: Officials along the Dam central line – River bed**
	
Fig. 1.9: View of Left Flank from River bed along the Dam central line	**Fig. 1.10: Hon’ble Minister for water resources GOK showing the central line of dam axis**
	
Fig. 1.11: Joint site inception - Dam C/L by CNNL officials accompanied by Hon’ble Minister, Water Resources GOK	**Fig. 1.12: Official briefing to Hon’ble Minister, Water Resources GOK**

1.8.2 Socio economic aspects

The Concept of water and development has been changing in the recent decade. Water for life (i.e. drinking water), energy, agricultural, industrial and domestic sectors should be widely managed between upstream and downstream sides of the water source. These water managements will mitigate the socio-economic impacts in the local regions. The notion of economic impact refers to the effects, on the local and regional economics, of project construction and subsequent operating activities. These include direct and secondary demands for labor and services, as well as the effects on local resources and thus on the very structure of the local economy. Such economic effects also cause significant social impacts which impinge on economic parameters. Also various impacts stem directly from the project activities and these also have economic implications. Overall, socio-economic impacts endanger a complex dynamic stage which is not easy to predict accurately.

Socio economic factors are of greater interest in the recent years in EIA as they represent specific aspects of human environment and the changes represent the most critical alterations associated with project implementation.

Further, a detailed study will be conducted which will provide us the understand of how the potential changes could be increase /decrease in population, disruption of settlement patterns, change in land use, disruption in religious pattern, attitudes and life styles, changes in transportation systems, relocations of highways and rail roads. Detailed studies will be provided on the Infrastructure and cultural sites located within 10 km radius of the project site.

1.9 History (Earlier proposals)

1.9.1 Proposals

The need to harness Hydro Electric Potential on the river Cauvery below Shivasamudram and upto Mettur is being considered since a very long time. The head available between Shivasamudram and Full Reservoir Level of Mettur is about 1200 ft. Mention of the Mekedatu project can be found in the press communiqué issued on July 3rd, 1924, by the Joint Secretary to Government, PWD, Madras after the signing of the 1924 Agreement. In that communique it was stated as follows:

> *"This Government have further agreed with the Mysore Darbar that Mysore shall utilise the water power available at Mekedatu for the development of electric power, subject to the right of Madras to purchase power from this source, if required, at a concession rate. In view of the very large sources of power which are available in this Presidency, it is doubtful whether power from Mekedatu will be required."*

Originally, Govt. of Mysore examined the possibility of developing power from Mekedatu project during 1948. Proposed scheme consisted of 30 m high masonry dam at a site 2.4 km below the confluence of the Cauvery and the Arkavati River. Water conductor system consisted of RCC flumes, surge tank, penstock and surface power house. Power house location was about 8km d/s of the dam. At that time Kollegal territory was part of Madras Presidency, in view of lesser demand for power at that time and availability of other economical projects, this project was not been taken up for further investigation till the State Reorganisation in year 1956.

After the reorganization of State in year 1956, Hydro Electric Project Investigation Department of Govt. of Mysore further examined the development of power projects across the Cauvery River below Shivanasamundram.

On a study of the topography of the Cauvery river in its last reaches of 42 km from Shimsha to the state border, three sites named A,B and C for the construction of storage dams were selected and studied. The locations of these alternative sites are shown in **EIT-1328-WRE-XX-CS-A009**.

Site 'A' is about 11.2 km upstream of the confluence of the Cauvery and Arkavathy rivers, ie., Sangam; 'B' is about 7.2 km. upstream of Sangam; and site 'C' about 2 km downstream of Sangam. At that time it was contemplated to create reservoir with a storage capacity of 180 TMC.

After a detailed reconnoitory survey, it was found that sites 'A','B' and 'C' suites best for high dams as the river flows through high hilly valleys. The bed levels at these sites are as follows; i. Site-A, 377.950 m, ii. Site-B, 370.300 m and iii. Site-C, 361.100 m.

Based on a preliminary studies carried out way back in 1966, site 'C' becomes the most suitable as at this site there is a rapid fall of ground level to an extent of 41 m within 2.4 km from the proposed dam site to the junction at Mulehalla stream joining river the Cauvery downstream of Mekedatu falls. This topographic set up was utilized to locate the surface power house at Mulehalla junction Detailed investigations were then carried out at and around Site C.

The power scheme contemplated during year 1966 was known as the Cauvery Hydro Electric scheme. It was proposed to construct a 125 m high dam across the Cauvery river with an Installed capacity of 756 MW (6 Nos of 126 MW).

In the year 1970 the earstwhile "Hydro-electric Project Investigation Department of GoM/GoK" was merged and further Investigations/execution of works were transferred to "Karnataka Power Corporation Limited (KPCL)"

In 1981, Government of Karnataka had constituted a Committee to study the feasibility of Hydro Electric Projects below Shivasamudram. This Committee had submitted its report during September, 1981 including the power projects of Shivasamudram, Mekedatu and Hogenakal. Based on the report of the Committee in year 1981, Karnataka in year 1987 prepared a comprehensive scheme covering Shivasamudram Seasonal Power House, Mekedatu located in the State of Karnataka and Hogenakal on the common boundary. At the same time Tamil Nadu had also thought of projects at Hogenakal and Rasimanal in the reach of common boundary.

In the year 1987 KPCL formulated a Detailed Project Report for Shivanasamudram Seasonal Electric Project, Karnataka submitted to the Central Electricity Authority for Techno Economic Clearances a project report of Shivanasamudram Seasonal Electric Project for 270 MW installed capacity. This project was not cleared by Central Electricity Authority (CEA) which directed the State to submit the report after the resolution of the Inter-State Issues.

The Cauvery Water Disputes Tribunal (CWDT) was constituted on 02.06.1990. The State of Karnataka in its Statement of Case filed in September 1990 before this Tribunal had mentioned the proposals for the power schemes in the reach Shivasamudram to Mettur (consisting of Shivasamudram Seasonal Hydro electric Project, Mekedatu and Hogenakal). The Tribunal had framed an issue on power projects – Issue No.32 which reads as under:

> *"32 – whether directions are required to be issued to ensure that the waters of Cauvery and its tributaries may be developed by each of the State, singly or jointly to generate maximum Hydro Electric Power without detrimental to irrigation uses".*

When the State of Karnataka in 1992 signed an MOU for implementation of Shivasamudram Seasonal Scheme, the State of Tamil Nadu filed Civil Miscellaneous Petiton (CMP 24 of 1992) before the Cauvery Water Dispute Tribunal praying for restraining State of Karnataka from proceeding with the Project. However the application was withdrawn with liberty to file a fresh and appropriate application.

The Government of Karnataka constituted a High Power Apex Committee in 1995 for monitoring the progress of Cauvery Basin Projects and Cauvery Water Dispute. On the recommendations of this Committee Government constituted a sub-committee in July 1995 to examine the possibilities of utilising waters of Cauvery below KRS for production of Hydel Power.

The Advisory Committee took into cognizance the report of the Committee constituted by the Government of Karnataka in 1981 on the feasibility of Hydro Electric Project in the Cauvery Basin.

After considering the various alternatives, the sub-committee in 1995 recommended the following for phased development of power projects as follows:

- Report of Shivasamudram Seasonal Scheme with an installed capacity of 270 MW is already before Central Electricity Authority for clearance. This clearance is stalled only because of the objections of Tamil Nadu in view of the Cauvery Water Dispute. As this is the most attractive power scheme on hand in Karnataka with the cost of generation being only Rs.0.60 per unit, this fact should be effectively and intensively canvassed at the highest levels to secure clearance to the project.
- Construction of Mekedatu dam with FRL at EL 440.00 m (with a flexibility of 5 m on either side and storage capacity of 60.45 TMC annually) with an installed capacity of 180 MW in the first stage and another 180 MW in the ultimate stage with an annual electrical energy generation of 486 MU initially and 635 MU ultimately.
- To take up Hogenakal scheme with a full reservoir level of 305 m and operate it in combination with Mekedatu to generate additional energy of 322 MU annually. The Hogenakal scheme can either be taken up as a joint venture of Karnataka and Tamil Nadu (as it comes on the common boundary of the two states) with suitable sharing of cost and benefits to be negotiated at an appropriate time and forum or as a centrally sponsored scheme.

1.9.2 Implementation of the proposed schemes

As per these recommendations of the 1995 sub-committee, Karnataka Power Corporation in 1996 prepared project Reports for Shivanasamudram Seasonal Power Scheme and Mekedatu Power Scheme in the first instance, out of the four schemes planned to be taken in the river reach between Shivanasamudram and Mettur.

The details of the projects to be taken up were shown in **Table 1.2.**

Table 1.2:Proposed schemes during the year 1996

No.	Name of the Project	Installed capacity	Land required to be acquired
1	Shivanasamudram in Karnataka	270 MW	70 ha
2	Mekedatu in Karnataka	460 MW	5845 ha
3	Rasimanal in common boundary	360 MW	1435 ha (in both States)
4	Hogenakal in common boundary	120 MW	253 ha (in both States)

Again Tamil Nadu filed CMP No.1 of 1998 with prayers to restrain the State of Karnataka from proceeding with the execution / implementation of the Shivanasamudram Project.

1.9.3 Decision of Government of Karnataka regarding execution of project by M/s NHPC

Sri P.R.Kumaramangalam, Union Minister of Power, GOI wrote a letter in November 1998 to the Chief Ministers of Karnataka and Tamil Nadu, stating that both Karnataka and Tamil Nadu have submitted separate proposals for Mekedatu, Hogenakal and Rasimanal and that Tamil Nadu has opposed Shivanasamudram Project and the proposals submitted by both the States are mutually irreconcilable. He suggested that NHPC may finance, construct and operate all these power projects with equal energy sharing between Tamil Nadu and Karnataka with a small portion being given to other constituent States in the region.

Accordingly, efforts were made by Government of India and NHPC with the two States to come to an understanding so as to take up the projects.

After prolonged correspondence and deliberations these projects did not take any shape in view of huge submersion of forest area under Mekedatu, Hogenakal and Rasimanal and its effect on wild life sanctuary and non-clearance of the scheme by MoEF and since power sharing aspects between States had not been resolved.

In D.O. letter No: DE 82 APC 99, dt: 22.12.2006, Additional Chief Secretary and Principal Secretary to Government, Energy Department, Government of Karnataka addressed to Secretary (Power), Government of India, Ministry of Power, indicated as below:

> *"… The decision of Government of Karnataka is that Karnataka will wait for the award of the Cauvery Water Disputes Tribunal and till such time, it is not possible to give consent for execution of Shivasamudram and Mekedatu Hydro Electric Projects by M/s NHPC".*

1.9.4 Tribunal Report

The Cauvery Water Disputes Tribunal had pronounced its Judgement on 5th February 2007. The Cauvery Water Disputes Tribunal in its Final Order of 05.02.2007 under Clause XIII stated as below:

"Clause XIII :

> *The States of Karnataka and Tamil Nadu brought to our notice that a few Hydro-Electric power projects in the common reach boundary are being negotiated with the National Hydro Electric Power Corporation (NHPC). In this connection, we have only to observe that whenever any such Hydro-power project is constructed and Cauvery Waters are stored in the reservoir, the pattern of downstream releases should be consistent with our order so that the irrigation requirements are not jeopardized".*

From the above Clause of Tribunal's Final Order, it follows that Karnataka can take up both the Shivasamudram and Mekedatu HEP on its own accord, while maintaining the requirements of the award.

1.9.5 Application of Karnataka filed before the Tribunal on 03.05.2007

As regards Shivasamudram and Mekedatu Projects, keeping in cognizance Clause XIII of the Tribunal Order dt: 05.02.2007, Karnataka has in its Sec 5(3) Application filed before the Tribunal on 03.05.2007 had sought explanation / guidance from the Tribunal that:

> *"It may be explained and clarified that storage in Mekedatu project for Hydro Power Generation and diversion in Shivasamudram Project for Hydro Power Generation are the rights and responsibilities of the State of Karnataka and are not necessarily dependant or controlled by NHPC for their construction".*

The Sec. 5(3) Application in paras 8, 9 and 10 has expressed in detail the issues of Shivasamudram and Mekedatu as follows:

> "8. It is submitted that it is well nigh impossible to ensure delivery month to month without the reservoir at or above the Inter-State border indicated as Mekedatu. Whilst the Tribunal has directed that the pattern of downstream releases should remain unchanged even if the project is constructed and Cauvery waters are stored in the reservoir, it is in the fitness of things that – even assuming whilst denying the share of Tamil Nadu to be 192 TMC at the inter-State border, guidance would be necessary. This could not have been referred originally to this Hon'ble Tribunal. It is only after construction of the reservoir at the border and its operation, that the stipulated releases – monthly or otherwise – could be directed.

9. To enable the "tentative monthly deliveries" during a normal year to be made by the State of Karnataka at the Inter-State "contact point" presently identified as Biligundlu gauge and discharge station located at the common border, it is imperative that a storage reservoir immediately upstream of the "contact point" be considered by Karnataka and only this would enable the monthly deliveries to be ensured without hardship to either side.

10. Besides, Mekedatu power project is proposed by the State of Karnataka and is not dependent necessarily or exclusively on the NHPC for its construction and development. In the event of negotiations with NHPC not being acceptable, power projects of Shivasamudram and Mekedatu continue to be the responsibility of the State of Karnataka. The provisions of Clause XIII, should not be open to misconstruction. Mekedatu power project is not dependent on NHPC for its construction."

1.9.6 Special Leave Petition of the State of Karnataka, Kerala and Tamil Nadu

The States of Karnataka, Kerala and Tamil Nadu in May 2007 filed Special Leave Petition Nos: 7808, 8413 and 8818 of 2007 in the Supreme Court of India under Article 136 of the Constitution challenging the Final Orders and decision of the Cauvery Water Disputes Tribunal dt: 05.02.2007. The Civil Appeals which have been numbered as 2453, 2454 and 2456 respectively are yet to be disposed of by the Supreme Court.

1.9.7 Letter of the State of Karnataka addressed to the Govt. of India 11.06.2007

On 11.06.2007, State of Karnataka addressed a letter to the Secretary, Ministry of Power, Government of India as under :

"Since there is no specific direction of the Tribunal that the project can only be undertaken through the NHPC and since the two projects of Shivasamudram and Mekedatu are exclusively within the territory of Karnataka and in view of the urgent power needs of Karnataka and the vital importance of having a storage facility at the border of Karnataka and Tamil Nadu, the State through Karnataka Power Corporation Ltd. Proposes forthwith to execute the projects in respect of which the following preliminary works have already been undertaken.

i) Survey work

ii) Geo-Technical Investigation

iii) Soil investigation

1.9.8 Civil Appeal No: 2453 of 2007 of the State of Tamil Nadu

In Civil Appeal No: 2453 of 2007 the State of Tamil Nadu on 20.11.2008 has filed I.A. No. 10 of 2008 with the following prayers:

> "(i) issue an injunction restraining the State of Karnataka from executing the Shivanasamudram and Mekedatu hydro electric projects by themselves pending disposal of the appeal before this Hon'ble Court and the application for clarification pending before the Tribunal;
>
> (ii) issue directions to the Union of India to execute all the four hydel projects as a package through the NHPC or any other appropriate Central Power Generation Utility so as to derive the maximum benefits of the power potential available in the reach; and…."

The Minister of Power, Govt. of India has called the Core Committee Meeting on 08.07.2009.

1.9.9 Reply of Karnataka on 22.09.2009

After reply of Karnataka was furnished on 29.09.2009 to Tamil Nadu's I.A.no 10 of 2008 in Civil Appeal No 2453 of 2007, the State of Karnataka on 30.03.2012 sent the DPR of Shivanasamudram seasonal Hydro Power Project prepared by Karnataka Power Corporation Ltd, to Central Electricity Authority for approval. However, the DPR was returned during May 2012 with the observation that the project would be taken for examination after interstate issues are resolved. To CWC comments of May 2012, the M.D, KPCL while replying specifically indicated that since Shivanasamudram and Mekedatu projects lie within the State of Karnataka and are not situated on the common boundary as per Clause XIII of final order of CWDT, the State of Karnataka is well within its Rights to execute these two projects on its own. However, during March 2014, Central Electricity Authority while forwarding its comments requested the State to obtain views / comments of basin States especially Tamil Nadu and Puducherry on the DPR and forward the same to CEA to examine the DPR from interstate angle.

In the meanwhile, the State of Tamil Nadu on 18.11.2014 filed I.A. No 20 of 2014 in Civil Appeal No 2453 of 2007 requesting the court to direct the State of Karnataka to withdraw the notice inviting Global Expression of Interest for Technical Study to construct two reservoirs at Mekedatu. The State of Karnataka has suitably replied on 5.10.2015 to this I.A, quoting that as these two projects of Mekedatu and Shivanasamudram lie well within the State of Karnataka, the construction of these two projects will be taken up by the State on its own. However, the Supreme Court will be kept informed of the developments before taking up the construction.

The stand of Karnataka for taking up Hydro-Electric Projects are as below:

1. As per the CWDT order the monthwise releases (**Table 1.3**) to Tamil Nadu are as follows: (Gauging point Biligundlu)

Table 1.3: Month wise releases to Tamil Nadu

Month	TMC	Month	TMC
June	10	December	08
July	34	January	03
August	50	February	2.5
September	40	March	2.5
October	22	April	2.5
November	15	May	2.5

2. There is a head of about 370.00 m from Shivasamudram to Mettur on the river Cauvery. To exploit this head, four Hydro-Electric Projects at Shivasamudram, Mekedatu, Rasimanal and Hogenakal have been contemplated in the reach. These projects could not be pushed through in view of Cauvery Water dispute. Of the four projects, the first two are entirely located in Karnataka territory and are capable of being taken by Karnataka independently. The downstream two projects are on the common reach boundary of the river and these schemes on common reach can be taken only as joint schemes by Karnataka and Tamil Nadu.

3. Regarding the Hydro-Electric Schemes the Tribunal has stated in Clause XIII of final decision dt: 5th February 2007 as follows:

   "*The State of Karnataka and Tamil Nadu brought to our notice that a few Hydro-Electric Power Projects in the common reach boundary are being negotiated with the National Hydro-Power corporation (NHPC). In this connection, we have only to observe that whenever any such hydro-power project is constructed and Cauvery waters are stored in the reservoir, the pattern of downstream releases should be consistent with our order so that the irrigation requirements are not jeopardized.*"

4. It is also to be reported that Clause XVIII of the Final Order of Tribunal dated 05.02.2007 reads as follows.

   "*Nothing in the order of this Tribunal shall impair the right or power or authority of any State to regulate within its boundaries the use of water,or to enjoy the benefit of waters within that State in a manner not inconsistent with the order of this Tribunal*"

5. To inform Ministry of Power that as the entire head and submersion of Shivasamudram and Mekedatu Power Projects lies well within the Karnataka territory, Karnataka State reserves it's right for implementation of these two project.

6. To withdraw the Shivasamudram and Mekedatu Power Projects from National Hydro-Electric Power Corporation and allot the same to Karnataka Power Corporation Limited.
7. To take up the implementation of the Shivasamudram and Mekedatu Power Projects by Karnataka Power Corporation Limited.
8. Government of Karnataka appointed CNNL as the nodal agency and directed to take up immediate action regarding the preparation of the DPR and related activities for the Mekedatu Site.

1.9.10 Judgement of Hon'ble Supreme Court on the Civil Appeal 2453 of 2007

Hon'ble Supreme Court of India passed a Judgement on the Civil Appeal 2453 of 2007 on the Cauvery River Dispute on 15/02/2018.

The jist of final decision of the Hon'ble Supreme Court is indicated below.

X.10 Revised Water Allocation amongst competing States

Sub Point 396 Page 447 states:

"The river Cauvery originates in Karnataka and eventually after its full flow through the other vriparian States of the basin assimilates in the bay of Bengal. With the evolution of the principle of equitable apporioment which is really to ensure equal justice to the basin States, the concept of prescriptive right or right to the natural flow of any inter-state river has ceased to exist. Having regard to the historical facts which demonstrate the constraints suffered by Karnataka resulting in its limited access and use of the surface flow of cauvery in spite of being the upper riparian state, compared to Tamil Nadu, then madras presidency, as well as severally drought conditions in its 28 districts/ taluks, **we are inclined to award an additional 14.75 TMC in all, i.e., 10 TMC (on account of availability of ground water in Tamil Nadu) + 4.75 TMC (for drinking and domestic purposes including such need for the whole city of Bengaluru).** On these considerations, we consider Karnataka to be more deserving amongst the competing States to be entitled thereto. Out of this, 14.75 TMC would be deducted from the quantum allocated by the Tribunal in favour of tamil nadu. In other words, the final allocation of the shares in view of this determination would be as hereunder:

Table 1.4:Allocation of water as per CWDT Award

No	Share of the waters	Quantity in TMC
7.	**Karnataka**	**284.75 TMC (270 + 14.75)**
8.	Tamil Nadu	404.25 TMC (419 - 14.75)
9.	Kerala	30.00
10.	UT of Puduchery	7.00
11.	Environmental Protection	10.00
12.	Inevitable escapages into the Sea	4.00
	Total	**740.00**

Sub Point 397 Page 449 states:

"As a consequence of the aforesaid allocation, the State of Karnataka would now be required to make available at the inter-state border with Tamil Nadu, i.e., at Biligundlu, 177.25 TMC of water for the basin. Apart from the modifications effected hereinabove, no interference with the dermination and findings recorded by the Tribunal, in view of the scrutiny of the available materials on record, is called for".

Sub Point 400 states,

"In view of the reduction in the quantum of water, now required to be released by Karnataka at the Inter-state border with Tamil nadu, i.e., at Biligundlu, there would be logically a proportionate decrese in the monthly releases as worked out by the Tribunal. However, the same pattern therefor, as modified by it would be maintained for reduced releases.

Accordingly, the monthly release table for the reduced releases are worked out shown in **Table 1.5**.

Table 1.5: Month wise realeases to Tamil Nadu as per the recent Judgement of Hon'ble Supreme Court of India

Month	TMC	Month	TMC
June	9.18	December	7.35
July	31.25	January	2.75
August	45.95	February	2.50
September	36.76	March	2.50
October	20.22	April	2.50
November	13.79	May	2.50

1.10 Choice of project

Alternative studies carried out for various major components of the project and including water resources planning and final choice of project

Consequent to several studies carried out as explained in para 1.9.1 and also after evaluating the relative merits and demerits, It was finally decided to select the location for the construction of the dam approximately 2 kms ("C" Site) downstream of confluence of Cauvery and Arkavathi River. Further studies have been carried out in order to arrive at the height of the dam including fixing the FRL and MWL for the Resevoir the details of which is narrated below:

Option 1: High dam with a FRL of EL 478.00 m.

The river bed (foundation grade level) of the dam site is at EL 350.00 m and the corresponding height of the dam is estimated as 139 m. The extent of submergence is about 10,000 Ha and the storage capacity is 180 TMC.

Option 2: High-dam with a FRL of EL 440.00 m

The river bed (foundation grade level) of the dam site is at EL 350.00 m with the deepest foundation being at RL 341.00 m and the corresponding height of the dam is estimated as 99 m. The extent of submergence is about 4996.0 Ha and the storage capacity is 67.16 TMC.

Considering the vast submergence of the forest and other lands and also its related impacts, Government of Karnataka during 1995 decided to restrict the FRL of the proposed Mekedatu Dam to EL 440.00 m and consider the proposal for implementation.

1.10.1 Recommendation of the Proposal by the Advisory Sub-committee to the GoK

The Government of Karnataka accepted the following proposal for implemenatation.

Construction of Mekedatu dam with FRL at EL 440 m (with a flexibility of 5 m on either side and storage capacity of 67.16 TMC) with an installed capacity of 180 MW in the first stage and another 180 MW in the ultimate stage with an annual energy generation of 486 MU initially and 635 MU ultimately.

1.10.2 Detailed Feasibility Report

As per the latest guidelines of CWC New Delhi, it is mandatory to submit a feasibility report covering detais of the project along with other details required for giving approval to submission of DPR.

GoK submitted Detailed Feasibility report in respect of Mekedatu balancing resourvoir cum drinking water project to CWC for obtaining in principle approval.

CWC, vide letter dated 22.11.2018 directed GoK to go ahead with the preparation of DPR (attaching suggections/observatoions of different directorates) with specific remarks that the report has to be discussed in Cauvery Water Management Authority and also obtain approval from CEA for power components in the project.

1.10.3 Present Proposal

The various proposals studied and narrated above were considered before the CWDT award and hence, it was essential to honor the decisions of the CWDT in toto to take up the implementation of the Projects accordingly. This necessitated preparation of fresh DPR which will cover the decisions of the CWDT and also the latest guidelines of the CWC which is in vogue. The Judgement of the Hon'ble Supreme Court of India dated 16/02/2018 has further necessitated preparation od DPR as per modified allocation among the riparian States.

Accordingly, this proposal envisages Construction of Concrete Gravity Dam at 'C' Site (as finalized by KPC) with a FRL of EL 440.00 m having a storage capacity of 67.16 TMC. The installed capacity has been kept as 400 MW (3x120 MW + 1x40 MW).

1.10.4 Justification for taking up the Mekedatu Balancing Reservoir cum Drinking Water project by Karnataka

The proposal of GoK to take up Mekedatu Balancing Reservoir cum Drinking Water project can be justified by the following.

- ✓ Regarding the Hydro-Electric Schemes the Tribunal has stated in Clause XIII of final decision dt: 5th February 2007 as follows:

  "*The State of Karnataka and Tamil Nadu brought to our notice that a few Hydro-Electric Power Projects in the common reach boundary are being negotiated with the National Hydro-Power corporation (NHPC). In this connection, we have only to observe that whenever any such hydro-power project is constructed and Cauvery waters are stored in the reservoir, the pattern of downstream releases should be consistent with our order so that the irrigation requirements are not jeopardized.*"

- ✓ The Tribunal, in its award has clearly stated that "**Nothing in the order of this Tribunal shall impair the right or power or authority of any State to regulate within its boundaries the use of water, or to enjoy the benefit of waters within the State in a manner not inconsistent with the order of this Tribunal".**

- ✓ This means, Karnataka can plan and build Mekedatu Balancing Reservoir cum Drinking Water Project since it is located well within its boundary and with the Primary Objective that the releases as per the allocated share of water to Tamil Nadu (in a normal year) is ensured besides taking care of the drinking water needs of Bengaluru and its surrounding areas. **This will be consistent with the order of the Tribunal.**

- ✓ As per the Cauvery Disputes Tribunal, "**any delay in the advent of monsoon would affect the inflows and consequently dislocate the schedule of releases from Krishnaraja Sagara & Kabini Reservoirs, the Tribunal felt it to be advisable that at the end of May each year, as much storage as was possible during a good year should be consciously conserved as that would help in adhering to the schedule of monthly deliveries".**

- ✓ If Karnataka has to meet these objectives, then it becomes necessary to plan a reservoir with sufficient storage capacity. This is inevitable considering the fact that both KRS & Kabini do not have the capability to hold excess water in times of good monsoon.
- ✓ As per the study that has been carried out and also the recommendation of the earlier Committee set up by the Government of Karnataka, it has been decided to restrict the FRL of the proposed Balancing Reservoir to RL 440.00 meters.
- ✓ Further, the need for conserving water to ensure environmental releases (2.50 TMC every month from February to May of every year) is also considered while fixing the capacity of the proposed reservoir due to the following reasons.
    - ➢ During the period from February to May, flow in the River will be either very lean or nil flow and hence releases have to be from KRS or Kabini.
    - ➢ The distance between KRS /Kabini to Biligundlu is about 130 km and 175 km respectively, which in effect means the water let out from either of the dams have to travel a long distance when the river is in a dry condition.
    - ➢ To ensure that 10 TMC water reaches Biligundlu in the months indicated above, it is necessary to release a little more than 10 TMC of water from KRS /Kabini.
    - ➢ Kabini being a small dam with limited capacity cannot be relied upon for releases. Hence, it becomes necessary to release a little more than 10 TMC of water from KRS itself in order to meet the specified quantum of releases to Tamil Nadu during these months.

Clause XXVIII of the final order of the Tribunal states thus,

"Nothing in the order of this Tribunal shall impair the right or power or authority of any State to regulate within its boundaries the use of water or to enjoy the benefit of water within that State in a manner not inconsistent with the order of this Tribunal".

As per the above order of CWDT, the water flowing in a State can be regulated within its boundaries for using it and enjoying the benefit of the same. Karnataka, by building Mekedatu balancing reservoir cum drinking water project would not only be ensuring releases effected to as per the order (both by CWDT and Hon'ble Supreme Court), but at the same time is entitled to utilize this 60.45 TMC of water by way of storage in the proposed project since it will be within the allocated share of water as per CWDT Award and modified by the Hon'ble Supreme Court.

Sub point No 391 of the order of the Hon'ble Supreme Court of India states thus

"At this juncture, we need to recount that as per the National Water Policy, not only drinking water has been placed at the top of the other requirements in the order of priority but it has also been predicated that adequate drinking water facilities should be provided for the entire population, both in urban and rural areas and that drinking water should be made a primary consideration. It was declared as well that drinking water needs of Human being and animals should be the first charge on any available water".

In view of the above challenges and need to address the ever growing drinking water demand of Bengaluru Metropolitian Region including surrounding areas besides meeting the releases to downstream riparian States, construction of Balancing Reservoir is inevitable.

1.10.5 Reservoir Capacity Determination

The storage requirement of Mekedatu Reservoir is arrived at on the following considerations.

- ✓ In the months of June and July, the past data shows that there is a shortfall of 5 TMC and 8 TMC respectively in the water to be released to Tamil Nadu as per the obligation (as computed in the working tables enclosed as Annexure-IV, Hydrology report). This 13 TMC has to be accommodated in the Mekedatu Balancing Reservoir Cum Drinking Water Project.
- ✓ The obligatory environment flow of 10 TMC to be released from February to May (summer months) has to be stored in the Reservoir.
- ✓ Utilizing additional 4.75 TMC of water (Consumptive use) to provide drinking water facility to Bengaluru metropolitan region, its adjoining area etc as per the CWDT award, further modified by the Hon'ble Supreme Court of India vide its Judgement dated 16.02.2018, by way of proposing a scheme to tap water from the foreshore of the intended Mekedatu Balancing Reservoir cum Drinking water project amounting to 23.75 TMC. This allocation is based on the 2011 census data of population. As at present (between 2011 and 2018), the city has witnessed further growth of nearly 28 %.
- ✓ As per CPHEEO guidelines, the drinking water requirement of Bangalore Metropolitan Region will be 64.0 TMC as per projected requirement for the year 2044. Drinking water is a fundamental right under the Constitution and it gets the highest priority as per National Water Policy. Presently, 14.52 TMC is being drawn from Netkal balancing Reservoir (vide para 13, page 101-102, Volume-5 of CWDT report~~.~~ Hence the amount of water to be stored to meet Bangalore Metropolitan Region drinking water requirement will be 49.48 TMC i.e., (64 TMC – 14.52 TMC). Two-Thirds of this namely 33.15 TMC will be required as storage. Since the height of the dam cannot be increased as

and when needed (as per the then requirement), it is prudent to plan for this additional storage to be provided in the present proposal of the Mekedatu Balancing Reservoir cum Drinking Water Project itself.

- ✓ Allowing for evaporation losses and sedimentation, a provision of 3.85 TMC is considered in the storage.

Thus the total live storage required at Mekedatu Reservoir is 13+10+33.15+3.85 = 60.00 TMC.

The gross storage of the reservoir is 67.16 TMC and the dead storage is 7.7 TMC. Hence the live storage available will be 59.46 TMC which almost matches with the required storage of 60 TMC. The intake structure on the foreshore of the Mekedatu reservoir shall be designed to meet this ultimate requirement

1.10.6 Stages / Phases of development of project

The present Project is proposed to be implemented in a single Stage of 4 working seasons scheduled from September 2020 after a mobilisation period of 3-4 months prior to construction activity and completed by June 2024.

1.11 Fitment of the scheme in overall development of River Basin

The allocation of water in Cauvery basin is based on 50% dependable yield. This can be ensured only if sufficient storage is available in the basin. The present project with a storage of 67.16 TMC will help meeting the intended objective and ensuring specified releases to Tamil Nadu as per the CWDT award further modified by the Hon'ble Supreme Court of India vide its Judegement dated 16/02/2018. The additional allocation of 4.75 TMC made for drinking water supply to Bengaluru Metropolitan Region, its surrounding areas by the Supreme Court of India can also be met with.

Under the present proposal, it is envisaged to build a balancing reservoir which will aid Karnataka to achieve its objectives in the following ways:

- ✓ Utilizing additional 4.75 TMC of water to provide drinking water facility to Bengaluru Metropolitan Region, its adjoining area etc by way of proposing a scheme to tap water from the foreshore of the intended Mekedatu Balancing Reservoir cum Drinking water project.
- ✓ To regulate the required quantum of water to Tamil Nadu on a monthly basis (in a normal year) as per the CWDT award, as modified by the Hon'ble Supreme Court of India vide its Judgement dated 16.02.2018. It is further proposed to store the flood waters otherwise escaping to sea as it happened in the monsoon of 2018.

- ✓ Harnessing nearly 400 MW (650.28 MU of renewable energy annually @90 % dependable year) of renewable energy annually by utilizing the fall in the natural bed profile of the Cauvery River upto the state border from the monthly releases effected to (in a normal year) as per the modified award (by the Hon'ble Supreme Court of India vide its Judgement dated 16.02.2018.)

With the project being planned at the end of the Cauvery river course within Karnataka State Border,the existing or proposed system of planning would not get affected and the proposed scheme could be easily fitted to the present environment.

The quantum of water so proposed to be stored shall be during the monsoon months from June to October and all efforts will be made to protect the downstream commitments which is precisely what the project would achieve on implementation. Eventhough, as a part of the submission to CWDT, Chamarajasagar Reservoir and Hesaraghatta were identified as additional resources to provide drinking water supply to Bengaluru and surrounding areas, it has to be reiterated that both these lakes have almost become dry and are not in a position to supply the intended quantum of drinking water.

Hence, it is now indicated that there is no alternative source of water supply to meet the additional demand of drinking water supply to Bangalore Metropolitan Region and its surrounding areas.

Hon'ble Supreme Court of India, in its Judgement on Civil Appeal 2453 of 2007 has allocated additional 14.75 TMC of water to the State of Karnataka. Out of this allocation, 4.75 TMC of water is specified to be utilized for drinking water requirement of Bengaluru Metropolitan Region, its surrounding areas etc in the Cauvery Basin.

While meeting the demands of the releases to Tamilnadu at Biligundlu and the drinking water needs as indicated above, there is a possibility of generating substantial quantum of power. This is due to the available elevation difference between the FRL of the reservoir and the river bed drop between the proposed site and the State border. This elevation difference could be effectively utilized for generating the power from obligatory releases to be made downstream of the reservoir.

This development would surely be a welcome proposition and is expected to aid industrial growth as well fitting this scheme in the overall development of Cauvery River Basin is quite affirmative.

1.12 Intimation to other developmental authorities

All the other departments concerned like WRDO, MI, KPC, KPTCL, RDPR, BWSSB, KUWS & DB, Zilla Panchayats, Forest etc have been intimated regarding the proposed Project.

1.13 Public announcements & Public hearings

As a part of the EIA, EMP, SIA and R & R, Public announcements and Public hearings shall be conducted.

1.14 Interlinking of the scheme with neighbouring schemes

The present proposal envisages constructing a balancing reservoir to take care of the regulating discharges during every month of the year including catering to the drinking water requirement as indicated above.

1.15 Interstate / International aspects

Details enumerated in a separate Chapter on Interstate / International aspects.

1.16 Cost & benefit of the scheme

- The Cost of the project works out to **Rs. 9000.00 Crores** as per Schedule of rate 2018-19.
- Project will provide drinking water to nearly 100 lakh people (135 lpcd).
- Generate power of 650.28 MU (400 MW) annually by utilizing the elevation difference (in the bed level between the project site and the State border) out of the releases effected to as per the CWDT Award further modified by the Hon’ble Supreme court of India dated 16/02/2018.

1.17 Public co-operation & participation

The affected people in project area will have both direct and indirect benefits since the implementation of project will address major issues such as drinking water shortages, drought besides energy requirements. The project will generate employment, tourism in the area, besides aiding in considerable improvement in the underground water table around the reservoir rim. During the project implementation, the project authorities will take into confidence the project affected people in terms of bringing awareness before proceeding with the activities of the project. All the efforts will be made to rehabilitate the affected people if any to the possible extent and as per prevelant norms issued by the Government Authorities.

1.18 Provision for Domestic & Industrial water supply

As indicated above, it is envisaged to provide drinking water equirements of Bengaluru Metropolitan Region, its surrounding areas etc in the basin within Karnataka.

The groundwater condition is expected to improve considerably which may facilitate augmenting drinking water supply of the Bangalore region.

Chapter 2
Physical features

2.1 Geographical disposition

The proposed Mekedatu project is located at Latitude 12° 16´ 20° N and Longitude 77° 26´ 25˝ E in Muguru and Mekedatu villages, Kanakapura and Kollegal taluks of Ramanagara and Chamarajanagar districts, Karnataka.

2.2 Topography of the Basin

The Cauvery basin is bounded on the north by the ridges separating it from Krishna and Pennar basins, and the basin area covered by the streams between Palar and Cauvery on the south and by the Eastern Ghats on the east and by Western Ghats on the west. The upper reach of the basin is covered with hill ranges of the Western Ghats and the basin area are broad and open with gently undulating country. In the north – west and south, there are a number of hill ranges which have steep slopes. The maximum length of Cauvery basin Catchment from west to east is upto the sea is 800 km. The maximum width from north to south is 255 km.

2.3 Geology of the basin and reservoir

2.3.1 Geology of the basin

The geology of the drainage basin is predominantly formed from Precambrian rocks, principally the Dharwars, Peninsular Granitic Gneiss, Charnockites and the Closepet Granite. The Dharwar metamorphics mainly comprise of phyllites, slates, schists with chlorite, biotite, garnet, and hornblende. Accompanying these are greenstones and quartzite. The Closepet Granite of the upper reaches of the Cauvery basin is a pink granite consisting mainly of quartz, plagioclase, microcline, perthite, and subordinate hornblende. Over the main basin, the peninsular granites and gneisses comprising of biotite granitic gneiss, hornblende granitic gneiss are widely found. The Charnockites are confined to the Nilgiri Range in the central part of the drainage basin. These are represented by gabbros, olivine norites, and pyroxene. Cretaceous sediments crop out in the coastal region and consist of conglomeratic sandstone, coralline limestone, and shale.

2.3.2 Geology of the balancing reservoir site

Granite Gneisses form the major rock type in the project site. These pink/grey rocks are banded and foliated, They are often massive, fine to medium grained but cut irregularly by close joints and fracture zones. The foliation strikes N-S to NW-SE running almost parallel to the river flow at the site, exhibiting westerly dips ranging from 35° to 65°. The prominent joint sets are;

1) N 60°E -S 60° W, dipping 80°-85° NW, closely spaced.

2) N 55°W-S 55° E, dipping 80° -85° NE, widely spaced.

3) N-S, dipping 15° E, widely spaced.

2.3.3 River system and Basin Characteristics

River Cauvery is physically perhaps the most remarkable river of the Peninsular India (Spate et al., 1972). The Cauvery rises in the Brahmagiri range of the Western Ghats in Coorg district of Karnataka at an elevation of 1341 m. Its basin is located between the latitudes 10° 7' N and 13° 28' N and longitudes 75° 28' E and 79° 52' E.

Cauvery has a drainage area of 81,155 sq.kms of which Kerala has 3.53%, Karnataka 42.25% and Tamilnadu 54.24% (Rao,1975). The basin lies roughly in a NW-SE direction. This SE trend of the Cauvery river is due to the uplift of the Western Ghats and slight tilt of the Peninsular Indian mass to the east during the Miocene age (Krishnan, 1981). The River Cauvery flows for about 800 kms and breaks into innumerable small branches before emptying into the Bay of Bengal.

The river Cauvery flowing south-east has its flow across the foliation direction of rocks. Hence, dendritic pattern of drainage is very well noticed in the river basin. Furthermore, the long profile of the river Cauvery through terraces and knick points clearly indicate the possible uplift and erosion in the geological past (Paramasivam, 1968)

The tributaries of the river Cauvery include Harangi, Hemavathi, Shimsha, Arkavathi, Lakshman Thirtha, Kabini and Suvarnavati in Karnataka and Bhavani, Noyyal and Amaravathy in Tamilnadu.

The Cauvery basin extends over an area of 81155 km^2, which is nearly 2.5% of total geographical area of the country. The basin area of the river Cauvery lies in the States of Kerala, Karnataka and Tamil Nadu and the Union Territory of Pondicherry.

2.3.3.1 Rainfall

The western side of the catchment mainly experiences the south-west monsoon from June to September and the eastern side the north – east monsoon from October to December. The rainfall during the non-monsoon period is not significant. The annual rainfall over the catchment varies from 574mm to 5411 mm.

2.3.3.2 Temperature

The climate of the catchment remains dry except in the monsoon months. The mean daily maximum temperature in the basin varies from 19.5°C to 33.7°C and the mean daily minimum temperature varies from 9.1°C to 25.2°C.

2.3.3.3 Relative Humidity

The mean relative humidity is high during the monsoon period and comparatively low during the post-monsoon period. In summer the weather is dry and the humidity is low. The relative humidity in the basin ranges from 49% to 86 %.

2.3.3.4 Wind Speed

Winds blow mainly from the directions between the south – west and north – west during the south – west monsoon season. In the post monsoon season, wind blows mainly in the north easterly or easterly direction. During the rest of the year, wind blows from the direction between north and east. The mean wind speed in the basin varies from 5.4 km/hr to 18.9 km/hr.

2.3.3.5 Cloud Cover

Sky is generally heavily clouded during the monsoon season. During the post-monsoon months, extent of cloudiness decreases. During the rest of the year, the sky is clear or lightly clouded. The cloud cover in the basin varies from 4.1 to 5.3 oktas.

Chapter 3
Interstate aspects

3.1 States traversed by Cauvery River

The Cauvery River, is an inter-State river which originates in the State of Karnataka and falls into Bay of Bengal in Tamil Nadu. The catchment area of the basin lies in the States of Karnataka, Kerala, Tamil Nadu and Pondicherry. Cauvery traverses from West to East for a length of about 800 km through Karnataka and Tamil Nadu.

River Cauvery after originating traverses in Karnataka for a length of 320 km before entering Tamil Nadu with a common boundary of 64k. It passes through Tamil Nadu for a length of 357 km before draining in to the Bay of Bengal.

Source: *Water Atlas of India*

3.2 Distribution of Catchment in the States and yields from the catchment of the States

The total catchment area of Cauvery basin is 81,155 Sq. km and the distribution of the same in the basin states is as indicated in **Table 3.1**

Table 3.1: Catchment area of states in Cauvery Basin

No.	Name of the basin state	Catchment area in (Sq. km)
1	Karnataka	34,273
2	Kerala	2,866
3	Tamil Nadu	43,868
4	Puducherry	148
		81,155

3.3 Award of Cauvery Water Dispute Tribunal

The Cauvery Fact Finding Committee (CFFC), constituted in 1972, utilized flow data of all the available gauge discharge sites as well as the utilization under the various irrigation systems in the Tamil Nadu and Karnataka and worked out the yield at Krishnarajasagar, Mettur and Lower Coleroon Anicut (LCA).

The Committee has estimated the yield at 50%, 75% and 90% dependability at three salient points of the river. Refer **Table 3.2.** Since there are reservoirs at Krishnarajasagar and Mettur, they decided that the yield figures would be of high degree of reliability if assessed at these points.

The Committee also arrived at the yield of the Cauvery basin at LCA as about 670 TMC at 75% dependability basis and as about 740 TMC at 50% dependability basis.

Table 3.2: Yield in the Cauvery basin

Description	50% dependable yield (TMC)	75% dependable yield (TMC)	90% dependable yield (TMC)
KRS	219.4	187.8	167.6
Mettur	507.8	451.4	414.2
Lower Coleroon anicut	740	670	623

The area permitted and the quantum of water as apportioned by the Tribunal is indicated in **Table 3.3.**

Table 3.3: Area permitted and the quantum of water as apportioned by the Tribunal

No.	Description	States				Total
		Kerala	Karnataka	Tamil Nadu	UT of Puducherry	
I.	Area (lakh acres)	1.93	18.85	24.71	0.43	**45.92**
II.	Irrigation requirement (TMC)	27.9	250.62	390.85	6.35	**675.72**
III.	Domestic & Industrial water requirement projected for 2011 (TMC)	0.35	1.85	2.73	0.27	**5.2**
IV.	Water requirement for environmental protection (TMC)	-	-	-	-	**10**
V.	Inevitable escapes into sea (TMC)	-	-	-	-	**4**
VI.	Share in balance water (based on population) (TMC)	1.51	17.64	25.71	0.22	**45.08**
	Total	29.76	270.11	419.29	6.84	**740**
	Say	30	270	419	7	**726+14** **740**

The Tribunal has ordered the tentative monthly deliveries during a normal year to be made available by the State of Karnataka at the Inter-State contact point presently identified as Biligundlu gauge and discharge station located on the common border as 192 TMC, but however a choice of any other contact point between Biligundlu and Mettur in the common reach has been clearly given, which has been split up into a monthly pattern. Refer **Table 3.4.**

Table 3.4: Details of Yield and quantum of water to be made available by Karnataka.

No	Description	TMC
1.	Total yield of the basin at 50% dependability.(CFFC)	740
2.	Yield at Mettur reservoir (CFFC)	508
3.	Yield generated in Tamil Nadu area above Mettur reservoir and below Biligundlu	25

No	Description			TMC
	(a) Yield available below Mettur (740 - 508)			232
	(b) Deducting following uses:			
	(i)	Allocation to Kerala in Bhavani sub basin	6	20
	(ii)	(Amaravathy) Pambar sub basin	3	
	(iii)	Allocation to UT of Puducherry	7	
	(iv)	Inevitable escapades' into sea	4	
			20	
	(c) Balance available for use in Tamil Nadu (232-20)			212
4.	Total water available for use in Tamil Nadu (212 + 25)			237
5.	Allocated share of Tamil Nadu			419
6.	Balance to be made available at the Interstate contact point (419 - 237)			182
7.	Allocation for environmental protection to be made available at that point			10
8.	Total delivery to be made at the Interstate border (182 + 10)			**192**

The Tribunal, in its unanimous decision in 2007, determined the total availability of water in the Cauvery basin at 740 thousand million cubic (TMC) feet at the Lower Coleroon Anicut site, including 14 TMC (10 TMC for environmental protection + 4 TMC for Inevitable escapages in to the sea) for environmental protection and escapages into the sea. The final award makes an annual allocation of 419 TMC to Tamil Nadu in the entire Cauvery basin, 270 TMC to Karnataka, 30 TMC to Kerala and 7 TMC to Puducherry.

The final award of the Cauvery Water Disputes Tribunal (CWDT) notified by the Centre on 19.02.2013 has settled the definition of a normal year and irrigation season which has been the bone of contention between Karnataka and Tamil Nadu.

A "normal year" shall mean a year in which the total yield of the Cauvery basin is 740 TMC. A "water year" shall mean a year commencing on June 1 and ending on May 31 and the "irrigation season" shall mean the season beginning on June 1 and ending on January 31 of the next year.

In a normal year, Karnataka has to make available to Tamil Nadu at Biligundlu 192 TMC on monthly basis. This comprises of 182 TMC towards the allocated share of Tamil Nadu, in addition to 10 TMC for environmental purposes. In a distress year, the allocated shares shall be proportionately reduced among the States of Kerala, Karnataka, Tamil Nadu and Puducherry.

The Cauvery includes the main river, all its tributaries and all other streams contributing water directly or indirectly to it. The award authorizes the Board/Authority to monitor the monthly releases with the help of the States concerned and the Central Water Commission for five years. Thereafter, if any modification/adjustment is needed in the schedule, it may be worked out in consultation with the party-States and help of the CWC “without changing the annual allocation amongst the parties”.

3.4 Judgement of Hon’ble Supreme Court of India – Civil Appeal No 2453 0f 2007

In the Hon’ble Supreme Court of India, a Civil Appeal no 2453 of 2007 was filed against the verdict of the Cauvery Water Disputes Tribunal. After hearing the case, the Hon’ble Supreme Court on 16/02/2018 gave its judgement.

In the wake of the judgement of Supreme Court on the pleadings of the States concerned, the following reference need to be considered as of paramount importance as far as implementation of **Mekedatu Balancing Reservoir & Drinking Water Project** is concerned.

In Point no 11 - Final Water Allocation amongst States and further under Point no 12 – Monthly Schedule for delivery of water at Inter State Contact points, Sub Point no 287, Page 331, the Supreme court on delivering of 177.25 TMC by the State of Karnataka to Tamil Nadu at the inter-state border states:

“In this regard, the three components contributing to the annual quantum of water to be delivered by the State of Karntaka at the inter-state contact point were identified as herein below:

- Flows coming in the River Cauvery from the uncontrolled catchment of Kabini sub-basin downstream of the Kabini Reservoir, the catchment of main stream of Cauvery river below Krishnarajasagara, uncontrolled flows from Shimsha, Arkavathy and Suvarnavathy sub-basins and various other small streams
- Regulated releases from Kabini Reservoir; and
- Regulated releases from Krishnarajasagara reservoir.”

Sub point no 289, Page 333 & continued in Page 334, the Supreme court states thus:

“It was also made clear that in case the yield was less in a distress year, the allocated shares would be proportionately reduced amongst the States involved by the Regulatory Authority. Having regard to the fact that the irrigation season starts form 1st of June and the normal date of onset of South West monsoon in Kerala is of the same date so much so that any delay in the advent of monsoon would affect the inflows and consequently dislocate the schedule of releases from Krishnaraja Sagara & Kabini Reservoirs, **the Tribunal felt it to be advisable that at the end of May each year, as much storage as was possible**

during a good year should be consciously conserved as that would help in adhering to the schedule of monthly deliveries".

This is precisely the intention of proposing the Mekedau Balancing Reservoir cum Drinking Water project by Karnataka.

The Supreme Court has also dwelt in detail the different Clauses of the Final order and decision of the Cauvery Tribunal.

Reference to Clause XVIII is of relevance to be quoted here states thus:

"Nothing in the order of this tribunal shall impair the right or power or authority of any State to regulate within its boundaries the use of water, or to enjoy the benefit of waters within the State in a manner not inconsistent with the order of this tribunal"

Regarding the drinking water requirement of Karnataka particularly with reference to Bangalore, The Hon'ble Supreme Court vide **Page no 441, Sub point no 390, states thus**:

"Apart form the fact that there is no basis wahatsoever for the tribunal fo having quantified the water requirement for urban population to be 8.70 TMC as well as for rural population to be 8.52 TMC, its assumption that 50 % thereof would be met from ground water only in view of its perception that wells and tube wells in urban and rural areas cater to the substantial requirement of drinking water, in our view, is unacceptable and cannot be sustained. That apart, in the context of Benagaluru City, especially in view of the growth and rise of population in space and time, the Tribunal's approach of confining the entitlement of its population in general to only 1/3rd of their requirement only in view of the location of 1/3rd of its physical entity within the Cauvery Basin demands scrutiny.True it is, the concept of a basin and the beneficial uses of the water thereof ought to be traced generally to the sites and population tgereof located in the basin, nevertheless, the principles of apportionment and the conception of reasonable and equitable share perceived for such uses comprehend a basin State addressing the social and economic needs of its community as a whole. **Territorial or geographical demarcation for extension of beneficial uses of an inter-state river basin cannot always be strictly construed**."

Further continue to state thus:

"We are inclined to think so as the perception of a basin State inheres in it a degree of flexibility in approach in a unique fact situation to justify a warrantable flexibility and departure from such rigoristic approach. We are disposed to think so, for the city of Bengaluru, as an evident phenomenon, has burgeoned over the years and has grown today into a progressively sophisticated, sprawling, vibrant and a much aspired seat of intellectual excellence particularly in information technology and commercial flourish. It has transformed into a nerve centre of contemporaneous significance and its population is daily on the rise, thus registering an ever enhancing demand for all civic amenities. Having regard to its exclusive attributes, it is incomparable in many ways not only to other urban areas in the State, but also beyond. The requirements of its dependent population as a whole for drinking and other domestic purposes, therefore, cannot justifiably, in the prevailing circumstances, be truncated to their prejudice only for consideration of its physical location in the context of the river basin, We think so since the city of Bengaluru cannot be segregated having an extricable composition and integrated whole for the purposes of the requiremets of its inhabitants, more particularly when the same relates to allocation of water for domestic purposes to meet their daily errands. **It will be inconceivable to have an artificial boundary and deny the population the primary need of drinking water. We hold so in the special features of the case keeping in view the global status the city has attained and further appreciating the doctrine of equitable proportionality on the bedrock of pressing huan needs."**

Sub point no 391 states thus:

" At this juncture, we need to recount that as per the National Water Policies, not only drinking water has been placed at the top of the other requirements in the order of priority, but it has also been predicated that adequate drinking water facilities should be provided for the entire population, both in urban and rural areas and that drinking water should be made a primary consideration. It was declared as well that drinking water needs of human beings and animals should be the first charge on any available water. Article 14 of the Berlin rules also mandates that in determining and equitable and reasonable use, the States shall first allocate water to satisfy vital human needs".

Sub Point 392 states thus;

"In view of the above, we are constrained to observe that the approach of the tribunal cannot be approved in the facts and circumstances indictaed hereinabove. We are, thus, of the considered opinion that the allocation of water for drinking and domestic purposes for entire city of Bengaluru has to be accounted for. Noticeably, Karnataka had claimed 14.52 TMC, i.e., 6.52 TMC for existing water schemes for Bengaluru and 8.00 TMC for the ongoing drinking water schemes for the city as in June ,1990. It had demanded 30 TMC as drinking water requirement for the city with the projection of 2025. Having regard to the percentage of decennial growth, as has been adopted by the Tribunal, in 2011, the demand of Karnataka for drinking water requirement for Bengaluru Metropolitan Region would be in the vicinity of 24 TMC. Even excluding the computation for urban population of the State to be 8.70 TMC as arrived at by the Tribunal and that too without any basis and accepting the water requirement of rural population to be 8.52 TMC though also without any basis, the total figure representing drinking and domestic water requirement of the urban and rural population would be 32.50 TMC rounded upto 33 TMC in comparison to 46 TMC as claimed by Karnataka in its statement. Having rejected the assumption that 50 % of the drinking water would be met from ground water, this 33 TMC would, in our estimate, be a safe and acceptable figure qua drinking water requirement of the State of Karnataka for its urban and rural population. **By applying the consumptive percentage of 20 %, the volume of water to be allocated to Karnataka on this count would be 6.50 TMC in lieu of 1.75 TMC awarded by the Tribunal, i.e., an increase by 4.75 TMC".**

Sub Point No 393 states thus:

" Qua the view against transbasin diversion, suffice it to state that not only in the context of Bengaluru Metropolitan Region, for the reasons cited herein above, a digression from the confines of the concept of in-river basin would be justified, since the **National Water Policy of 1987, in categorical terms, enjoined that water should be made available to water short areas by transfer from other areas including transfers from one river basin to another.** This very conspicuously emphasizes on an inclusive comprehension and in a deserving case like Bengaluru Metropolitan Region, it would not be incompatible with the letter and spirit of the factors that ought to inform the determinarion of reasonable and equitable share of water in an inter state river as well as of the National policies formulated for planning and development of the precious natural resource involved".

Futher while revising the allocation amongst competing States, Hon'ble Supreme Court vide point X.10, **Sub point 396, Page 447 states thus:**

"The river Cauvery originates in Karnataka and eventually after its full flow through the other riparian States of the basin assimilates in the bay of Bengal. With the evolution of the principle of equitable apporioment which is really to ensure equal justice to the basin States, the concept of prescriptive right or right to the natural flow of any inter-state river has ceased to exist. Having regard to the historical facts which demonstrate the constraints suffered by Karnataka resulting in its limited access and use of the surface flow of cauvery in spite of being the upper riparian state, compared to Tamil Nadu, then madras presidency, as well as severally drought conditions in its 28 districts/ taluks, **we are inclined to award an additional 14.75 TMC in all, i.e., 10 TMC (on account of availability of ground water in Tamil Nadu) + 4.75 TMC (for drinking and domestic purposes including such need for the whole city of Bengaluru).** On these considerations, we consider Karnataka to be more deserving amongst the competing States to be entitled thereto. Out of this, 14.75 TMC would be deducted from the quantum allocated by the Tribunal in favour of tamil nadu. In other words, the final allocation of the shares in view of this determination would be as hereunder,

Table 3.5:Allocation of water as per CWDT Award

No	Share of the waters	Quantity in TMC
13.	**Karnataka**	**284.75 TMC (270 + 14.75)**
14.	Tamil Nadu	404.25 TMC (419 - 14.75)
15.	Kerala	30.00
16.	UT of Puduchery	7.00
17.	Environmental Protection	10.00
18.	Inevitable escapages into the Sea	4.00
	Total	**740.00**

Sub Point 397 states thus

“As a consequence of the aforesaid allocation, the State of Karnataka would now be required to make available at the inter-state border with Tamil Nadu, i.e., at Biligundlu, **177.25 TMC** of water for the basin. Apart from the modifications effected hereinabove, no interference with the dermination and findings recorded by the Tribunal, in view of the scrutiny of the available materials on record, is called for**”.**

Sub Point 400 states thus

“In view of the reduction in the quantum of water, now required to be released by Karnataka at the inter-state border with Tamil, Nadu, i.e., at Bligundlu, there would be logically, a proportionate decrese in the monthly releases as worked out by the Tribunal. However, the same pattern therefor, as modified by it would be maintained for the reduced releases.

Sub Point 404 (vii), Page 460 states thus

“This court in ***In Re: Presidential reference (Cauvery Water Disputes tribunal)*** has held that waters of an inter-state river passing through corridors of the riparian States constitute a **National Asset and no single State can claim exclusive ownership of its water.** In this context, the principle of equitable apportionment internationally recognized by the Helsinki Rules, Camione rules and Berlin Rules which have also been incorporated in the 1987 to 2002 national Water policies, have been regarded to be the guiding factor for resolving disptes qua apportionment of water of an inter-state river.

“It is obligatory to clearly state that in view of the acute scarcity of the water resources and the intensely contested claims of the States, it is expected that the allocations hereby made would be utilized for the purposes earmarked and accepted and no deviancy is shown in carrying out the verdict of this court”.

3.5 Existing riparian use and Quantum of water utilized

Refer section 3.3 above.

3.6 Operation and regulation of the project

The present proposal is envisaged primarily to construct the balancing reservoir to achieve regulation of the flows to Tamil Nadu as per the CWDT Award further as modified by the Hon'ble Supreme Couirt of India vide its Judgement dated 16/02/2018. The total quantum of water to be made available by Karnataka to Tamil Nadu in a normal year is 177.25 TMC (167.25 TMC + 10 TMC for environmental flows) annually. For details refer 3.3 above.

3.7 Concurrence of the riparian State for additions / alterations of existing project

Not applicable to the present proposal.

3.8 Consumptive use of water

Withdrawal of water consists of 49.48 TMC for drinking water supply to Bengaluru Metropolitan Region.

3.9 Details of quantity of water diverted for drinking / cooling / industrial purpose

Nil.

Chapter 4
Surveys and Investigations

Karnataka Power Corporation Limited, had earlier carried out survey and investigations to identify a suitable location for Mekedatu Project. Based on this, three locations were identified for siting the dam. They are Site A, Site B, and Site C. After studying the merits and demerits of each site including the storage capacity and generation of power , KPC had selected Site 'C' for siting the dam and other appurtenant works including the power components.

Parameters considered during desktop study are as follows;

- Topography (Ridges and valleys)
- Water availability
- Level at which water is available
- Special ground features and soil conditions
- Land use
- Existence of locations of historic and cultural importance.
- Any other constraints
- All the available details from the respective field authorities were also considered in the desktop study

Field Reconnaissance Survey has been carried out at selected locations to validate the observations during desktop study. The field inputs and constraints, if any noticed are updated in the base map.

4.1 Topographical Survey

Mekedatu Project is located on the River Cauvery almost at the tail end of its course in Karnataka State approximately 2.0 km downstream of confluence of Cauvery and Arkavathy rivers , (Sangama) in Kanakapura and Kollegal Taluk of Ramanagara and Chamarajnagar District at a Latitude 12° 16´ 20˝ N and Longitude 77° 26´ 25˝ E respectively. While the left flank falls under Ramanagar District, right flank falls under Chamarajnagar District, the river Cauvery being the administrative boundary between the two Districts. It is located between Sangama and Biligundlu CWC gauge site.

Mekedatu dam site falls under Mugur State forest (Left flank) and Chikkyalur Reserved forest (Right flank) and hence limited accessibility is available. The Chikkyalur Reserved forest has been declared Wild Life Sanctury and hence any activity within this area requires prior permission of the relevant authorities .

In view of this, the information regarding the topographical survey and Geotechnical investigation has been extracted from the earlier detailed investigation carried out by Karnataka Power Corporation Limited (KPCL). During the preparation of the present report, physical verification has been carried out to validate the data and confirm that the available data and information meets the project requirement.

Survey of India had carried out aerial survey mapping of the project area including reservoir based on the specific request from KPC. SOI had compiled base map on 1:15000 scale with 2.5 m contour interval and the same was supplied to KPC. This has been utilized to arrive at the Capacity of the proposed reservoir as well as calculating the submergence area and development of Master plan for the entire project area.

	
Fig. 4.1: DGPS observation along the centerline of the dam	**Fig. 4.2: Geological formation at the Dam site**
	
Fig. 4.3: Dam centerline	**Fig. 4.4: Confluence of Mulehalla with Cauvery**

	
Fig. 4.5: DGPS survey at Bridge location	**Fig. 4.6: Bridge location at RL 440.00 m (Submergence level)**

4.1.1 River

At Mekedatu, which is about 55 km below Shivanasamudram, the river is very narrow. The starting point of the 64 km stretch of the river which forms the common boundary between Karnataka and Tamilnadu States is 5 km below Mekedatu. For cross-section of River, refer dwg. **EIT-1328X-WRE-XX-CS-A009**.

4.1.2 Reservoir

The Elevation, Area, Capacity relationship has been developed based on the 2.5 m contour intervals as per the survey sheets supplied by the Survey of India and is shown in **Fig 5.1/ Appendix 2**.

4.1.3 Head works (Dam including Dyke, Barrage, weir etc)

The Survey carried out by KPCL for dam and power house has been utilized. Refer dwg. **EIT-1328X-WRE-XX-PLN-A007.** Headwork details narrated in Chapter 7.

4.1.4 Plant and Colony layout

The colony layout including the Plant has been clearly marked in the Master plan of the Project. Enclosed in Vol III – Drawings. Refer dwg **EIT-1328X-WRE-XX-MTP-A012**

4.1.5 Canal and Water conductor system and Canal structures

Not applicable.

4.1.6 Power house switch yard, surge shaft, tail race etc

Refer dwg**. EIT-1328X-WRE-XX-GLD-A038**. Details narrated in Chapter 7

4.1.7 Tunnel, Adits and Pen stocks

Refer dwg. **EIT-1328X-WRE-XX- GLD-A038**. Details narrated in Chapter 7

4.1.8 Command Area

As Mekedatu is a Balancing reservoir and drinking water project, no irrigation is envisaged and command area is not relevant in the present project

4.1.9 Catchment Area / Watershed survey, identification of inter-se priorities of watersheds for soil conservation

Catchment Area map is shown in drawing. Refer Drawing No. **EIT-1328X-WRE-XX- GLD-A006**

4.1.10 Any other

No other components are envisaged

4.2 Other surveys

4.2.1 Archeological survey in the reservoir area

Nearly 96.17% (5051 Ha) of project area falls under the forest and only 3.83% (201 Ha) falls under private/Revenue land. There are no places of archeological importance within the preoject area except few historical temples which area likely to be submerged. The project authorities have planned for relocating or protecting such locations based on the sentiments and needs , which will be confirmed as a part of social impact assessment survey.

4.2.2 Mineral survey in the Catchment / reservoir area

Not applicable as there are no minerals of commercial value located in the project area.

4.2.3 Right of way survey for the reservoir

Mekedatu balancing reservoir Dam is located about 5 km upstream of the Interstate border having poor connectivity in view of the forest area. There are no established roads/utility corridors to access the project location. For ensuring smooth and safe connectivity and also for the timely completion of the project including operation and maintainance, nearly 13.5 km of road network having a 60 m wide right of way has been earmarked. The road along with appurtenant structure including two major bridges planned will ensure accessibility to all the facilities planned in the project. For the purpose of ensuring efficient communication and other utilities, corridors have been earmarked within the 60 m right of way proposed.

4.2.4 Communication survey

Mekedatu balancing reservoir Dam is located about 5 km upstream of the Interstate border having poor connectivity in view of the forest area. There are no established roads/utility corridors to access the project location. Mekedatu Balancing Reservoir cum Drinking water project is located about 2 km downstream of the confluence of Arkavati and Cauvery river with the river bed at elevation 351.0 m and the FRL is 440 meters above MSL. The confluence of Cauvery and Arkavati river is called the Sangama which is a historical place wherein number of tourists visit this location regularly. The existing state highway (SH-92) originates from National Highway (NH-209) near Kanakapura (Taluk Headquarters) and runs for a length of about 34.4 km up to Arkavathi River crossing leading to left flank of Arkavathi River. From there left flank of the dam is accessed through a metaled road of about 2.5 km length.. Enroute from Kanakapura there is another major village, Doddalahalli which is located about 18 km from Kanakapura. This road will be the main access to the dam site. Other than this, there are no other roads available to reach the dam and similarly accessibility from the right flank is limited in view of the forest area. The nearest rail head will be Ramanagara and is located at 66 km from the dam site. The nearest airport is located at a distance of 125 km and is located Bangalore. The nearest sea port is Mangalore, located 370 km from the site. For details regarding accessibility to the dam site through the existing road network involving National Highway (NH 209), the State Highway (SH 92) and other roads – Refer **Fig. 4.7**–Route Map for access to project site

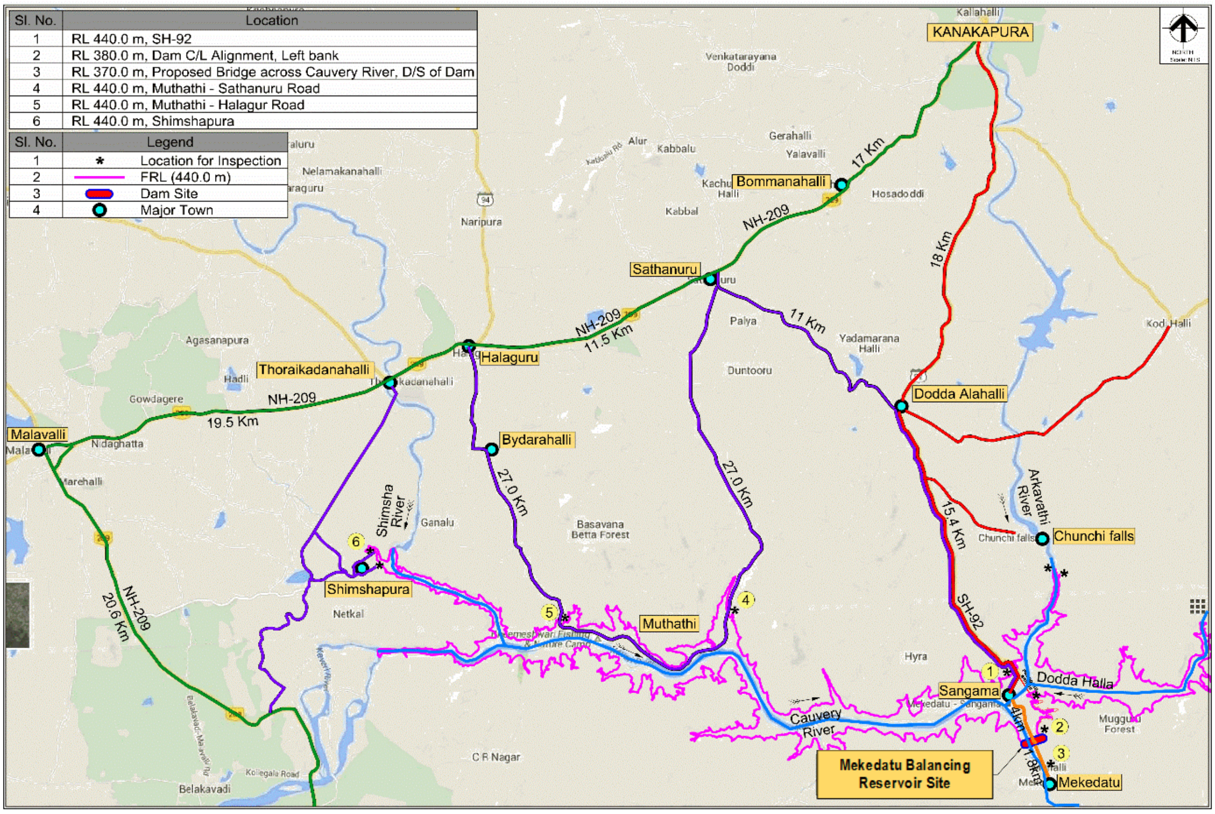


Fig. 4.7: Route Map for access to project site

4.2.5 Drainage survey

Not applicable

4.2.6 Soil surveys

Not applicable

4.3 Geology, Geo-Technical features and seismicity

4.3.1 Geology and Geotechnical features

The surface and sub-surface investigations, include surface geological mapping and exploratory drillings carried out at various project locations with pre-defined objectives to delineate the foundation level/grades and to assess the geological conditions of foundation and tunneling media, which helps in formulating the treatment plan and design recommendations.

Geological investigations have been planned with following objectives:

- Surface geological mapping of project components as well as the reservoirarea to delineate all the geological features exposed at surface.
- Borehole investigations along the river channel and abutments to assess the deepest foundation level, foundation condition, in- situ permeability of rock mass and at the tunnel/cavern grades to assess the rock mass characteristics. The recovered core samples have been subjected to laboratory rock mechanics test to arrive at design geotechnical parameters.
- Geophysical Survey to assess sub-surface foundation condition, which further corroborated with borehole data.
- Exploratory drifting on both the abutments, Intake and power house cavern to access sub surface geological conditions and to conduct various in-situ rock mechanics tests.
- Site Specific Seismic studies to derive earthquake parameters and seismic coefficient

a) Regional Geology

The region comprise of rocks belonging to Charnockite group, Sargur group, Peninsular gneissic complex (PGC), Closepet granite, and basic and younger intrusives. Charnockite group is represented by Chanockite. Sargur group comprises of ultra mafic rocks, amphibolite, banded magnetite quartzite, occurring as small bands, and lenses within the migmatite and gneisses. The PGC includes granites, gneisses and migmatite and occur to the east and west of Closepet granite. Transformation of PGC into

Charnokite is reported locally in the district. The Closepet granite occurs as intrusive bodies trending nearly N-S within the gneisses over a distance of 50km and for a width of 15-20km. The Closepet granite contains enclaves of migmatite, gneisses, quartzite and amphibolites and is reported to be of variable composition. The basic intrusives are represented by dolerite, gabbro, occasionally Norite and pyroxenite. The dolerite is dominant among the basic dykes. There are three major lineaments in the district trending NNW-SSE direction. These lineaments range in length from 45 km to 70 km. Interpretation of this data revealed the presence of deep seated fault tending NNW-SSE, which cuts across the Closepet granites

Around and at the project site, Achaean and Closepet granite forms the country rock, a coarse grained, porphyritic, slightly foliated rock mass. However, the dominance of fine to medium grained, massive, banded and foliated pink/grey granite at the site, resembling the peninsular gneiss is also noticed. Closepet granite intrudes into the Charnockites and thus contain within them tongues and apophasis of the charnockitic formations. Refer **Fig. 4.8** below

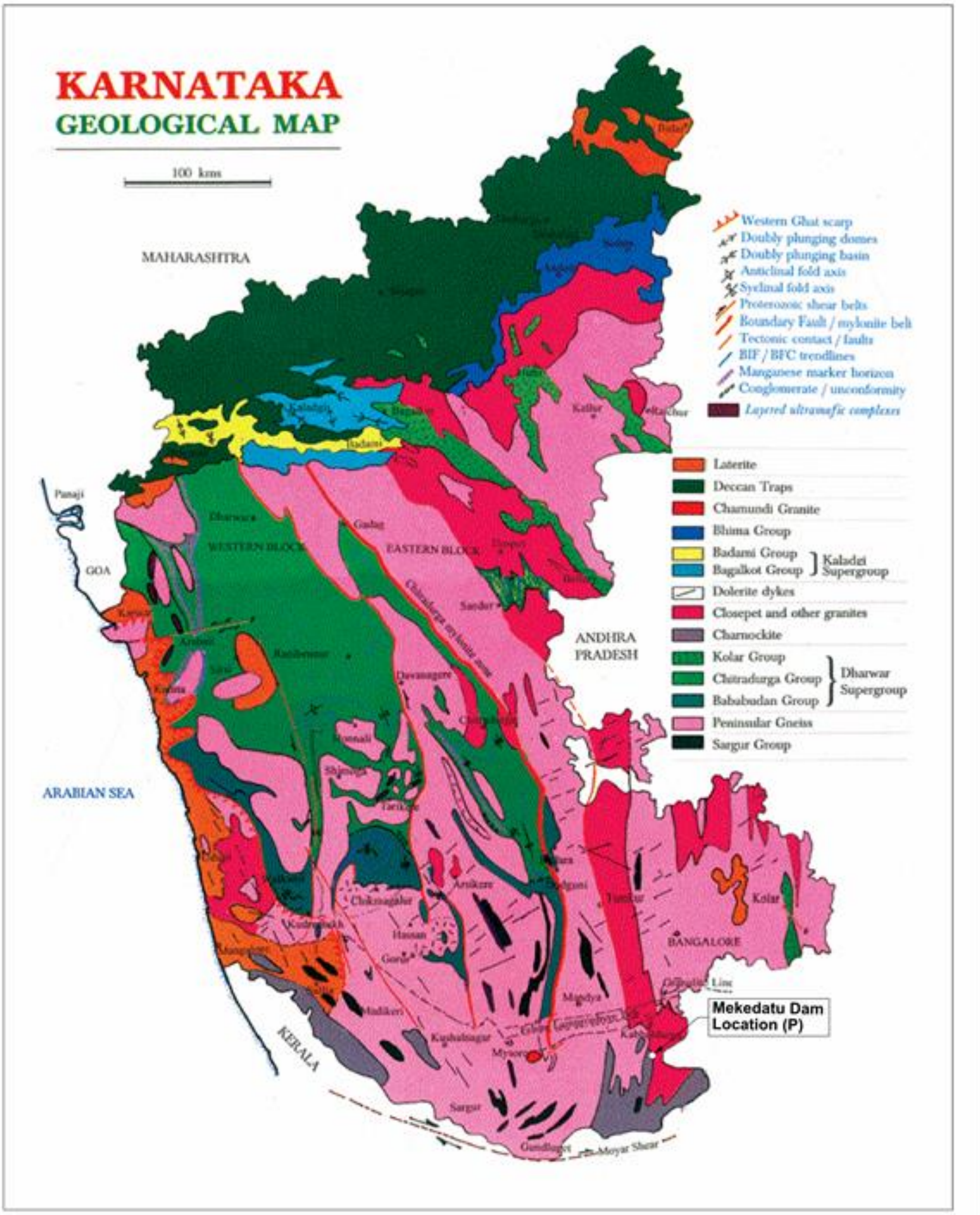


Fig. 4.8: Regional Geology plan

b) Status and location of sub-surface investigation (pitting, drilling, drifting, Geophysical probing rock mechanics etc) in the project area.

The entire project area has been geologically mapped to decipher the bed rock status for foundations of all the major structures of the project . Apart from this totally 38 bore holes have been drilled at various locations to appreciate the sub-surface geological conditions. The surface and sub-surface data are used for the preparation of geological sections and assessment of the medium.

c) Result of exploration and tests

Entire project area has been geologically mapped to decipher the bed rock available for the foundations of the major components of the project. The granite-gneiss bed rock being extensively exposed in the river bed and on the banks and also available under shallow cover of overburden deposits in the dam abutments and powerhouse complex/tailrace areas, the geology mapping itself is sufficient to supplement the subsurface investigations to understand the geological set up. The surface geological investigations involving geological traverse mapping has been done for the project area covering dam, powerhouse complex and tailrace alignment. However, substantial subsurface investigations have been conducted in this project involving about 38 number of drill holes covering dam axis and its base, powerhouse area. The geological logs done by earlier investigation agency (KPCL) and field investigation works carried out by the GSI between the years 1966 and 1982 are appended. The core recovery and RQD have been fair to excellent indicating presence of massive and competent rock. These surface and subsurface investigations data are used for preparation of geological sections and other assessment of foundation and underground media.

The drilling on the left flank shows 6.58 m to 14.32 m thick zone of soil and talus cover. Bed rock is moderately weathered but hard for 6.00 m to 12.00 m depth. In the river bed, fresh and hard rock is exposed at the surface which may require 2.00 m to 3.00 m stripping to reach the foundation grade strata.

In the right flank, 2.50 m to 9.14 m of soil with talus cover and 1.0 m to 3.0 m where the bed rock has been met with. The drills have further indicated fresh and hard granite gneiss and banded gneiss, massive in nature but with minor and irregular closely jointed fractured zones.

d) Surface and sub-surface geological investigations of the project area

Archean Closepet granite is the predominant rock in and around the project site. Though the typical Closepet granite is coarse in texture, porphyritic and slightly foliated, the granite at the site area is fine to medium grained pink and grey, massive, banded and foliated. It resembles peninsular gneiss at some places. These Closepet granites are intrusive into the Charnockites and hence contain inclusions and lenticular (xenolithic) bands of the Charnockite. In general for the frequent reference, the bed rock is referred as Granite-Gneiss for the project area. Refer **Drawing No: EIT-1328X-XX-GEO-A011-1**

The proposed site is located at Latitude 12◦ 16’ 20” and Longitude 70◦ 26’ 30”, 2 km downstream of the confluence of Arkavathy and Cauvery River. The Cauvery River, before confluence, flows in the easterly direction. After confluence, the Cauvery River flows in a southerly direction for a distance of 4.5km and then takes a turn towards east. The Cauvery river at the upstream of the proposed dam site (confluence) has 90º bend towards westerly direction probably along master joints of the terrain. At the proposed site the valley is relatively narrow having 1:1 sloping abutment. Details of Geotechnical Investigation core log , and consolidated note on Geology are presented in **Appendix 4A and 4B – Vol II.**

4.3.2 Seismicity

The area under study falls under seismic Zone-II as per the seismic zoning map of India published in IS: 1893-2002.. Refer **Fig. 4.9** below.

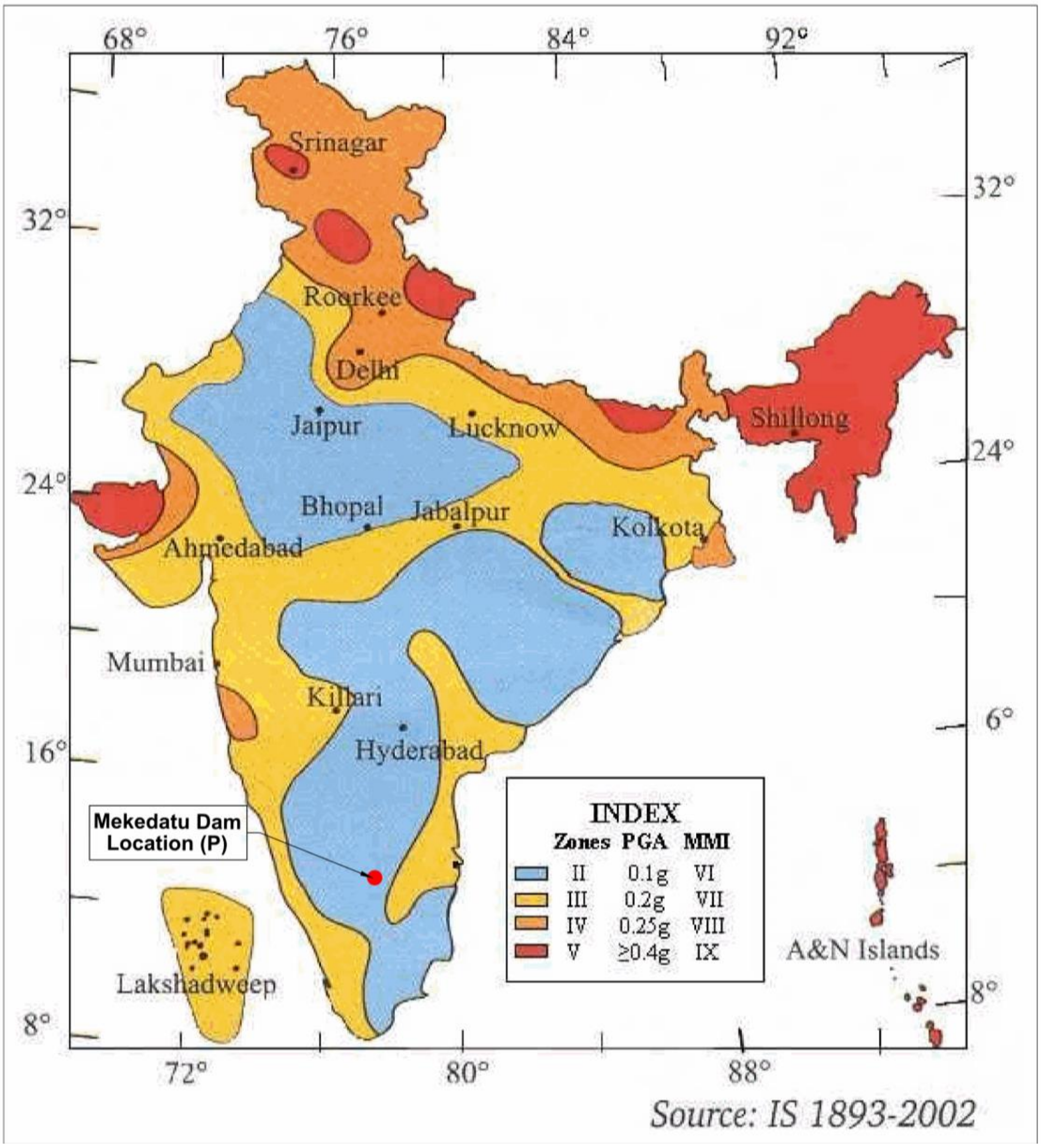


Fig. 4.9: Map showing the Seismic zone

4.4 Foundation Investigations

4.4.1 Earth and Rock fill dam

Not applicable

4.4.2 Concrete dam

The height of the dam is 99 m. Hard rock is met throughout the dam alignment. As river valley is wide and the rock is met at the surface itself, concrete gravity dam is suitable.The width of the river bed is 250 m and river bed level is at RL ±360m. The riverbed is rocky for more than 150 m on upstream side and more than

180m towards downstream side. At the proposed dam site river bed is exposed with fresh granite- gneiss rock. Both the abutments up to the top of the proposed dam height having 45° to 50º slope and covered with thin slope wash materials with sporadic bed rock exposures. The rocks are exposed on both the banks of the dam axis for entire distance of about 200 m upstream and downstream area. Fresh, strong to very strong competent granite- gneiss rock is available in the energy dissipating area also. Refer **Drawing No: EIT-1328X-XX-GEO-A011-2**

The rocks present at this site are pink and grey colored fine to medium grained, strong to very strong massive granite- gneiss and banded gneiss. The foliation trend varies from N-S to NW-SE, generally parallel to river flow and dipping westerly direction at 35°-65° that is towards the right bank of the river.Some of the other prominent joint sets present in the bed rock are:

1. N60E-S60W dipping 80-85 NW, close to moderately spaced, upstream dipping.
2. N55W-S55E trending, dipping 80 NE widely spaced, upstream dipping.
3. N-S trending and dipping east that is towards left bank.

Structural control of the river course appears around 90º turn of River Cauvery at its confluence with Arkavathy River and Mulehall. During the detailed field examination, it is observed that river has carved out along foliation trend of the area and fracture zones. At Mekedatu or Goat leap, that is towards far downstream of dam site, foliation planes are intersected by sub horizontal fractures and river has eroded the rocky bed along foliation planes and leads to formation of narrow deep gorge along foliation planes. Refer Drawing No: **EIT-1328X-XX-GEO-A011-3.**

Even at and around the dam axis/site, smoothened rock surfaces with open joints, pot holes are observed as part of riverine action on the bed rock.The joints dissecting rock mass are generally moderate to widely spaced, some of them are quite persistent for more than 50 m to 100 m. Most of the joint planes are rough planar or smooth undulating with infilling of quartz minerals in some of the open joints. But clay mineral filling are not seen as such. The aperture of joints are generally tight (less than0.25 mm) but some of them are partly open to open (0.25 mm to 2.5 mm). Minor and irregularly closely jointed and fractured zones are also observed in the area at places.

4.4.2.1 Strength of the rock

The bed rock, Archean granites and gneiss rock, and being fresh even in the river bed, the strength of the rock seen to be generally very strong. The bed rock requires many blows of geological hammer to fracture or it can only be can be chipped, indicating very strong (R5- UCS 100-250 MPa) to extremely strong rock

(R6-UCS-more than 250 MPa), very difficult to chip of the rock even with several blows using the geological hammer. Because of the tight joints, the permeability of the bed rock is expected to be generally in the range of 2 to 5 lugeons. There could be some high lugeon, may be around 10 lugeon or so values if the bore hole intercepts open persistent joints.

4.4.2.1 Geotechnical evaluation of dam site

The present dam site was selected based on the topographical advantages, available hydraulic gradient and the presence of competent bed rock on the river bed and the abutments portion. Sh. A. N. Aggarwal, GSI has carried out the geological studies during Apr.- May. 1980. Based on his observations of explorations conducted till then, he opined that the construction of 125 m high concrete dam across the Cauvery at Mekedatu proposed site is feasible. The proposed dam site comprises hard and compact granite gneiss rock without significant structural disturbance, except three sets of joints sets.

There are certain joint sets trending parallel to dam axis, gently dipping in downstream direction and parallel to river course. The rock ledge protruding along such joints having its toe exposed in the dam foundation will require removal of the same. Due to river action, joint at places are opened up near the river bed surface along with formation of shallow pot holes, smooth rock surface etc. This will require removal of rock mass for about 2-3m depths to get acceptable foundation grade at the dam foundation even though strong and bed rock is available.

The rock dissected with 3 to 4 set of joints having high persistence, trending from upstream to down stream direction and can be the path of percolation/ water leakage from the reservoir. Hence the foundation will require consolidation/area grouting and curtain grouting to seal the joints for suitable depths as per the codal requirements. Further, pot holes or any openings would require dental treatment before the placement of concrete in dam blocks. No major shear-zone or fault zone is observed in the dam area which may require special foundation treatment. However provision shall be required to take care of closely jointed or fractured zones through suitable treatments as foundation treatment normally done.

The granite-gneiss available at dam foundation is very strong to extremely strong, capable enough to withstand the high stress because of high dam of more than 100 m in height. The energy dissipation area in the downstream portion of the dam toe is also exposed with very strong granitic rock and is the good media to withstand against river erosion.

The abutment portions which is under cover of shallow overburden deposits mainly of talus nature require its removal to fresh bed rock depth as envisaged in the engineering proposal. The Granite-gneiss bed rock expected in abutment portions shall be very strong rock and with grouting, expected to provide competent and water tight foundation for abutment blocks of the dam.

Field Season reports of the GSI are appended.

4.4.3 Canals

Not applicable

4.4.4 Power house , Tunnels, de-silting chamber, surge tanks, transformer cavern etc and canal

4.4.4.1 Intake and inclined pressure shafts

Due consideration has been given to the selection of the intake and inclined pressure shafts on right bank. The proposed intake site surface area is covered by thin slope wash material along with granite gneiss rock out crops at places. The proposed pressure shafts are aligned in NE-SW direction on the right bank between dam and underground power house. It is expected that hard and competent granite gneiss rock with adequate rock cover is available for opening of intake face. For pressure shafts competent good Granite Gneissic rock of class I and class II will be the tunnelling media during excavation.

4.4.4.2 Underground Power House Complex

The proposed Underground power house will be located below the hill mass on the right bank of the Cauvery River adjacent to dam abutment. This will enable excavation of caverns to locate the underground power house complex. The invert level is fixed at RL 290 m, the proposed location is about 100 m inside rocky hill mass. The ground surface of underground powerhouse site is covered with shallow cover overburden deposits mainly having talus deposits along with bed rock exposures at places confirming availability of good bed rock at powerhouse grade with sufficient rock cover above the powerhouse complex. The proposed power house size is 139 m (L) x 22 m (W) x 42 m (H). At the proposed location, the power house will have a vertical cover of about 150 m above the invert level. The hill range, where the power house is located extends almost parallel to the river course following southerly course.

A detailed geological mapping has been carried out covering both pressure shaft and power house site and TRT. The foliation strikes N-S to N10W-S10E with 60 dip towards west (into the hill). The exposed rocks at the power house area are very strong granite- gneiss with bands of closepet granites and charnokite. Refer **Drawing No: EIT-1328X-XX-GEO-A011-4**

The other sets of joints observed are

1. N 50E-S 50W dipping 80 towards North west (hill side)
2. N 50W-S 50E dipping 85 Northeast (river side)
3. N-S dipping 20 East.

4.4.4.3 Geotechnical evaluation of Powerhouse complex:

The longitudinal axis of the power house complex is proposed with good angle to foliation plane (about 50^0) to get optimum stability benefits. Since the bed rock is massive with moderate to widely spaced joints and very strong with expected tight joints, hence the jointscan be secondary issue for the stability of the underground openings in this very strong granitic rock. The invert level of power house is below river course and some of the joints are dipping towards power house side from the river side. During the power house excavation water seepage can be anticipated to some extent especially during high flood season.Refer **Drawing No: EIT-1328X-XX-GEO-A011-5**

The rock mass classification based on Q-system of classification indicate the Q- values falling under 10 to 40 with some stray values exceeding Q values of 40 and even lesser values around 5 for small stretches. On conservative side, it is recommended to consider Q values of about '10 to 12' in this case. Over all it will be good to very good rock as per Q and RMR system of rock mass classifications. Rock bolting and shotcreting shall be the primary rock supports based on further design analysis with respect to length and spacing of rock bolts/anchors and shotcrete thickness.

The rock being very strong rock having high UCS values, considerations can be made to put the EOT crane beam on the rock benches with rock bolts instead of concrete columns.

In view of the above, about 40 m spacing between Powerhouse cavern and transformer gallery, downstream surge tanks appears to be in order.

4.4.4.4 Approach Adit to Underground Power house

Approach adit has been located on the right bank of the Cauvery river near Lakihalla. The approach tunnel to the Underground Power House (located at 12º 16´ N and 77º 26´ 30" E) would be about 833 m long. The vertical rock cover along the alignment ranges from 60.00 m to 140.00 m. Hard, crystalline massive granite gneiss, charnockite and migmatite occur along the tunnel route.

The proposed 8.5m dia aditis 840 m long which runs below the right bank of Cauvery river. The adit portal has been fixed at RL388.5 m i.e. 5 m above the nala bed. The maximum cover above adit is about

130-140m and minimum cover of 8m is expected at the portal. As the proposed Adit is aligned N-S direction, it will be sub parallel to the TRT alignment. The detailed surface geological mapping of the proposed Adit has been carried out along the alignment. The geological details will be almost as in the case of TRT. Along the proposed Adit alignment the surface is mainly covered by thin slope wash materials and at places rock out crops are exposed. The thickness of slope washes materials 1to3m depth and Rock is exposed in the nala bed.

The rock type encountered during traverse mapping is granitic gneiss with Close pet and Charnokite rock intrusions. The strike of the foliation varies N50W-S50E to NW-SE and dipping 600towards west.

It is observed that rocks are under gone deformations leading to shearing, warping and fracturing. The rocks are dissected by two to three joint sets and descriptions of which are given below.

1) Foliation joints vary between N-S to N 10W-S10E dipping 35 to 60 west.

2) N60W-S60E with dipping 80NE.

3) N10E-S10W with dipping 40NW.

4.4.4.5 Geotechnical Evaluation Main Access Tunnel (MAT) to powerhouse complex

Sufficient rock cover is present along proposed adit alignment. In general, the granitic gneiss rock with bands of Closepet Granite Gniess and Charnokite rocks will be present at the tunnel grade. Though granitic gneiss is a good tunneling medium, closely jointed zones at places may decrease the rock quality. Minor Structural disturbances like fractures and shear zones are likely to be encountered at places along adit. Over breaks may occur in closely jointed zones.Steep to vertical dip joints are common. As the N-S route of the approach tunnel is almost parallel to the foliation direction of the granite gneiss, some over breaks can be anticipated. Fresh rock inferred from the borehole nos 15 & 16 occur at 2.50 m to 7.50 m depth below the ground level at location of underground power house.

Foliation in rock varies from N-S to N10W-S10E with dip of 35° to 60° towards west. Adit alignment will be parallel to sub-parallel with the foliation. This phenomenon coupled with presence of different sets of joints requires rock bolting to prevent wedge failure. Because of westerly dip, controlled blasting is required at crown portion to achieve the desired circular shape.

Broad assessment made to classify the rock on the basis of observations from the rock exposures indicated that about 25% of tunnel length will come under class I, 45% class II, 25% class III and rest5% in class IV. Since the classification arrived at mainly from the surface data projected to tunnel grade, there can be some variations in the percentage of rock class occurrence during actual excavation.

During tunnel excavation full face blasting is suggested for class I, II&III rock mass. For class IV rock controlled blasting, heading and benching/fore polling etc may be required depending upon rock mass.

4.4.4.6 Tail Race Tunnel

The tailwater from the powerhouse is proposed to be led back to river through twin tunnels to take advantage of the available head in the river gradient. The proposed 9.5 m dia (twin) tail race tunnel is 2.150 km long, which runs below the hill range along the right bank of Cauvery river. The invert level of TRT is RL 300 m and maximum cover above the TRT is about 160 m and the minimum cover is about 70m. As the proposed, TRT is aligned almost running N-S direction. The detailed surface geological mapping of the proposed TRT has been carried out along the alignment. The geological details have been provided in L-section. Along the proposed TRT alignment the surface is mainly covered by thin slope wash materials and at places rock out crops is exposed. The thickness of slope washes materials 1m to3 m depth and Rock is exposed in the nala bed and also on the right bank of the Cauvery River.

The rock type encountered during traverse mapping and along right bank of the river was granitic gneiss with close pet and Charnokites rock intrusions. The strike of the foliation varies N5W-S5E to NW-SE and dipping 60° west.

However, from scanty rock out crops along the alignment and rock exposures along the right bank of the river, it is observed that rocks are have under gone deformations leading to some shearing shearing, warping and fracturing. The rocks are dissected by number of joint sets and descriptions of which are given below.

1) Foliation joints vary between N-S to N 10W-S10E dipping 35 to 60 west.
2) N 60 W-S 60 E with dipping 80 NE.
3) N10 E-S 10 W with dipping 40 NW.
4) E-W with dipping 20 North.

While taking traverse along the right bank of Cauvery River some structural features s like shears and fractures were also observed at places. The bed is closely jointed between Ch850m and Ch 950m and between Ch 2050 and 2100m.

4.4.4.6 Geotechnical Evaluation of Tail Race Tunnel (TRT)

Enough top and lateral rock cover exist along proposed TRT alignment. In general, the granite- gneiss rock with bands Closepet and Charnokite rocks will be present at the tunnel grade. Though strong to very strong granite- gneiss is a good tunneling medium, closely jointed zones at places may decrease the rock quality. Minor Structural disturbances like fractures and shear zones are likely to be encountered at places in TRT. Over breaks may occur in closely jointed and fracture zones.

Foliation in rock varies from N-S to N10W-S10E with dip of 35 to 60 towards west. Tunnel alignment will be parallel to sub parallel with the foliation. This phenomenon coupled with presence of different sets of joints requires rock bolting to prevent wedge failure. Because of westerly dip, control blasting is required at crown portion to achieve the desired circular shape.

Due to presence of master joints and shear zones observed on the right bank of the river, water seepage is anticipated at places at the tunnel grade. An attempt has been made to classify (RMR/Q system) the rock on the basis of observations from the rock exposures along the right bank of the river. It is expected that about 25% of tunnel length will come under class I, 40% class II, 25% class III and rest 10% in class IV. Since the classification arrived at is mainly from the surface data projected to tunnel grade, about 10% variation on the above classification is expected during excavation.

During tunnel excavation it is preferred to have heading and benching excavation. Mainly rock bolts/anchors and shotcrete based supports shall be required with some provision of steel rib supports to cater for poor tunnel media if encountered with water flow.

4.5 Construction Material Investigations

4.5.1 Soils and rock fill

Since the proposal is for construction of a concrete dam large quantities of soils and rockfill are not proposed to be utilized. However, these may be required in relatively smaller quanties as materials for the backfill which can be met with from the excavated material and impervious material for coffer dams could be met with from the nearest borrow areas.

4.5.2 Sand

The sand is proposed to be sourced from the quarry on River Arkavathy at a distance of 35 km from the site. Refer dwg. **EIT-1328X-WRE-XX-QUM-A008.**

4.5.3 Rock and Aggregates

The rubble / coarse aggregates are proposed to be sourced from Arekoppa located at a distance of 11 km from the project site.

4.5.3.1 Coarse Aggregates

As the project area lies in the granite area and all the excavated fresh granite material and underground components excavated material will be yielding around 2.5 lakh cum, same will be used for coarse aggregates. Any shortage will be quarried from the identified Mekedatu Betta.

The Mekedatu Betta is situated on the left bank of river Cauvery at a distance of 2.5 km downstream of the dam site.

4.5.3.2 Sand quarries

Various sand deposits are available all along river Arkavathy from Ramanagara to Sangama. The quantity assessed is about 9.5 lakhs cubic meters of sand. The leads to dam site from these quarries varies from 3 km to 55 km.

The tests for suitability of both coarse aggregate and fine aggregates (sand) from these quarries to be used as construction materials, will be got conducted by the Karnataka Engineering Research Station, Mysore.

4.5.4 Bricks / Tiles

Will be obtained from the local suppliers for use in proposed building works.

4.5.5 Pozzolana

Will be used to the extent possible based on the requirement for mass concrete works.

4.5.6 Lime stone

Limestone is not needed for the proposed project

4.5.7 Cement and Steel

Cement and Steel shall be sourced from Kanakapura at a distance of 35 km from the project site.

4.5.8 Scarce materials

Not envisaged

4.5.9 Investigation of material

Reconnaissance for sourcing the construction materials have been carried out and are available as indicated above

4.5.10 Any other material

Not envisaged

4.6 Hydrological and Meteorological investigations

The nearest IMD Station is Bangalore. The average meteorological data for the period 1971 to 2000 is published in Climatological normals , Pune.

4.6.1 Hydrological data

4.6.1.1 Rainfall

The mean annual rainfall in the Bangalore station is 974.5 mm. The highest rainfall is 241.0 mm in Sept. and minimum rainfall is 1.8 mm in January. The rainfall considered is the average from 1971 to 2000.

4.6.1.2 Temperature

The daily maximum and minimum temperature recorded are 34.1 °C and 15.3 °C in the months of April and January respectively.

4.6.1.3 Humidity

The daily maximum humidity observed is in the month August at 89% at 8.30 AM and 67% at 5.30 PM.

4.6.1.4 Wind

The maximum mean wind speed is in the month of June i.e, 8.9 Kmph and minimum observed is in 4.8 kmph in Oct and Apr.

4.6.1.5 Cloud cover

Maximum cloud cover observed is in the month of Jul and minimum in the month of March. For all the above data refer **Appendix 3**. **Vol II.**

4.6.1.6 Evaporation

Evaporation rates are taken from the actual measured data at KRS by the Irrigation Department.The same has been adopted for the present project. These rates are as follows:

Month	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Evaporation, mm/day	4.199	3.212	3.195	3.293	4.048	3.319	3.187	3.122	3.048	3.408	4.885	5.120

4.6.2 Dischage data

Daily discharge data of Biligundlu River Gauge station is available for 41 years from 1972-73 to 2016-17 and is considered for the present study. The monthy discharge table is attached as **Appendix 4 – Vol II**

4.6.3 Sediment data

In the case of Cauvery river on which the proposed project is envisaged, the sediment load measurements have been carried out by CWC at its river gauging station at Biligundlu from year 1973 – 2017, which lies on the downstream of the proposed site of Mekedatu balancing Reservoir cum drinking water project.. As such, for working out the capacity at various levels and probable sediment load deposition calculation, the said data has been considered as the basis.The details of daily sediment data is attached as **Appendix 5-Vol II**.

Refer **Table 4.1** for data considered in the present proposal as per the CWC guidelines.

Table 4.1: Data considered in the present proposal as per the CWC guidelines

Type of information	Minimum length	Now considered
River gauge data	10 years	As indicated above, sufficiently long data is available at Biligundlu gauging station maintained by CWC from which all the data have been utilized for the said project.
River flow discharge	10 years	
Sediment flow and grain size distribution	3 years	
Water quality	3 years	
Water salinity River profiles cross sections showing flow levels	3 years	
Panevaporation	3 years	

4.6.4 Flood data

Design flood (PMF) of 8,00,000 cusecs is considered for design of spillway and gates. **Refer Chapter 5, para 5.1.8.**

Chapter 5 Hydrology (Working Tables, Performance tables, Flow tables)

The river Cauvery originates in the Brahmagiri range western ghats in Talakaveri of coorg district. It traverses through Karnataka and Tamil Nadu before draining into the Bay of Bengal. It has many tributaries in Karnataka as well as in Tamil Nadu and Kerala.

Major dams have been built across Cauvery both in Tamil Nadu as well as in Karnataka. It is to be noted that beyond KRS (127 km distance) and Kabini (175 km distance) upto the State border with Tamil Nadu, no major water retaining structures are present and/or envisaged. Thus, CWDT while giving its order has clearly indicated that nearly 80 TMC of water will be received from the independent catchment below KRS and Kabini.

As per CWDT Award, Karnataka is supposed to release 192 TMC of water (as measured at Biligundlu CWC G &D station in a normal year). However, Hon'ble Supreme Court of India vide its judgement dated 16.02.2018, modified the CWDT award and allocated additional 14.75 TMC of water to Karnataka correspondlingly reducing the releases to Tamil Nadu from 192 TMC to 177.25 TMC (in a normal year). The additional 14.75 TMC allocated to Karnataka consists of 10 TMC for various uses (to be decided by GoK) and 4.75 TMC exclusively for drinking water supply to Bengaluru Metropolitian Region and surrounding areas.

Emphasis was laid on providing drinking water to Bengaluru Metropolitian Region and surrounding areas by the Hon'ble Supreme Court considering its global status.

The Cauvery Water Disputes Tribunal, while giving its judgement considered the area of Bangalore in Cauvery basin to be about 33% and accordingly allocated share of drinking water to it. However, due to expansion of Bangalore under the name Bruhat Bangalore Mahanagara Palike and further as Bengaluru Metropolitan Area and Bengaluru Metropolitan Regional Development Authority, additional areas in the Cauvery Basin have been amalgamated.

It could be seen that originally, the extent of area falling under Cauvery Basin was only 33 % (also as per CWDT Award) and as per the latest amalgamation of areas under Bengaluru Metropolitan Regional Development Authority, the extent of area falling under Cauvery Basin has increased to 73.47 %.

In view of the above increase in the area and subsequent increase in the population (whose drinking water needs are to be met with), present supply is not sufficient to cater to this increased drinking water requirement. Hence it has become necessary to augment the supply by proposing new project /s and one such project envisaged is Mekedatu Balancing Reservoir cum Drinking Water project which can serve the purpose.

Cauvery is the only perennial source of water available and any project or proposal to provide drinking water can only be from this source.

GoK having realized the need for basic and fundamental rights of its people in the region to be provided with safe and potable drinking water had made an appeal to the Hon'ble Supreme Court of India requesting for additional allocation over and above the allocation as per the CWDT award (Civil Appeal No. 2453 of 2007).

5.1 Hydrologic inputs to the project planning

Hydrologic studies are carried out in order to assess the quantity of available water including time variation, estimating the required maximum flood data (for hydraulic design as well as for the safety of the structure) and sedimentation study, an important factor in assessing the project life as well as the live storage.

5.1.1 Processing of Hydrologic data

Refer **Appendix 7, Vol II** for details

5.1.2 Type of proposed data development

Long term gauge data are available at CWC Gauging station at Biligundlu. These data have been used for preparing working tables.

5.1.3 Analysis of data for preparation of inputs

10 daily flows have been aggregated from daily discharge data in the preparation of working tables

5.1.4 Seriousness of sediment problem and its effect on reservoir storage

50 years sedimentation has been considered and adjustment of Capacity tables carried out and the adjusted capacity of the reservoir is used in the working tables. With the basin on the Upstream harnessed by construction of Dams on the main river and its tributaries, much of the sediment load gets absorbed in the upstream basin. Observations at Biligundlu and further analysis of the sediment data indicate that sedimentation is not a serious problem.

5.1.5 Catchment area:

- The catchment area of Cauvery river basin upto KRS = 10,619 Sq. km

- The catchment area of Kabini river upto Kabini Dam = 2141.90 Sq. km
- The total catchment area of Cauvery at Mekedatu Dam site = 34,273 Sq. km
- The total catchment area at Biligundlu = 36,682 Sq. km

5.1.6 Reservoir Area Elevation, Capacity Curve

Topographic survey of the reservoir area forms the basis for obtaining the area elevation capacity curves, which are respectively the plots of elevation of the reservoir versus surface area and elevation of the reservoir versus volume. In the present study, the Elevation Area Capacity relationship has been developed based on the 2.5 m contour intervals and is shown in **Appendix 2- Vol II**. The graphical representation of the Elevation Area Capacity is indicated in **Fig. 5.1**.

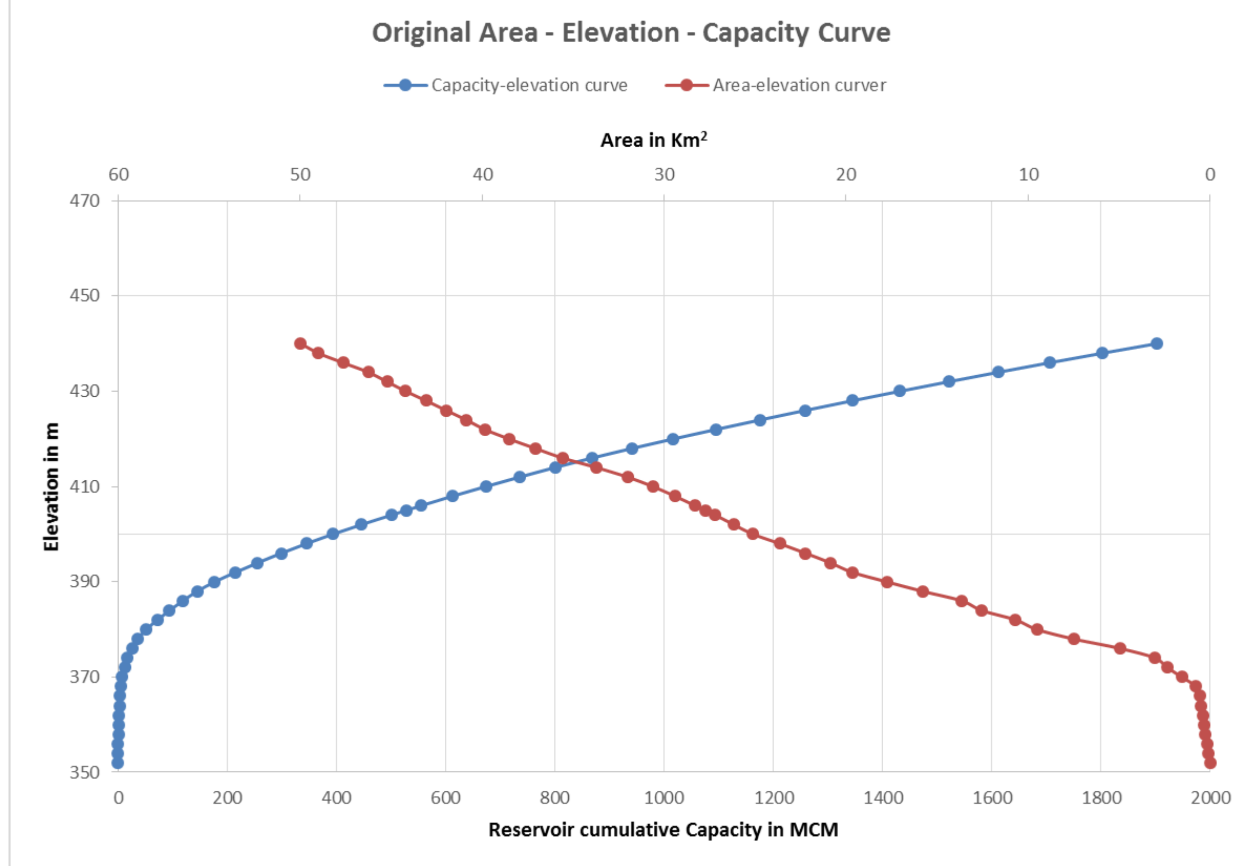


Fig. 5.1: Reservoir Area- Elevation - Capacity Curve

5.1.7 Rainfall and analysis

The information regarding rainfall data has been collected from IMD and Directorate of Economics and Statistics GoK. This information has been used to to check the data Consistency. Regarding Design flow, since the information regarding the long term flow is available at Biligundlu G & D station (maintained by CWC), the same has been used while arriving at the Design Flood.

5.1.8 Data consistency

Double mass curve Analysis (Rainfall vs. Runoff) is carried out between cumulative average annual rainfall and the cumulative annual flow .

A trend analysis and a test for Stability of Variance (f-test) and Mean (t-test) are conducted on the Discharge data of Biligundlu station. **The discharge time series is found to be stationary.**

Conclusion: The Discharge data has been checked for internal and external consistency by Double mass curves and Statistical test and it is found that the data is consistent. Refer **Appendix 7**. **Vol II.**

5.1.9 Demand

The principal demand as far as the present proposal is concerned comprises of the following:

- ✓ Utilizing additional 4.75 TMC of water to provide drinking water facility to Bengaluru Metropolitan Region, its adjoining area etc by way of proposing a scheme to tap water from the foreshore of the intended Mekedatu Balancing Reservoir cum Drinking water project.

- ✓ To regulate the required quantum of water to Tamil Nadu on a monthly basis (in a normal year) as per the CWDT award, as modified by the Hon'ble Supreme Court of India vide its Judgement dated 16.02.2018. It is further proposed to store the flood waters otherwise escaping to sea as it happened in the monsoon of 2018.

- ✓ Harnessing nearly 400 MW (650.28 MU of renewable energy annually @90 % dependable year) of renewable energy annually by utilizing the fall in the natural bed profile of the Cauvery River upto the state border from the monthly releases effected to (in a normal year) as per the modified award (by the Hon'ble Supreme Court of India vide its Judgement dated 16.02.2018.)CWDT Releases in Normal Year

As per the CWDT Award, following monthly flow volumes should be ensured at Biligundlu in a normal year:

Month	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
Volume of Flow, TMC	10	34	50	40	22	15	8	3	2.5	2.5	2.5	2.5	**192**

These flow volumes can be reduced pro-rata in a sub-normal year. First priority is accorded to this commitment in preparing the working tables. A scheme for determining releases in subnormal periods is described later.

5.1.9.1 Releases as per the Judgement of Hon'ble Supreme Court of India on 16/02/2018

On 16.2.2018, the Supreme Court passed an order partially modifying the CWDT award. The Order allocated 284.75 TMC as Karnataka's share of Cauvery water and reduced the total flow to be ensured at Biligundlu from 192 TMC to 177.25 TMC. The Order has not specified how the reduction of 14.75 TMC is to be effected in the monthly distribution. For the purpose of preparing the working tables, the following distribution in a normal year is adopted in this report, based on the past monthly flows at Biligundlu reducing the releases proportionately.

Monthly Flows to be assured at Biligundlu in the Light of Supreme Court Order													
Month	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
Volume of Flow, TMC	9.18	31.25	45.95	34.76	20.22	13.79	7.35	2.75	2.5	2.5	2.5	2.5	**177.25**

A scheme for determining releases to Biligundlu in subnormal periods is described later.

5.1.9.2 Allowance for Kerala Utilisation

Kerala has been allocated 21 TMC from the Kabini basin. But it has been utilizing only 11.7 TMC. In future it may utilize the remaining 9.3 TMC, in which case inflow volumes into Mekedatu will be reduced by that quantity. It is assumed that Kerala will store the water from June to October in proportion to the average flows in Kabini during those months. Thus, Kerala abstractions from Kabini in a normal year in the future periods are calculated as follows:

Table 5.1: Kerala abstractions from Kabini in a normal year

Months	Average Flow in Kabini, Mcft	Kerala Abstraction, Mcft
Jun	13082	1142.28
Jul	35691	3116.42
Aug	33348	2911.83
Sep	15044	1313.59
Oct	9344	815.88
Total	**106509**	**9300**

In a sub-normal year, the Kerala abstractions are reduced in the same manner as Biligundlu obligation.

5.1.9.3 Drinking water requirements

Drinking water requirements of Bangalore Metropolitan Region, its surrounding areas etc in the Cauvery basin will be met out of the allocated share of water for the State of Karnataka.

5.1.10 Water availability

Detailed computation of the working tables shows that the main project objectives of releasing mandated quantum of water to Tamil Nadu at 50% dependability and providing drinking water to Bangalore Metropolitan Region can be met.

Clause XXVIII of the final order of the Tribunal states thus,

"Nothing in the order of this Tribunal shall impair the right or power or authority of any State to regulate within its boundaries the use of water or to enjoy the benefit of water within that State in a manner not inconsistent with the order of this Tribunal".

As per the above order of CWDT, the water flowing in a State can be regulated within its boundaries for using it and enjoying the benefit of the same. Karnataka, by building Mekedatu balancing reservoir cum drinking water project would be ensuring releases as per the order (both by CWDT and Hon'ble Supreme Court),

Sub point No 391 of the order of the Hon'ble Supreme Court of India states thus

"At this juncture, we need to recount that as per the National Water policies, not only drinking water has been placed at the top of the other requirements in the order of priority but it has also been predicated that adequate drinking water facilities should be provided for the entire population, both in urban and rural areas and that drinking water should be made a primary consideration. It was declared as well that drinking water needs of Human being and animals should be the first charge on any available water".

5.1.11 Evaporation from Reservoir

Evaporation losses are calculated in the working tables based on the mean waterspread area during the concerned ten-day period and the corresponding evaporation rate. Evaporation rates are taken from the available data at KRS which is adopted for Mekedatu site. These rates are as follows:

Month	Jun	Jul	Aug	Sep	Oct	Nov
Evaporation, mm/day	4.199	3.212	3.195	3.293	4.048	3.319
Month	Dec	Jan	Feb	Mar	Apr	May
Evaporation, mm/day	3.187	3.122	3.048	3.408	4.885	5.120

5.1.12 Design Flood

In the present proposal of Mekedatu Balancing Reservoir cum Drinking Water Project, the main objective is to meet the drinking water requirement of Bengaluru Metropolitan Region, its surrounding areas etc in the Cauvery Basin out of the allocated share of 4.75 TMC. Further, the releases to Tamil Nadu (during a normal year) as per CWDT award and further modified by the Supreme Court vide its Judgement on 16/02/2018 is proposed to be ensured. The quantum of water to be released in a normal year is 177.25 TMC. To meet these objectives and further to meet the drinking water requirement of Bengaluru Metropolitan Region and its surrounding areas it is necessary to build a dam / reservoir of capacity 67.16 TMC which shall be designed considering the design flood.

In the present proposal, balancing reservoir is primarily built to take care of providing drinking water to Bengaluru Metropolitan Region, its surrounding areas etc in Cauvery basin. This would also ensure the downstream releases by Karnataka to Tamil Nadu as per CWDT award further modified and revised by the Hon'ble Supreme Court of India (177.25 TMC in a normal year spread over 12 months) in an year including the releases to take care of environmental flows & inevitable escapages in to the sea. It is proposed to generate power from the releases effected to by utilizing the available elevation difference (between the reservoir level and in the bed level between the project site and the nearby State border).

The Design flood for the project can be one of the following:

1. Design flood already considered at Mettur reservoir (11,185 cumecs or 4,00,000 cusecs) which can be considered as such.
2. Design flood estimated by the following methods
    a. Hydro-meteorological approach

b. Flood frequency analysis

Further, it is necessary to conduct a Dam break analysis to assess the stability of the proposed dam in case of failure of dams on the upper reaches.

The major dams on Cauvery upstream and downstream of Mekedatu are Hemavathy, Harangi, KRS, Kabini and Mettur:

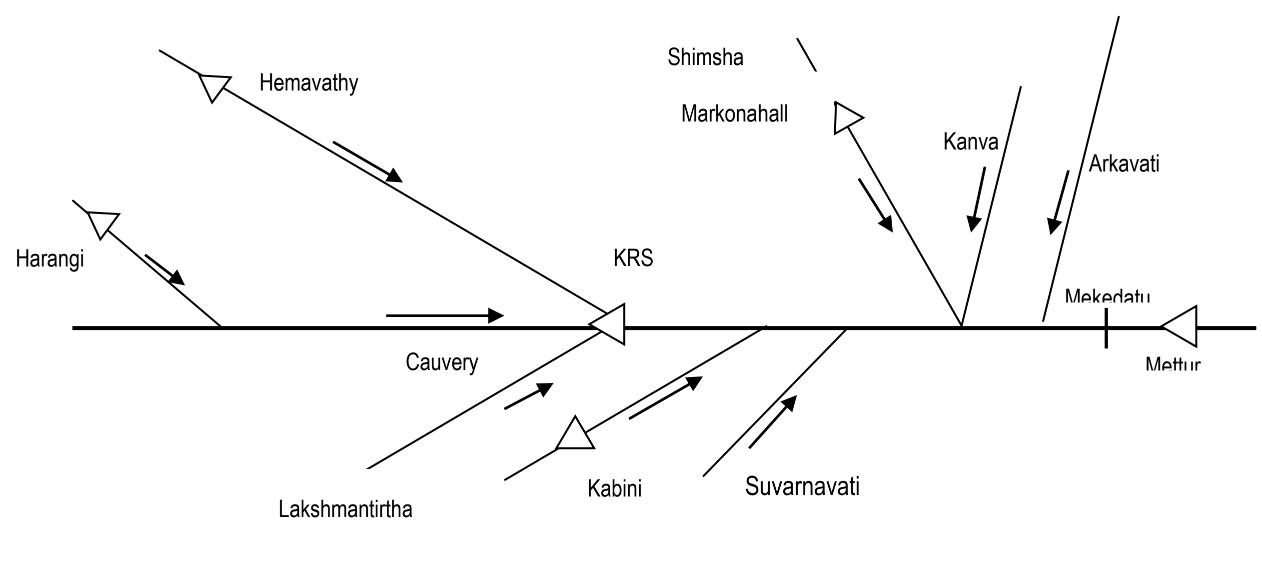


Fig. 5.2: Tree Diagram with Major Tributaries of the Cauvery basin within Karnataka State

The spillway capacities of these dams are as follows:

Name of the Reservoir	cumecs	cusecs
Harangi	3398	120000
Hemavathy	3625	128000
Kabini	5493	194000
KRS	9794	345800
Mettur	11185	400000

5.1.12.1 Peak maximum Flow

As per IS 11223, the proposed dam / reservoir can be Classified as Major dam / reservoir and the design shall consider PMF as the basis. For arriving at the PMF value for the proposed Mekedatu Balancing Reservoir cum Drinking water Project, the following are considered.

The probability that PMF occuring simultaneously in both Kabini and KRS is very low. The flood in Kabini has to travel about 80 km up to the confluence with Cauvery. The KRS flood has to travel about 60 km up to the confluence. In this process, both floods get attenuated. Further attenuation takes place through the 80 km stretch of the river from this point up to Mekedatu dam site.

5.1.12.2 Criteria for selection of Design floods for each structure

Para 3.1.2.& 3.1.3. of I S Code 11223 classifies the dam / reservoir to their size, hydraulic head and fixes the design flood for safety of dam for each of them as under.

Table 5.2: Classification for the dam

Classification	Gross Storage	Hydraulic Head
Small	Between 0.50 M Cum & 10.00 M Cum	Between 7.50 m & 12.00m
Intermediate	Between 10.00 M Cum & 60.00 M Cum	Between 12.00 m & 30.00 m
Large	Greater than 60.00 M Cum	Greater than 30.00 m

The proposed Balancing Reservoir by virtue of having its height more than 60.00 m falls under the Category of Large Dams.

Table 5.3: Inflow design flood for safety of the dam

Size as determined in 3.1.2	Inflow design flood for design of dam
Small	100 year flood
Intermediate	Standard Project Flood (SPF)
Large	Probable Maximum Flood (PMF)

As per above Table 5.2 and Table 5.3, for designing the Balancing Reservoir, it is necessary to consider Probable Maximum Flood (PMF).

It is also stated that larger or smaller magnitude may be used if the hazard involved in the eventuality of a failure is particularly high or low.

5.1.12.3 As per Hydrometeorological approach

The PMF value for the proposed balancing reservoir is arrived at following the Hydrometeorological approach. As per the Classification, the proposed Balancing Reservoir has to be designed for PMF.

The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against the event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rather than flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk managememnt study.

5.1.12.3.1 Hydrometeorological approach

In the Hydrometerological Approach, attempt is made to analyze the causative factors responsible for production of severe floods. The design flood computation mainly involves **estimation of a design storm hyetograph** and derivation of **catchment response function**. The catchment response function used can be either a lumped system model or a distributed lumped system model. In the former, a unit hydrograph is assumed to represent the entire catchment area and in the distributed model, the catchment is divided into smaller sub-regions, and the **unit hydrographs** of each sub-region applied with channel routing will define the catchment response. The main advantage of this method is, it gives a complete flood hydrograph and this allows making a realistic determination of the moderating effect while passing through a reservoir or a river reach. This method has certain limitations also such as requirement of long term Hydrometerological data, knowledge of rainfall process etc.

The river Cauvery in Karnataka rises in Kodagu district. Several tributaries join it in Karnataka upstream of the Mekedatu dam site. The tree diagram, with major tributaries including the four major dams *viz* Hemavati, Harangi, Kabini and KRS, is shown in **Fig. 5.3**. The dam is designed for the PMF, obtained with the hydrometeorological approach.

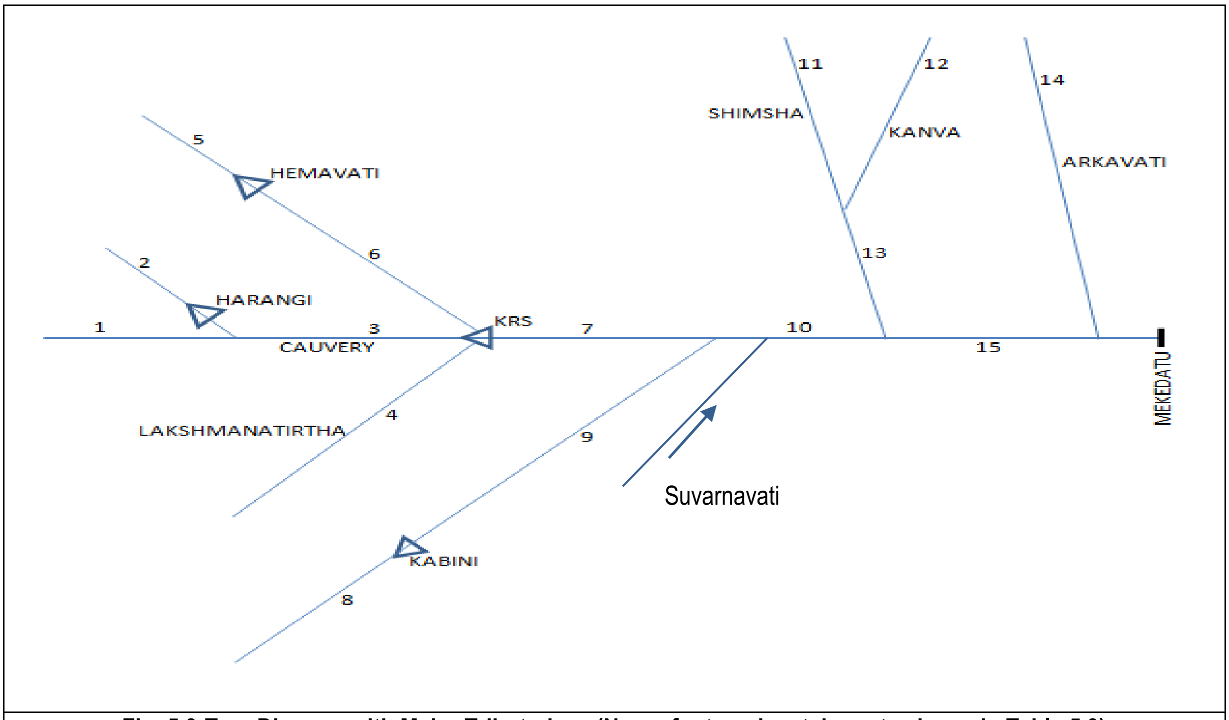


Fig. 5.3:Tree Diagram with Major Tributaries , (Nos refer to sub catchments shown in Table 5.3)

5.1.12.3.2 Design Storm

Design storm determination is the most important part of the Hydrometerological approach. The design storm can be a SPF or PMF or a T-Year storm. In the present proposal, as per the Classification of Dams (IS 11223), for design storm PMF has to be considered. Accordingly, PMF is calculated by using the 1 day, 2 days and 3 days PMP values as per "*PMP Atlas for Cauvery and Other East Flowing River Basins*", Volume I prepared by CWC & IMD.

5.1.12.4 Methodology

The catchment area above Mekedatu is 34,273 km^2. It is divided into 15 subcatchments as shown in Table 5.4, each of area less than 5000 km^2 except one. The method described in the CWC publication "*Flood Estimation Report for Kaveri Basin Subzone*-3(i)" (Design Office Report No. CB/11/1985) is adopted to determine synthetic unit hydrograph and design hydrograph for each subcatchment. It consists of the following steps:

- Preparation of catchment area plan
- Determination of physiographical parameters viz subcatchment area (A), length of longest stream in the subcatchment (L), length of longest stream from a point opposite the centre of gravity to the outlet of the subcatchment (Lc), and equivalent stream slope (S)
- Determination of 1-hour synthetic unitgraph i.e. peak discharge per km2 (qp), peak discharge in the subcatchment (Qp), basin lag (tp), peak time of UG (Tm), and time base of unitgraph (TB)
- Determination of UG ordinates at 1-hour intervals
- Estimation of design storm duration (TD). This was taken to be the same as TB since the PMF is being determined for a storage reservoir
- Estimation of point rainfall and areal rainfall for design storm duration
- Distribution of areal rainfall during design storm duration to obtain hourly rainfall increments
- Estimation of rainfall excess
- Estimation of base flow
- Computation of design flood hydrograph

The catchment area plan and the subcatchments numbered from 1 to 15 are shown in **Fig. 5.3**, corresponding to those shown in the tree diagram of **Fig. 5.2.** are shown in Table below.

Table 5.4:Particulars of Sub Catchments of Basin

No	Description	Catchment area in Sq. Km (A)	Length of Longest Stream (L) in Km	Length of longest stream from a point opp the CG of Catchment to the d/s end of the river segment (Lc) in Km	Equivalent Stream Slope (S)
A	B	C	D	E	F
1	Origin of Cauvery up to Confluence with Harangi	1117.58	72.6	35.4	1.73
2	Origin of Harangi up to Harangi dam	419.60	31.3	17.17	4.86
3	Harangi confluence up to KRS	1591.19	64	29.8	1.65
4	Origin of Lakshmanatirtha up to confluence with KRS	1697.67	96.8	45.3	0.33
5	Origin of Hemavati up to Hemavati dam	2810.00	86.6	38.6	1.99
6	Hemavati dam up to confluence with KRS	2537.38	126	63.3	1.33
7	KRS dam up to confluence with Kabini	1570.90	46.13	32.14	1.54
8	Origin of Kabini up to Kabini dam	2141.90	78.3	42	1.59
9	Kabini dam up to confluence with Cauvery	4533.21	109.5	63	2.26
10	Confluence of Kabini to confluence of Shimsha	3007.94	106.7	54.24	6.20
11	Origin of Shimsha up to confluence with Kanva	6412.41	171.8	81.4	3.71
12	Origin of Kanva up to confluence with Shimsha	1094.26	112	53.4	3.80
13	Shimsha- Kanva confluence up to Shimsha confluence with Cauvery	780.89	38.89	20.04	7.90
14	Origin of Arkavati up to confluence with Cauvery	4352.69	140.12	69.74	2.56
15	Shimsha-Cauvery confluence up to Mekedatu	205.36	23.2	12.08	2.53
	Total Catchment Area (A)	**34273.00**	**1303.94**	**657.61**	

The values of A, L, L_c and S were determined using GIS.

The UG parameters were determined using the following formulae:

$$t_p = 0.553(LL_c/\sqrt{S})^{0.405}$$

$$q_p = 2.043/(t_p)^{0.872}$$

$$T_B = 5.083(t_p)^{0.733}$$

$$T_m = t_p + t_r/2$$

$$Q_p = q_p \times A$$

The unitgraph adopted is in the form of a triangle with the above time base and peak discharge. No attempt was made to reduce the unitgraph widths at 50% and 75% of Q_p with a view to adopt a conservative approach. A one-hour rainfall excess is considered, so t_r = 1.

The calculations are shown in **Table 5.4**, the last column gives the peaks of the unitgraphs. The time base T_B is rounded off to the nearest hour. The unitgraph ordinates are given in **Appendix-6.1, Vol II**

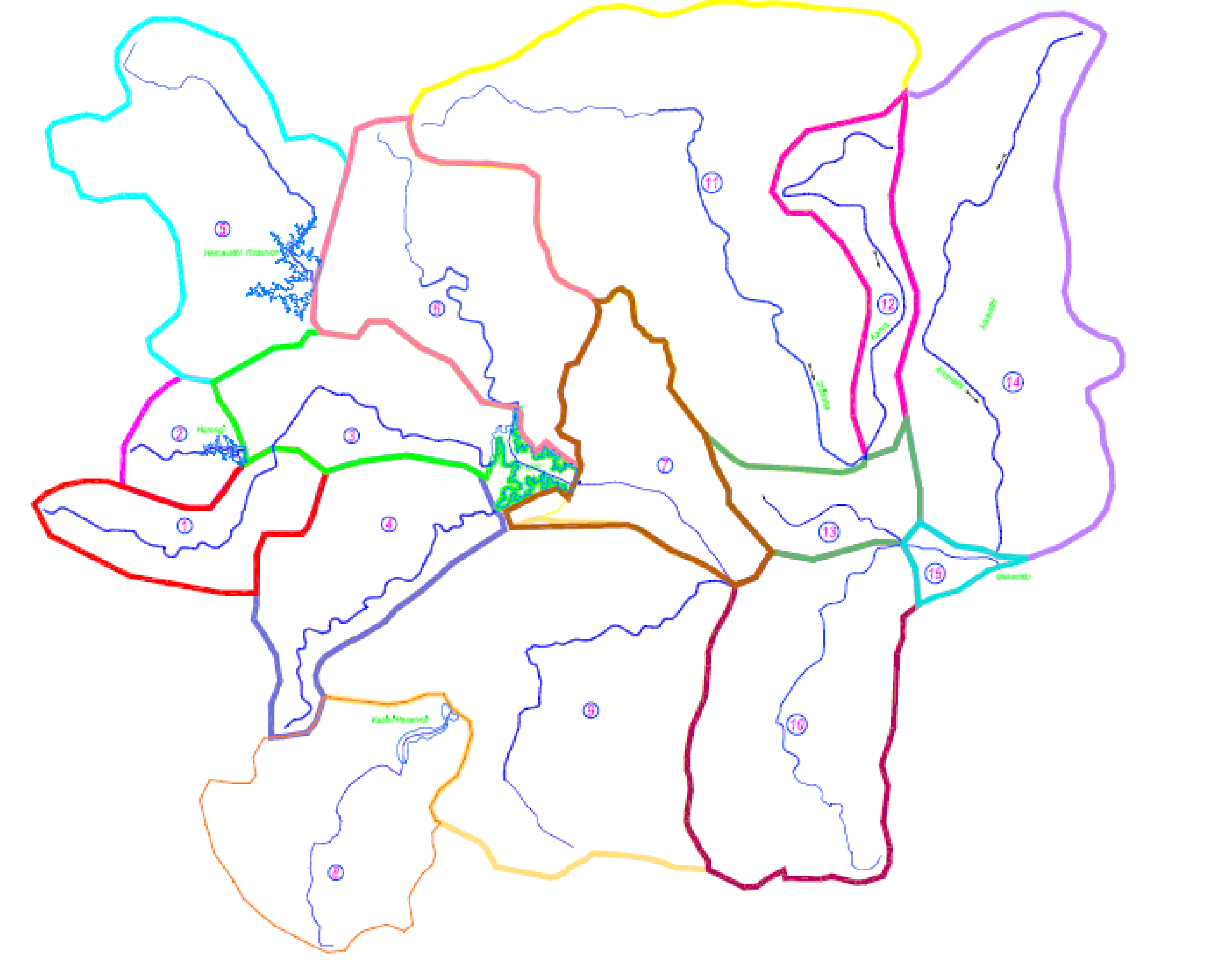


Fig. 5.4:Catchment Area Map with Subcatchment

5.1.12.5Probable Maximum Precipitation

The CWC and IMD have prepared a PMP atlas entitled "PMP Atlas for Cauvery and Other East Flowing River Basins", Volume I of which contains 1-day, 2-day and 3-day PMP values. **Fig. 5.4** shows the area considered by them, where the Cauvery basin up to KRS dam is designated by 302 U (high rainfall), and from KRS dam to a point downstream of Mekedatu by 302 M (lower rainfall). The sub basin 302 U consists of subcatchments 1 to 6 of the present report, and the remaining subcatchments 7 to 15 lie within 302 M.

The PMP values for 302 U are shown in **Table 5.6**, and those for 302 M in **Table 5.7** of this report. The 3-day PMP values are chosen for the calculation of PMF in this report. They are taken from **Table 5.6** for subcatchments 1 to 6 and 8, and **Table 5.7** for subcatchments 7 and 9 to 15. Although subcatchment 8 (Origin of Kabini up to Kabini dam) is included in 302 M, it actually lies in the high rainfall region of Western Ghats, and hence its PMP is taken from 302 U.

The PMP is based on point rainfall, and hence needs to be multiplied by an area correction factor. This factor is shown in **Table 5.8**. The final PMP for each subcatchment is shown in **Table 5.10**. The rainfall is then distributed in time as per **Table 5.9** over the duration TB. Hourly rainfall increments are then derived from the distributed rainfall. A loss rate of 0.5 cm/hr is assumed, and this is deducted from the rainfall increments to obtain the rainfall excess increments. These increments are then sequenced such that the highest increment is paired with the highest UG ordinate, the second highest increment is paired with the second highest UG ordinate, and so on. The sequence is then reversed to maximize the flood. These rainfall excess increments are shown for all the subcatchments in **Appendix – 6.1- Vol II**

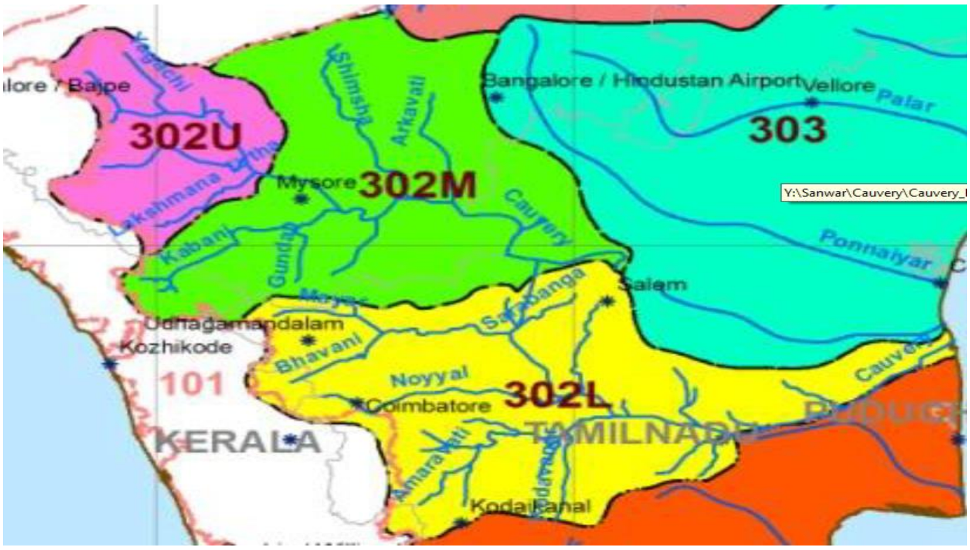


Fig. 5.5: PMP Atlas for Cauvery and Other East Flowing River Basins", Volume I of which contains 1-day, 2-day and 3 day PMP values

5.1.12.6 Generation of Direct Runoff Hydrograph

Direct runoff hydrograph is computed for each subcatchment by the convolution of the corresponding UG and rainfall excess increments. This was done using a Fortran program, which is shown in **Appendix – 6.2 Vol II**

5.1.12.7 Base Flow and Flood Hydrograph

Base flow for each subcatchment is calculated as 0.05 cumec/km^2 of catchment area. This is added to the direct runoff hydrograph to obtain the flood hydrograph for the subcatchment. These hydrographs for all 15 subcatchments are shown in **Appendix – 6.3 Vol II**

5.1.12.8Flood routing

The hydrographs have to be routed through reservoirs and river channels from the first subcatchment up to Mekedatu. All four reservoirs in the catchment being meant for conservation storage, the gates are in practice operated during floods to keep the reservoir level constant, i.e., outflow is kept equal to inflow. Hence routing through the reservoirs is done by equating outflow to inflow. This is on the conservative side, since flood moderation by the reservoirs is not taken into account.

The hydrographs are routed through river channel by the Muskingum method. The equations used are (Engineering Hydrology, K Subramanya)

$$Q2 = C0I2 + C1I1 + C2Q1$$

$$C_0 = (-Kx + 0.5\Delta t)/(K - Kx + 0.5\Delta t)$$

$$C_1 = (Kx + 0.5\Delta t)/(K - Kx + 0.5\Delta t)$$

$$C_2 = (K - Kx + 0.5\Delta t)/(K - Kx + 0.5\Delta t)$$

where Q1 and Q2 are the outflows at the beginning and end of the time interval Δt and I1 and I2 are the corresponding inflows. K and x are constants. Value of x is taken as 0.2.

The constant K is approximately the time taken by a flood wave to traverse the length of the river channel. For the subcatchments, the celerity of the flood wave is assumed as 5 m/s and the value of K is calculated based on the length of the longest stream L. Muskingum coefficients calculated in the above manner are shown in **Table 5.10**.

5.1.13 Results

The routing sequence is as follows where the numbers refer to the subcatchments:

(i) Hydrograph 2 is routed through Harangi reservoir and added to Hydrograph 1. The combined Hydrograph is routed through 3 and added to Hydrograph 3.

(ii) Hydrograph 5 is routed through Hemavati reservoir and then through 6. This Hydrograph is added to Hydrographs 6, 4 and the Hydrograph obtained in step (i) to obtain inflow to KRS.

(iii) KRS inflow is routed through 7 and added to Hydrograph 7

(iv) Hydrograph 8 is routed through Kabini reservoir and then through 9, and added to Hydrograph 9. This is added to the Hydrograph obtained in step (iii)

(v) Hydrograph obtained in step (iii) is routed through 10 and added to Hydrograph 10

(vi) Hydrograph 11 and Hydrograph 12 are added, routed through 13, and added to Hydrograph 13. The resultant Hydrograph is added to that obtained in Step (v).

(vii) Hydrograph obtained in Step (vi) is routed through 15 and added to Hydrograph 15 and then to Hydrograph 14. This gives the PMF at Mekedatu.

Appendix – 6.4 Vol II shows all the routing calculations.

With the above procedure, the PMF obtained is 19,039 cumecs, or 6.73 lakh cusecs. However, Karnataka Engineering Research Station (KERS - **Appendix 6.5 Vol II**) conducting the studies for estimation of the PMF as per CWC recommendations for the KRS dam have estimated the PMF at 16,876 cumecs (5,96,060 cusecs). Thus considering the downstream catchment area influence between the KRS and Mekedatu, a design flood at 22,654 cumecs (8,00,000 cusecs) has been adopted.

Table 5.5: Subcatchment and Unitgraph Parameters

No	Description	A	L	L_c	S	LLc/√S	tp	qp	TB	Tm	Qp
1	Origin of Cauvery up to Confluence with Harangi	1117.58	72.6	35.4	1.73	1952.397	11.896	0.236	31.217	12.396	263.509
2	Origin of Harangi up to Harangi dam	419.60	31.3	17.17	4.86	243.697	5.122	0.492	16.831	5.622	206.304
3	Harangi confluence up to KRS	1591.19	64	29.8	1.65	1483.379	10.643	0.260	28.772	11.143	413.403
4	Origin of Lakshmanatirtha up to confluence with KRS	1697.67	96.8	45.3	0.33	7625.708	20.656	0.146	46.779	21.156	247.400
5	Origin of Hemavati up to Hemavati dam	2810.00	86.6	38.6	1.99	2369.779	12.867	0.220	33.065	13.367	618.738
6	Hemavati dam up to confluence with KRS	2537.38	126	63.3	1.33	6920.694	19.860	0.151	45.451	20.360	382.658
7	KRS dam up to confluence with Kabini	1570.90	46.13	32.14	1.54	1193.072	9.745	0.281	26.971	10.245	440.764
8	Origin of Kabini up to Kabini dam	2141.90	78.3	42	1.59	2611.128	13.383	0.213	34.031	13.883	455.747
9	Kabini dam up to confluence with Cauvery	4533.21	109.5	63	2.26	4584.266	16.809	0.174	40.220	17.309	790.686
10	Confluence of Kabini to confluence of Shimsha	3007.94	106.7	54.24	6.20	2325.008	12.768	0.222	32.878	13.268	666.799
11	Origin of Shimsha up to confluence with Kanva	6412.41	171.8	81.4	3.71	7256.651	20.245	0.148	46.095	20.745	950.990
12	Origin of Kanva up to confluence with Shimsha	1094.26	112	53.4	3.80	3069.935	14.289	0.201	35.706	14.789	219.896
13	Shimsha- Kanva confl to Shimsha confl with Cauvery	780.89	38.89	20.04	7.90	277.251	5.396	0.470	17.488	5.896	366.839
14	Origin of Arkavati up to confluence with Cauvery	4352.69	140.12	69.74	2.56	6112.378	18.886	0.158	43.806	19.386	685.855
15	Shimsha-Cauvery confluence up to Mekedatu	205.36	23.2	12.08	2.53	176.102	4.490	0.551	15.284	4.990	113.246
	Total	**34273**									

Table 5.6: PMP Values for Subcatchments 1 to 6 and 8

Table 3-21: SPS (insitu) and PMP (insitu) values for catchment-302U

Area, sq. km.	1-Day				2-Day				3-Day			
	Storm	In-situ SPS (mm)	MMF	PMP (mm)	Storm	In-situ SPS (mm)	MMF	PMP (mm)	Storm	In-situ SPS (mm)	MMF	PMP (mm)
25	16 Jun 1984	644	1.09	702	15-16 Jun 1984	1037	1.09	1130	15-17 Jun 1984	1309	1.09	1427
100	16 Jun 1984	502	1.09	547	15-16 Jun 1984	806	1.09	879	15-17 Jun 1984	1010	1.09	1101
200	16 Jun 1984	446	1.09	486	15-16 Jun 1984	735	1.09	801	15-17 Jun 1984	924	1.09	1007
500	16 Jun 1984	369	1.09	402	15-16 Jun 1984	665	1.09	725	15-17 Jun 1984	849	1.09	925
1,000	16 Jun 1984	314	1.09	342	15-16 Jun 1984	601	1.09	655	15-17 Jun 1984	772	1.09	841
1,500	16 Jun 1984	292	1.09	318	15-16 Jun 1984	552	1.09	602	15-17 Jun 1984	728	1.09	794
2,000	16 Jun 1984	274	1.09	299	15-16 Jun 1984	515	1.09	561	15-17 Jun 1984	688	1.09	750
3,000	16 Jun 1984	248	1.09	270	15-16 Jun 1984	455	1.09	496	15-17 Jun 1984	623	1.09	679
4,000	16 Jun 1984	226	1.09	246	15-16 Jun 1984	408	1.09	445	15-17 Jun 1984	572	1.09	623
5,000	16 Jun 1984	206	1.09	225	15-16 Jun 1984	375	1.09	409	15-17 Jun 1984	529	1.09	577
7,500	22 Jul 1975	139	1.18	164	23-24 May 1957	214	1.20	257	14-16 May 1972	230	1.15	265
10,000	22 Jul 1975	120	1.18	142	23-24 May 1957	197	1.20	236	14-16 May 1972	215	1.15	247
20,000	14 May 1972	86	1.15	99	14-15 May 1972	152	1.15	175	14-16 May 1972	178	1.15	205
30,000	14 May 1972	74	1.15	85	14-15 May 1972	129	1.15	148	14-16 May 1972	156	1.15	179
40,000	14 May 1972	64	1.15	74	14-15 May 1972	112	1.15	129	14-16 May 1972	139	1.15	160
50,000	14 May 1972	50	1.15	58	14-15 May 1972	98	1.15	113	14-16 May 1972	126	1.15	145

Table 5.7:PMP Values for Subcatchments 7 and 9 to 15

Table 3-19: SPS (insitu) and PMP (insitu) values for catchment-302M

Area, sq. km.	1-Day				2-Day				3-Day			
	Storm	In-situ SPS (mm)	MMF	PMP (mm)	Storm	In-situ SPS (mm)	MMF	PMP (mm)	Storm	In-situ SPS (mm)	MMF	PMP (mm)
25	22 Jul 1975	321	1.18	379	22-23 Jul 1975	351	1.18	414	22-24 Jul 1975	406	1.18	479
100	22 Jul 1975	304	1.18	359	22-23 Jul 1975	340	1.18	401	22-24 Jul 1975	380	1.18	448
200	22 Jul 1975	291	1.18	343	22-23 Jul 1975	330	1.18	389	22-24 Jul 1975	368	1.18	434
500	22 Jul 1975	272	1.18	321	22-23 Jul 1975	312	1.18	368	22-24 Jul 1975	350	1.18	413
1,000	22 Jul 1975	250	1.18	295	22-23 Jul 1975	291	1.18	343	22-24 Jul 1975	327	1.18	386
1,500	22 Jul 1975	235	1.18	277	22-23 Jul 1975	276	1.18	326	22-24 Jul 1975	310	1.18	366
2,000	22 Jul 1975	222	1.18	262	22-23 Jul 1975	263	1.18	310	22-24 Jul 1975	296	1.18	349
3,000	22 Jul 1975	198	1.18	234	22-23 Jul 1975	241	1.18	284	22-24 Jul 1975	272	1.18	321
4,000	22 Jul 1975	180	1.18	212	14-15 May 1972	223	1.15	256	14-16 May 1972	257	1.15	296
5,000	22 Jul 1975	169	1.18	199	14-15 May 1972	214	1.15	246	14-16 May 1972	249	1.15	286
7,500	22 Jul 1975	139	1.18	164	14-15 May 1972	197	1.15	227	14-16 May 1972	230	1.15	265
10,000	22 Jul 1975	120	1.18	142	14-15 May 1972	185	1.15	213	14-16 May 1972	215	1.15	247
20,000	14 May 1972	86	1.15	99	14-15 May 1972	152	1.15	175	14-16 May 1972	178	1.15	205
30,000	14 May 1972	74	1.15	85	14-15 May 1972	129	1.15	148	14-16 May 1972	156	1.15	179
40,000	14 May 1972	64	1.15	74	14-15 May 1972	112	1.15	129	14-16 May 1972	139	1.15	160
50,000	14 May 1972	50	1.15	58	14-15 May 1972	98	1.15	113	14-16 May 1972	126	1.15	145

Table 5.8:Area Reduction Factors for 3-day PMP

Table 3-50: Selected area reduction factor for various catchments (3-day)

Area, sq. km.	Catchment No.						
	301	302L	302M	302U	303	304	305
25	1.00	1.00	1.00	1.00	1.00	1.00	1.00
100	0.96	0.95	0.93	0.92	0.95	0.96	0.96
200	0.94	0.93	0.89	0.87	0.93	0.94	0.94
500	0.90	0.88	0.82	0.80	0.90	0.92	0.92
1,000	0.86	0.84	0.75	0.74	0.87	0.90	0.90
1,500	0.83	0.81	0.71	0.71	0.85	0.87	0.88
2,000	0.81	0.79	0.69	0.69	0.84	0.86	0.86
3,000	0.78	0.75	0.64	0.65	0.81	0.83	0.84
4,000	0.75	0.73	0.61	0.62	0.79	0.80	0.81
5,000	0.74	0.71	0.59	0.60	0.77	0.78	0.79
7,500	0.70	0.67	0.54	0.55	0.72	0.74	0.75
10,000	0.67	0.65	0.50	0.52	0.68	0.71	0.72
20,000	0.58	0.57	0.44	0.45	0.56	0.61	0.63
30,000	0.52	0.51	0.38	0.41	0.48	0.55	0.57

Table 5.9:Time Distribution for 9-Day PMP

Table 3-46: Smoothened TD coefficients for entire Cauvery and Adjoining River Basins and for different catchments for 72-hour rainspells

Sub-durations (hours)	Catchment Wise Smoothened TD Coefficient (%)					All Rainspells
	301	302	303	304	305	Entire Basin
1	11.5	5.9	8.3	8.0	14.5	9.3
3	25.3	13.9	17.8	17.5	26.3	18.5
6	35.7	21.4	24.7	26.3	35.7	27.6
9	42.6	28.1	30.9	32.8	41.2	33.6
12	48.9	33.4	36.6	39.2	46.5	38.6
15	54.8	38.0	42.2	45.2	51.7	43.3
18	59.9	42.6	47.7	51.1	56.7	48.0
21	63.8	46.9	52.9	56.6	60.7	52.2
24	67.7	51.1	57.7	61.2	64.7	56.3
27	71.5	55.2	62.1	65.5	68.6	60.3
30	74.6	59.3	66.0	69.4	72.2	64.2
33	77.7	63.3	69.5	73.2	75.5	68.1
36	80.6	67.1	72.9	77.0	78.4	71.9
39	83.2	70.6	76.4	80.2	81.2	75.6
42	85.9	74.1	79.9	83.3	83.7	79.2
45	88.2	77.3	82.8	86.2	86.1	81.9
48	90.6	80.3	85.5	88.9	88.0	84.5
51	92.6	83.1	88.2	91.3	89.9	87.1
54	94.2	85.7	90.8	93.1	91.8	89.5
57	95.8	88.3	93.2	95.0	93.6	91.8
60	97.1	90.8	95.6	96.8	95.2	94.0
63	98.2	93.2	97.8	98.4	96.7	96.1
66	99.2	95.6	98.8	99.0	98.1	97.5
69	99.6	97.8	99.4	99.6	99.1	98.9
72	100.0	100.0	100.0	100.0	100.0	100.0

Table 5.10:PMP and Muskingum Routing Coefficients

Subcatchment	PMP, cm	L, km	K	x	C0	C1	C2
1	36.88	72.6	4	0.2	-0.08108	0.351351	0.72973
2	31.84	31.3	1	0.2	0.230769	0.538462	0.230769
3	45.82	64	3	0.2	-0.03448	0.37931	0.655172
4	43.24	96.8	5	0.2	-0.11111	0.333333	0.777778
5	28.83	86.6	4	0.2	-0.08108	0.351351	0.72973
6	36.78	126	7	0.2	-0.14754	0.311475	0.836066
7	43.49	46.13	2	0.2	0.047619	0.428571	0.52381
8	47.77	78.3	4	0.2	-0.08108	0.351351	0.72973
9	20.86	109.5	6	0.2	-0.13208	0.320755	0.811321
10	20.31	106.7	5	0.2	-0.11111	0.333333	0.777778
11	21.46	171.8	9	0.2	-0.16883	0.298701	0.87013
12	25.65	112	6	0.2	-0.13208	0.320755	0.811321
13	16.64	38.89	2	0.2	0.047619	0.428571	0.52381
14	22.32	140.12	7	0.2	-0.14754	0.311475	0.836066
15	16.48	23.2	1	0.2	0.230769	0.538462	0.230769

5.1.14 Flood frequency analysis

The flood frequency analysis worked out for different reservoirs already in operation in River Cauvery above the Mekedatu Project and these are indicated in **Table 5.11**:

Table 5.11: Flood frequency analysis for different reservoirs in River Cauvery

Dam	Spillway Capacity		Corresponding Return Period, years
	Cumecs	Cusecs	
Harangi	3398	120000	2,50,00,000
Hemavathy	3625	128000	1,100
Kabini	5493	194000	1,80,000
KRS	9794	345800	1,900
Mettur	10092	356400	1,400*

5.1.14.1 Dam break analysis

Mekedatu Balancing Reservoir is designed for a PMF of 8,00,000 Cusecs / 22650 cumecs. Dam break analysis is a tool used to decide whether a structure should be designed for PMF or a lower flood. Since the present project is already designed for PMF, Dam break analysis is not required.

5.1.15 Sediment Inflow

Sedimentation in a reservoir, in course of time will have the following effects.

a. Reduction in active storage resulting in reducing the capability of the reservoir and not meeting the purpose for which it has been built by way of reduced benefits.

b. Sedimentation at or near the dam will result in blocking the outlet causing difficulties in operation of gates, machinery parts etc. The accumulation of sediment in a given period time affects the design elevation of outlets for water withdrawals from reservoir. It may also cause operational difficulties by tending to jam the intake gates of the outlet when silt accumulation elevation reaches above the gate sill.

c. Accumulation of sediment at the dam face may increase the loading on the masonry / Concrete dam structure beyond what has been provided for.

d. It may also change the backwater profile from what it would have been but for sedimentation. This may also cause increase in flood levels in the upper reaches resulting in additional submergence etc.

e. The process of sedimentation tends to increase the turbidity of water causing environmental problems such as deterioration of water quality and reduction of visibility in the reservoir water for fish survival.

(Source: IS 12182 -1987)

The sediment data at Biligundlu river gauging station for a period 1973 to 2012 is collected and analysis has been carried out which is discussed in Section 8.2.

5.1.16 Reservoir sedimentation analysis

The sediment entering into a storage reservoir gets deposited progressively with the passage of time and thereby reduces the dead as well as total storage capacity of the reservoir, This causes the bed level near the dam to rise and the raised bed level is termed as new zero elevation. It is, therefore, necessary to assess the revised areas and capacities at various reservoir elevations that would be available in future and could be used in simulation studies to test the reservoir performance and also the new zero-elevation.

Several methods are in use for predicting sediment distribution in reservoirs for design purposes. For the present study , **Moody's method** to Find New Zero Elevation and **Area reduction method** to arrive the revised area capacity after Sedimentation is used which is discussed in Section 8.2.

5.1.17 Water balance studies

Karnataka Government proposes to build a dam across Cauvery at Mekedatu for regulating releases at Biligundlu to Tamil Nadu as per CWDT Award further modified by the Hon'ble Supreme Court of India on 16/02/2018, along with Drinking water supply to Bengaluru Metropolitan region, its surrounding areas etc in the Cauavery Basin. As an additional benefit, power generation is also envisaged by utilizing the elevation difference available between the project site and the State border through the releases.

5.1.17.1 Hydrology

5.1.17.1.1 Design Yield Series

Above the Mekedatu site, water is being withdrawn from the Cauvery basin for irrigation, industries and drinking through several large and medium projects as well as anicuts and tanks spread throughout the Basin. Between Mekedatu and Biligundlu (the point on the border with Tamil Nadu where the river is gauged), water withdrawal is negligible since the area is hilly, forested and sparsely populated. Since long term gauged data is available at Biligundlu, and since the intermediate catchment between Mekedatu and Biligundlu is relatively small (less than 700 km^2), it is more accurate to derive the net flows at Mekedatu from those at Biligundlu rather than from flows and withdrawals at points upstream of Mekedatu.

The flow at Biligundlu is related to that at Mekedatu by the relation

$$Q_B = Q_M + R_{MB} - W_{MB} - \Delta S_{MB} \qquad (1)$$

where Q_B is flow at Biligundlu, Q_M is flow at Mekedatu, R_{MB}, W_{MB}, and ΔS_{MB} are respectively the runoff, withdrawal and storage change in the intermediate catchment between Mekedatu and Biligundlu. In the above equation, W_{MB} and ΔS_{MB} are negligible. Hence, rearranging,

$$Q_M = Q_B - R_{MB} \qquad (2)$$

Daily flow at Biligundlu is available for 44 years from 1972-73 to 2016-17. Monthly Biligundlu flows calculated from them are shown in **Table 5.12.**

The intermediate catchment runoff R_{MB} is not gauged, but it can be eliminated from calculations.

5.1.17.1.2 Adjustment in Mekedatu Inflow for future Kerala & Karnataka Utilization

5.1.17.1.2.1 Kerala utilization in a Normal year

Kerala has been allocated 21 TMC from the Kabini basin. But it has been utilizing only 11.7 TMC. In future it may utilize the remaining 9.3 TMC, in which case inflows into Mekedatu will be reduced by that quantity. It is assumed that Kerala will store the water from June to October in proportion to the average flows in Kabini during those months. Thus, Kerala abstractions from Kabini in a normal year are calculated as follows:

Month	Average Flow in Kabini, Mcft	Kerala Abstraction, Mcft
Jun	13082	1142.28
Jul	35691	3116.42
Aug	33348	2911.83
Sep	15044	1313.59
Oct	9344	815.88
Total	**106509**	**9300**

In a sub-normal year, the Kerala abstractions are reduced in the same manner as Biligundlu obligation.

5.1.17.1.2.2 Karnataka utilization in a normal year

In addition to the utilization of 270 TMC of water as awarded by CWDT, as per the Hon'ble Supreme Court order, another 14.75 TMC is available for utilization by Karnataka. Thus, 14.75 TMC is available for Karnataka to be utilized in a normal year by Karnataka.

5.1.17.1.2.3 Bengaluru Metropolitan region Drinking Water

As per the Judgement of the Hon'ble Supreme Court of India dated 16.02.2018, Bengaluru Metropolitan region and its surrounding areas have been allocated an additional 4.75 TMC of water. While fixing the storage of Mekedatu Balancing Reservoir cum drinking water project, emphasis has been laid on following the latest guidelines of CPHEEO. As per this, any new schemes proposed for drinking water supply shall be designed considering the population growth projected upto a minimum of 30 years. In the present scenario, 4.75 TMC of water additionally allocated by the Hon'ble Supreme Court consideres the population as per 2011 census. With the guidelines of CPHEEO in view, the population of Bengaluru Metropolitan region has been projected upto 2044 (33 years from 2011-2044) to arrive at the requirement of drinking water as on 2044. The total dring water requirement will be 64.00 TMC.

As on date, Bengaluru Metropolitan region is being supplied with 14.52 TMC of water from Netkal Balancing reservoir. Thus, it becomes necessary to identify an additional storage to take care of the balance 49.48 TMC for meeting the drinking needs as on 2044. This additional storage has been considered in the present proposal of Mekedatu Balancing Reservoir cum drinking water project.

5.1.17.2 Mekedatu Yield Series

The 10-daily yield series at Mekedatu has been developed and are shown in col 4 of the working tables.

5.1.17.3 Distribution of Water

The primary objective of Mekedatu reservoir is to ensure flows at Biligundlu in accordance with the CWDT Award further modified by the Hon'ble Supreme Court. Other objectives are to provide drinking water to Bangalore Metropolitan region and to generate power from the flow released to Biligundlu.

The most accurate method of analyzing the ability of a reservoir at Mekedatu to meet demands for different end uses is by preparing working tables. The end uses are:

- Ensuring Biligundlu flows as per CWDT Award/SC Order
- Generating power from the above flows
- Utilisation of water to the extent allowed by Hon'ble Supreme Court – such that 177.25 TMC of water is ensured at Biligundlu at 50% dependability.

5.1.17.3.1 Releases mandated by CWDT Award, Post Supreme Court Verdict

As per the CWDT Award, a total flow of 192 TMC should have been ensured at Biligundlu in a normal year, with the following monthly distribution:

Month	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
Flow volume in TMC	10	34	50	40	22	15	8	3	2.5	2.5	2.5	2.5	**192**

These flows can be reduced pro-rata in a sub-normal year.

On 16.2.2018, the Supreme Court passed an order allocating 284.75 TMC as Karnataka's share of Cauvery water, reducing the total flow to be ensured at Biligundlu from 192 TMC to 177.25 TMC. The Order specifies that a pro rata reduction can be effected to in the monthly distribution (14.75 TMC). For the purpose of preparing the working tables, the following distribution in a normal year is adopted in this report, based on pro-rata reduction in monthly flows at Biligundlu (without reducing the environmental flows from February to May)

Month	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flow volume in TMC	9.19	31.24	45.95	36.76	20.22	13.78	7.35
Month	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Total**
Flow volume in TMC	7.35	2.76	2.5	2.5	2.5	2.5	**177.25**

First priority is accorded to the above commitment in preparing the working tables. A scheme for determining releases to Biligundlu in subnormal periods is described later.

5.1.17.3.2 Availability of Water

Detailed computation of the working tables shows that the main project objectives of releasing mandated quantum of water to Tamil Nadu at 50% dependability and providing drinking water to Bangalore Metropolitan Region can be met.

Clause XXVIII of the final order of the Tribunal states thus

"Nothing in the order of this Tribunal shall impair the right or power or authority of any State to regulate within its boundaries the use of water or to enjoy the benefit of water within that State in a manner not inconsistent with the order of this Tribunal".

As per the above order of CWDT, the water flowing in a State can be regulated within its boundaries for using it and enjoying the benefit of the same. Karnataka, by building Mekedatu balancing reservoir cum drinking water project would not only be ensuring releases effected to as per the order (both by CWDT and Hon'ble Supreme Court), but at the same time is entitled to utilize this 60.45 TMC of water by way of storage in the proposed project.

Sub point No 391 of the order of the Hon'ble Supreme Court of India states thus

"At this juncture, we need to recount that as per the National Water policies, not only drinking water has been placed at the top of the other requirements in the order of priority but it has also been predicated that adequate drinking water facilities should be provided for the entire population, both in urban and rural areas and that drinking water should be made a primary consideration. It was declared as well that drinking water needs of Human being and animals should be the first charge on any available water".

5.1.17.3.3 Reservoir Capacity Determination

The storage requirement of Mekedatu Reservoir is arrived at on the following considerations.

- ✓ In the months of June and July, the past data shows that there is a shortfall of 5 TMC and 8 TMC respectively in the water to be released to Tamil Nadu as per the obligation (as computed in the working tables enclosed as Annexure-IV, Hydrology report). This 13 TMC has to be accommodated in the Mekedatu Balancing Reservoir Cum Drinking Water Project.

- ✓ The obligatory environment flow of 10 TMC to be released from February to May (summer months) has to be stored in the Reservoir.
- ✓ Utilizing additional 4.75 TMC of water (Consumptive use) to provide drinking water facility to Bengaluru metropolitan region, its adjoining area etc as per the CWDT award, further modified by the Hon'ble Supreme Court of India vide its Judgement dated 16.02.2018, by way of proposing a scheme to tap water from the foreshore of the intended Mekedatu Balancing Reservoir cum Drinking water project amounting to 23.75 TMC. This allocation is based on the 2011 census data of population. As at present (between 2011 and 2018), the city has witnessed further growth of nearly 28 %.
- ✓ As per CPHEEO guidelines, the drinking water requirement of Bangalore Metropolitan Region will be 64.0 TMC as per projected requirement for the year 2044. Drinking water is a fundamental right under the Constitution and it gets the highest priority as per National Water Policy. Presently, 14.52 TMC is being drawn from Netkal balancing Reservoir (vide para 13, page 101-102, Volume-5 of CWDT report.. Hence the amount of water to be stored to meet Bangalore Metropolitan Region drinking water requirement will be 49.48 TMC i.e., (64 TMC – 14.52 TMC). Two-Thirds of this namely 33.15 TMC will be required as storage. Since the height of the dam cannot be increased as and when needed (as per the then requirement), it is prudent to plan for this additional storage to be provided in the present proposal of the Mekedatu Balancing Reservoir cum Drinking Water Project itself.
- ✓ Allowing for evaporation losses and sedimentation, a provision of 3.85 TMC is considered in the storage

<u>Thus the total live storage required at Mekedatu Reservoir is 13+10+33.15+3.85 = 60.00 TMC.</u>

The gross storage of the reservoir is 67.16 TMC and the dead storage is 7.7 TMC. Hence the live storage available will be 59.46 TMC which almost matches with the required storage of 60 TMC. The intake structure on the foreshore of the Mekedatu reservoir shall be designed to meet this ultimate requirement

5.1.17.3.4 Stages / Phases of development of project

The present Project is proposed to be implemented in a single Stage of 4 working seasons scheduled from September 2020 after a mobilisation period of 3-4 months prior to construction activity and completed by June 2024.

5.1.17.3.5 Evaporation Losses

Evaporation losses are calculated in the working tables based on the mean waterspread area during the concerned ten-day period and the corresponding evaporation rate. Evaporation rates at KRS reservoir are assumed to be valid for Mekedatu also. These rates are as follows:

Month	Jun	Jul	Aug	Sep	Oct	Nov
Evaporation, mm/day	4.199	3.212	3.195	3.293	4.048	3.319
Month	Dec	Jan	Feb	Mar	Apr	May
Evaporation, mm/day	3.187	3.122	3.048	3.408	4.885	5.120

5.1.17.4 Working Tables of Mekedatu Reservoir

Eq (2) gives the inflow at Mekedatu, but it contains the unknown R_{MB}. There is a way to eliminate this unknown. If B_m is the flow to be ensured at Biligundlu in the n^{th} period, then the flow to be released from Mekedatu will be $B_m - R_{MB}$. Thus,

Inflow at Mekedatu from eq (2) = $Q_M = Q_B - R_{MB}$

Flow to be released from Mekedatu = $B_m - R_{MB}$

Hence net inflow available at Mekedatu = $Q_B - R_{MB} - (B_m - R_{MB}) = Q_B - B_m$

Thus, the situation is the same as if inflow at Mekedatu is Q_B and a quantity B_m is released from Mekedatu. The term R_{MB} cancels out, and does not have to be calculated. Accordingly, inflow at Mekedatu is assumed to be equal to the flow at Biligundlu and the flow to be ensured at Biligundlu is released at Mekedatu in preparing the working tables.

5.1.17.4.1 CWDT Releases in Normal Year Modified as per Supreme Court Order

Releases to Tamil Nadu have to be effected monthly as per the schedule given in the award in a normal year (when the virgin flow at Lower Coleroon Anicut is at least 740 TMC), but the award has not spelt out releases in a subnormal year. The first step in preparing working tables, which contain normal as well as subnormal years, is therefore to devise a formula for releases in a subnormal year.

The schedule for releases to Tamil Nadu in a normal year is as follows:

Month	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flow, TMC	9.19	31.24	45.95	36.76	20.22	13.78	7.35
Month	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Total**
Flow, TMC	7.35	2.76	2.5	2.5	2.5	2.5	**177.25**

Releases from June to January are for utilization in Tamil Nadu and from February to May for environmental purposes

5.1.17.4.2 Proposed Releases from Mekedatu in Subnormal Years

Whether a water year is normal or subnormal will be known only at the end of the year, but releases to Biligundlu have to be made from the beginning of the year itself. It is therefore necessary to have a subnormality criterion from June itself. The flow measured at Lower Coleroon Anicut is a small fraction of the virgin flow because of enormous utilization upstream. Hence it cannot serve as a basis to estimate the extent of shortfall in the river flow. It is therefore proposed to use inflows into the four major Karnataka reservoirs, viz Hemavathi, Harangi, Kabini and KRS, as the basis for this purpose.

Over a number of years consisting of normal as well as subnormal years, the criterion to be satisfied is that 50% dependable release to Biligundlu is 177.25 TMC.

5.1.17.4.3 Inflows into Karnataka Reservoirs

The total inflows into the four Karnataka reservoirs are shown in **Table 5.13**. The total was calculated from the equation

Total Inflow into the four reservoirs = Inflow into Hemavathi + Inflow into Harangi + Inflow into Kabini + Inflow into KRS – Outflow over Hemavathi Spillway – Outflow over Harangi Spillway

Monthly inflow data are available for 43 years from 1974-75 to 2016-17 for all the four reservoirs. Harangi reservoir was commissioned in 1979-80 and Hemavathy reservoir in 1977-78, but their inflows before their commissioning are reflected in the KRS inflow.

5.1.17.4.4 Downstream Release Criterion

As already stated, release criterion is needed for every month from the beginning of every water year. Such a criterion is proposed here purely for the purpose of preparing working tables. It is not to be understood that this criterion has any official approval. The total inflow into Hemavathi, Harangi, Kabini and KRS is taken as a measure of the virgin flow in the Cauvery at LCA. Sub-normality is assumed to occur when the total inflow into the four reservoirs in any given period (which may be one or more ten-day periods) in a particular year is less than the long term average flow in that period.

Cumulative monthly inflows into the four Karnataka reservoirs are calculated from the 43 years data of **Table 5.14.** **Table 5.14** shows these cumulative flows (for example, cumulative flow up to end of September in the year 1979-80 = 29514 + 80035 + 154318 + 31665 = 295532 Mcft). The average monthly cumulative flows are shown in the last row of **Table 5.12**. Then the ratio of cumulative flow up to end of each month to the corresponding average cumulative flow is calculated for all the 43 years. These are tabulated in **Table 5.15** (for example, ratio for October in year 1985-86 = 208601/287024 = 0.727). After preparing the working tables, it was found that the ratio has to be multiplied by a factor of 1.09 in order to ensure 177.25 TMC release at 50% dependability. Hence all the ratios in **Table 5.15** are multiplied by 1.09 when used in the working tables, subject to a maximum value of 1.000. Release to Biligundlu is determined by multiplying the normal release by this revised ratio.

Since working tables are prepared for 10-day periods, release to Biligundlu during a 10-day period is calculated in the following way:

(i) For all three periods in a month of a given year, the ratio is taken to be the same as that for the month. For example, from **Table 5.15**, the ratio for the month of August 1988-89 is 0.704. This ratio is applicable for all three 10-day periods of that month. This procedure is adopted since the CWDT Award specifies only monthly flows to be ensured at Biligundlu.

(ii) The Supreme Court-mandated Biligundlu demands are divided into three equal parts for the three 10-day periods of a month and cumulative amounts are calculated (in Mcft):

Period	10-daily	Cumulative	Period	10-daily	Cumulative	Period	10-daily	Cumulative
1-Jun	3063	3063	1-Oct	6740	129880	1-Feb	833	168083
2-Jun	3063	6127	2-Oct	6740	136620	2-Feb	833	168917
3-Jun	3063	9190	3-Oct	6740	143360	3-Feb	833	169750
1-Jul	10413	19603	1-Nov	4593	147953	1-Mar	833	170583
2-Jul	10413	30017	2-Nov	4593	152547	2-Mar	833	171417
3-Jul	10413	40430	3-Nov	4593	157140	3-Mar	833	172250
1-Aug	15317	55747	1-Dec	2450	159590	1-Apr	833	173083
2-Aug	15317	71063	2-Dec	2450	162040	2-Apr	833	173917
3-Aug	15317	86380	3-Dec	2450	164490	3-Apr	833	174750
1-Sep	12253	98633	1-Jan	920	165410	1-May	833	175583
2-Sep	12253	110887	2-Jan	920	166330	2-May	833	176417
3-Sep	12253	123140	3-Jan	920	167250	3-May	833	177250

(iii) The cumulative Biligundlu demand up to end of a given 10-day period is multiplied by the ratio for the corresponding month or unity, whichever is lower. Let the result be *x*. For example, consider the last 10-day period in the month of July in year 1983-84. The ratio for this month is 0.811 from Table 4. Multiplying by the factor 1.037, the ratio becomes 0.811 × 1.037 = 0.841. The cumulative

Biligundlu demand up to the end of that period is 40430 Mcft from the Table given under (ii) above. Product of the two is 0.841 × 40430 = 34002. So, *x* = 34002 Mcft.

(iv) From x, subtract the releases made and spills that have occurred in the previous 10-day periods, i.e., June, 1-July and 2-July in year 1983-84. This will be the release obligation for 3-July. Thus, from the working tables for 1981-82,

Quantity to be released in 3-July is 34002 – 2528.92 – 2528.92 –1919.81 – 8905.96 – 8760.96 – 609.1 = 8748.33 Mcft (the slight difference between this figure and that in the working table is due to round-off).

It is to be noted that even in a normal year (when flow at the end of the water year turns out to be 740 TMC or more), cumulative flows up to some period may be subnormal (*vide* working tables for 1983-84, col 6 August and September). The above method is therefore applied for every year, and if the inflow becomes normal, the downstream release also adjusts itself accordingly. For example, in the year 1983-84, the ratio for June is 0.796 from **Table 5.15**, which becomes 0.826 when multiplied by the factor 1.037. Hence the release obligation in each 10-day period in June is not the mandated 3063 Mcft, but is 0.826×3063 = 2530 Mcft, which is what has been released (ignoring round-off effect).

5.1.17.4.5 Release for Bengaluru Water Supply

Mekedatu balancing reservoir cum drinking water project will ensure monthly releases to downstream riparian states as per CWDT award modified by Hon'ble Supreme Court. Consequent to the fulfillment of downstream riparian states' requirement, water available in the reservoir will be utilized by Karnataka to meet its drinking water requirements amounting to 1374 Mcft (which is the use in a 10-day period corresponding to annual utilization of 49.48 TMC).

5.1.17.4.6 Biligundlu Flows

The downstream releases from Mekedatu together with spill over spillway constitute the flow at Biligundlu. In addition, in very bad years, releases from upstream of Mekedatu will also flow to Biligundlu if required. Col 17 in the working tables (vide **Annexure 8**) shows the flow at Biligundlu realized in this way

5.1.17.5 Results from the Working Tables

Ten-daily working tables are prepared for Mekedatu with FRL of 440 m and MDDL of 395 m, and utilization of 49.48 TMC. The detailed 10-daily working tables are given in the **Annexure 8**. Annual abstracts of the results are shown in **Table 5.16**. Although data is available from 1974 75 to 2016-17, results from 1974-75 to

1984-85 may not be representative since utilizations from Hemavathi, Kabini and Harangi projects were not fully developed during that period. Hence, results for the 32 years from 1985-86 to 2016-17 only are given.

It is seen from **Table 5.16** that flow ensured at Biligundlu is equal to the obligation in distress years. During normal years, it is seen that there is excess as compared to the obligation. In such years, the flow can be stored at Mettur. In particular, it is seen from col 5 of **Table 5.16** that the flow at Biligundlu is equal to or more than 177.25 TMC in 16 out of the 32 years, thus ensuring the mandated release at 50% dependability.

Table 5.12: Monthly Flows at Biligundlu (Mcft)

Year	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Annual
1974-75	1443	48894	120444	55871	43393	15064	11845	3672	2777	2020	3066	8188	**316678**
1975-76	13883	71783	136132	83824	56153	48421	12715	6389	4104	5834	7743	8426	**455408**
1976-77	4388	5552	28701	28208	16594	10841	5447	3304	2662	3076	5942	13461	**128175**
1977-78	6231	41570	48500	49663	86701	35522	15071	8742	4148	4398	8516	8595	**317656**
1978-79	19503	75397	137794	58549	31091	28734	11905	7682	6219	4648	7720	11349	**400589**
1979-80	9820	32109	137048	52960	28956	27895	14254	7220	4828	3630	5416	7339	**331476**
1980-81	29795	181454	89530	40872	33409	21605	13503	8479	4275	5283	5606	9136	**442946**
1981-82	21283	27492	151892	98375	39866	28170	16826	8317	5922	5293	5365	8276	**417078**
1982-83	14122	19155	62752	26817	23436	18264	12806	8222	7950	5660	5467	9660	**214312**
1983-84	10748	23770	58366	49774	28123	21187	16108	10110	9548	10630	7050	9253	**254669**
1984-85	27272	91848	50944	30115	57494	20020	14298	7681	4014	4790	5668	6342	**320485**
1985-86	14165	21457	37397	27209	22369	16789	13826	6599	5065	3587	3550	3711	**175722**
1986-87	3342	11494	47190	27934	30796	26616	12815	10666	10728	4731	3547	4736	**194595**
1987-88	5171	3392	5688	10573	23648	18514	12104	4965	7088	4164	4548	7563	**107417**
1988-89	4485	18821	33170	55304	20427	13766	10518	10976	8331	5385	4688	5476	**191346**
1989-90	4380	29353	36429	25518	29880	17223	12126	6873	8496	4528	4867	7229	**186903**
1990-91	4752	16311	43182	18688	15827	18223	12932	6696	4297	4606	5220	7056	**157790**
1991-92	14258	77866	84959	31184	41147	41887	20616	9477	5019	4317	4633	5210	**340576**
1992-93	16695	61486	99197	53083	47688	31278	15981	8870	4708	5369	5989	8239	**358582**
1993-94	7721	26585	57395	24244	42711	21639	16496	9340	5188	4493	5941	8608	**230361**
1994-95	8138	118622	60896	52680	68373	36357	16937	9117	5371	4725	6181	6600	**393998**
1995-96	5111	23993	24418	48152	31623	19925	11680	12388	4548	4295	5071	4308	**195512**
1996-97	5236	19742	37132	40438	67153	23196	19428	9261	4883	6663	6304	7367	**246804**
1997-98	5673	27652	82947	29579	35227	37704	23460	9986	5327	5673	6858	6960	**277045**
1998-99	3923	40455	40594	43158	44951	30333	17432	8159	5468	6299	7544	10829	**259146**
1999-00	12038	29695	56794	16921	68838	34454	20581	9480	6077	5718	6929	6130	**273656**
2000-01	6133	22033	41950	59497	103547	27586	20923	9367	5710	5835	8827	7835	**319243**
2001-02	8249	27580	25996	24488	38096	29175	14409	6736	4190	4500	4461	3919	**191800**
2002-03	3360	7897	21634	13773	17946	19104	9812	6476	4545	2368	1503	1543	**109960**
2003-04	1408	2441	13397	13385	18010	11178	6464	2503	1523	701	2059	2489	**75557**
2004-05	11094	23767	42883	28863	30512	19863	9114	3980	2956	3401	3763	3712	**183906**
2005-06	3865	36733	87333	53373	90867	51108	24566	9366	4507	7520	5906	8768	**383912**

Year	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Annual
2006-07	12480	62940	69480	27579	25260	25434	12605	5304	4279	5165	4040	4003	**258568**
2007-08	3516	83355	88470	60382	48955	25781	12632	3729	3588	7629	7085	8501	**353623**
2008-09	7765	10946	58437	39308	35747	20440	15489	4537	3689	4335	3918	5509	**210119**
2009-10	4967	39040	33954	55514	27312	21840	11740	5337	3477	4418	6912	8148	**222657**
2010-11	7674	9230	24585	25393	28085	61171	17489	5996	4909	6590	9627	11008	**211756**
2011-12	9306	31055	37344	56371	32924	32406	14268	5503	4476	4593	6250	5954	**240451**
2012-13	4117	4153	11120	20759	21799	11787	12267	4222	4311	2280	2047	1576	**100438**
2013-14	11610	68909	73739	31128	22254	19878	7874	4061	2271	3099	3800	4954	**253577**
2014-15	5942	34379	60385	41342	37802	16698	10413	3973	1571	2594	5202	8302	**228603**
2015-16	12594	27259	26478	22345	19038	28435	9230	3683	1918	1924	1371	2011	**156287**
2016-17	2772	15507	14645	20074	7847	3173	1941	703	306	332	136	1330	**68765**

Table 5.13: Monthly Total Inflows into Four Karnataka Reservoirs (Mcft)

Year	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1974-75	2535	102400	123026	36858	21187	5762	4003	1636	1521	1415	1177	2587
1975-76	69917	82747	150143	68412	35490	17363	4106	2937	2893	3051	5409	2789
1976-77	2199	41172	55527	32081	6893	11322	2516	1293	1298	1280	2674	7234
1977-78	28704	101702	52170	52836	50586	24675	8780	1868	1292	1663	5193	7055
1978-79	61932	110338	158467	45422	18677	16462	5337	3623	1317	2277	4552	4142
1979-80	29514	80035	154318	31665	17144	17922	5353	0	3902	1405	4019	7483
1980-81	73646	209861	93801	41608	22883	15148	6661	1850	962	1144	0	4504
1981-82	41261	78947	173311	60739	23639	14157	5659	4235	1390	1244	416	3309
1982-83	24047	58118	105515	18344	13287	8803	4071	2850	459	39	0	1291
1983-84	24170	74116	100404	44653	27622	11735	8118	3245	2710	5559	2315	2668
1984-85	67682	128377	67706	29714	42229	5827	5546	3267	697	463	2752	2212
1985-86	46966	51034	73225	22702	14674	10376	7554	2364	528	0	341	2158
1986-87	32284	59495	101434	21664	12754	17026	2889	3328	30	0	0	0
1987-88	8199	26320	35416	20842	28643	15824	7684	1799	603	0	1438	1285
1988-89	9463	73335	69139	42949	16675	6488	6456	1302	0	924	283	1231
1989-90	20988	103288	70774	28962	21442	9167	6879	1238	1101	0	0	0
1990-91	29253	72689	103797	24753	22672	15234	8139	1622	824	0	2695	2118
1991-92	45152	167152	94872	23427	26971	14337	3883	232	0	0	0	3894
1992-93	75890	115611	116533	61958	34989	34469	8474	1371	0	0	1043	3804
1993-94	22157	79562	95951	21105	36549	10650	5434	308	0	0	1379	2419
1994-95	52072	197063	83175	58403	56120	21648	6597	2228	1033	980	3875	7112
1995-96	10312	93515	50877	81054	17400	13126	5562	946	232	0	1800	0
1996-97	35176	77922	65506	32429	53715	10535	11481	1816	559	0	0	4310
1997-98	8092	106652	133868	29609	22532	24484	9561	1286	1800	1485	2573	4045
1998-99	21489	111808	65800	45155	40649	19326	10151	1408	1938	0	2215	9660
1999-00	32897	104247	74272	18631	53376	13248	7875	1009	141	753	1193	1726
2000-01	36930	76797	88512	57864	42896	9846	11275	1573	1044	542	6259	4136
2001-02	36214	80806	67298	26006	24219	15348	6244	1271	301	0	138	920
2002-03	18566	26323	78175	20659	35673	15047	6257	1887	836	986	1282	227
2003-04	12102	41161	43697	18336	19960	6289	4114	1391	665	289	1061	9042
2004-05	59165	47133	103571	19435	21305	11622	2997	1448	923	1125	1166	1680
2005-06	16495	121325	117787	56518	50834	19866	10715	2303	922	905	2171	11156
2006-07	39434	134207	93947	40022	20721	18943	9205	2561	984	474	36	288
2007-08	28191	183845	113486	70376	46147	18794	14195	5424	3090	7678	4652	2843
2008-09	21507	48651	106939	43416	38692	16761	10037	3732	1347	846	1082	1619
2009-10	4913	146019	61418	78153	40062	27298	16229	7181	459	0	677	3666
2010-11	13299	48795	60254	52011	40765	62122	19660	7243	1766	1183	5005	3964
2011-12	40736	69868	72409	75693	33533	26924	15703	7673	3594	1899	3307	2427
2012-13	5776	33442	63009	49165	16645	11386	6056	1938	1088	1354	688	711
2013-14	55709	156402	92196	36521	21769	11139	9469	3573	919	84	605	5206
2014-15	18070	111433	97196	59584	30693	9580	14040	3843	983	872	1075	4771
2015-16	61599	43408	34250	25258	20089	19495	7084	2548	1023	644	661	447
2016-17	15132	58216	41941	18129	4504	2360	2130	1048	0	597	569	990

Table 5.14:Cumulative Total Inflows into Four Karnataka Reservoirs (Mcft)

Year	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1974-75	2535	104935	227961	264819	286006	291768	295771	297407	298928	300343	301520	304107
1975-76	69917	152664	302807	371219	406709	424072	428178	431115	434008	437059	442468	445257
1976-77	2199	43371	98898	130979	137872	149194	151710	153003	154301	155581	158255	165489
1977-78	28704	130406	182576	235412	285998	310673	319453	321321	322613	324276	329469	336524
1978-79	61932	172270	330737	376159	394836	411298	416635	420258	421575	423852	428404	432546
1979-80	29514	109549	263867	295532	312676	330598	335951	335951	339853	341258	345277	352760
1980-81	73646	283507	377308	418916	441799	456947	463608	465458	466420	467564	467564	472068
1981-82	41261	120208	293519	354258	377897	392054	397713	401948	403338	404582	404998	408307
1982-83	24047	82165	187680	206024	219311	228114	232185	235035	235494	235533	235533	236824
1983-84	24170	98286	198690	243343	270965	282700	290818	294063	296773	302332	304647	307315
1984-85	67682	196059	263765	293479	335708	341535	347081	350348	351045	351508	354260	356472
1985-86	46966	98000	171225	193927	208601	218977	226531	228895	229423	229423	229764	231922
1986-87	32284	91779	193213	214877	227631	244657	247546	250874	250904	250904	250904	250904
1987-88	8199	34519	69935	90777	119420	135244	142928	144727	145330	145330	146768	148053
1988-89	9463	82798	151937	194886	211561	218049	224505	225807	225807	226731	227014	228245
1989-90	20988	124276	195050	224012	245454	254621	261500	262738	263839	263839	263839	263839
1990-91	29253	101942	205739	230492	253164	268398	276537	278159	278983	278983	281678	283796
1991-92	45152	212304	307176	330603	357574	371911	375794	376026	376026	376026	376026	379920
1992-93	75890	191501	308034	369992	404981	439450	447924	449295	449295	449295	450338	454142
1993-94	22157	101719	197670	218775	255324	265974	271408	271716	271716	271716	273095	275514
1994-95	52072	249135	332310	390713	446833	468481	475078	477306	478339	479319	483194	490306
1995-96	10312	103827	154704	235758	253158	266284	271846	272792	273024	273024	274824	274824
1996-97	35176	113098	178604	211033	264748	275283	286764	288580	289139	289139	289139	293449
1997-98	8092	114744	248612	278221	300753	325237	334798	336084	337884	339369	341942	345987
1998-99	21489	133297	199097	244252	284901	304227	314378	315786	317724	317724	319939	329599
1999-00	32897	137144	211416	230047	283423	296671	304546	305555	305696	306449	307642	309368
2000-01	36930	113727	202239	260103	302999	312845	324120	325693	326737	327279	333538	337674
2001-02	36214	117020	184318	210324	234543	249891	256135	257406	257707	257707	257845	258765
2002-03	18566	44889	123064	143723	179396	194443	200700	202587	203423	204409	205691	205918
2003-04	12102	53263	96960	115296	135256	141545	145659	147050	147715	148004	149065	158107
2004-05	59165	106298	209869	229304	250609	262231	265228	266676	267599	268724	269890	271570
2005-06	16495	137820	255607	312125	362959	382825	393540	395843	396765	397670	399841	410997
2006-07	39434	173641	267588	307610	328331	347274	356479	359040	360024	360498	360534	360822
2007-08	28191	212036	325522	395898	442045	460839	475034	480458	483548	491226	495878	498721
2008-09	21507	70158	177097	220513	259205	275966	286003	289735	291082	291928	293010	294629
2009-10	4913	150932	212350	290503	330565	357863	374092	381273	381732	381732	382409	386075
2010-11	13299	62094	122348	174359	215124	277246	296906	304149	305915	307098	312103	316067
2011-12	40736	110604	183013	258706	292239	319163	334866	342539	346133	348032	351339	353766
2012-13	5776	39218	102227	151392	168037	179423	185479	187417	188505	189859	190547	191258
2013-14	55709	212111	304307	340828	362596	373735	383204	386778	387696	387780	388385	393590
2014-15	18070	129503	226699	286283	316976	326557	340596	344439	345422	346294	347369	352140
2015-16	61599	105008	139258	164516	184605	204100	211184	213732	214756	215400	216061	216508
2016-17	15132	73348	115289	133418	137922	140282	142411	143459	143459	144057	144626	145616
Average	**30361**	**121146**	**201098**	**240810**	**271413**	**287916**	**296388**	**298878**	**299769**	**300499**	**302076**	**305108**

Table 5.15. Ratios of Monthly Cumulative Inflows to the Average

Year	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1974-75	0.083	0.866	1.134	1.100	1.054	1.013	0.998	0.995	0.997	0.999	0.998	0.997
1975-76	2.303	1.260	1.506	1.542	1.498	1.473	1.445	1.442	1.448	1.454	1.465	1.459
1976-77	0.072	0.358	0.492	0.544	0.508	0.518	0.512	0.512	0.515	0.518	0.524	0.542
1977-78	0.945	1.076	0.908	0.978	1.054	1.079	1.078	1.075	1.076	1.079	1.091	1.103
1978-79	2.040	1.422	1.645	1.562	1.455	1.429	1.406	1.406	1.406	1.410	1.418	1.418
1979-80	0.972	0.904	1.312	1.227	1.152	1.148	1.133	1.124	1.134	1.136	1.143	1.156
1980-81	2.426	2.340	1.876	1.740	1.628	1.587	1.564	1.557	1.556	1.556	1.548	1.547
1981-82	1.359	0.992	1.460	1.471	1.392	1.362	1.342	1.345	1.345	1.346	1.341	1.338
1982-83	0.792	0.678	0.933	0.856	0.808	0.792	0.783	0.786	0.786	0.784	0.780	0.776
1983-84	0.796	0.811	0.988	1.011	0.998	0.982	0.981	0.984	0.990	1.006	1.009	1.007
1984-85	2.229	1.618	1.312	1.219	1.237	1.186	1.171	1.172	1.171	1.170	1.173	1.168
1985-86	1.547	0.809	0.851	0.805	0.769	0.761	0.764	0.766	0.765	0.763	0.761	0.760
1986-87	1.063	0.758	0.961	0.892	0.839	0.850	0.835	0.839	0.837	0.835	0.831	0.822
1987-88	0.270	0.285	0.348	0.377	0.440	0.470	0.482	0.484	0.485	0.484	0.486	0.485
1988-89	0.312	0.683	0.756	0.809	0.779	0.757	0.757	0.756	0.753	0.755	0.752	0.748
1989-90	0.691	1.026	0.970	0.930	0.904	0.884	0.882	0.879	0.880	0.878	0.873	0.865
1990-91	0.964	0.841	1.023	0.957	0.933	0.932	0.933	0.931	0.931	0.928	0.932	0.930
1991-92	1.487	1.752	1.527	1.373	1.317	1.292	1.268	1.258	1.254	1.251	1.245	1.245
1992-93	2.500	1.581	1.532	1.536	1.492	1.526	1.511	1.503	1.499	1.495	1.491	1.488
1993-94	0.730	0.840	0.983	0.908	0.941	0.924	0.916	0.909	0.906	0.904	0.904	0.903
1994-95	1.715	2.056	1.652	1.622	1.646	1.627	1.603	1.597	1.596	1.595	1.600	1.607
1995-96	0.340	0.857	0.769	0.979	0.933	0.925	0.917	0.913	0.911	0.909	0.910	0.901
1996-97	1.159	0.934	0.888	0.876	0.975	0.956	0.968	0.966	0.965	0.962	0.957	0.962
1997-98	0.267	0.947	1.236	1.155	1.108	1.130	1.130	1.124	1.127	1.129	1.132	1.134
1998-99	0.708	1.100	0.990	1.014	1.050	1.057	1.061	1.057	1.060	1.057	1.059	1.080
1999-00	1.084	1.132	1.051	0.955	1.044	1.030	1.028	1.022	1.020	1.020	1.018	1.014
2000-01	1.216	0.939	1.006	1.080	1.116	1.087	1.094	1.090	1.090	1.089	1.104	1.107
2001-02	1.193	0.966	0.917	0.873	0.864	0.868	0.864	0.861	0.860	0.858	0.854	0.848
2002-03	0.612	0.371	0.612	0.597	0.661	0.675	0.677	0.678	0.679	0.680	0.681	0.675
2003-04	0.399	0.440	0.482	0.479	0.498	0.492	0.491	0.492	0.493	0.493	0.493	0.518
2004-05	1.949	0.877	1.044	0.952	0.923	0.911	0.895	0.892	0.893	0.894	0.893	0.890
2005-06	0.543	1.138	1.271	1.296	1.337	1.330	1.328	1.324	1.324	1.323	1.324	1.347
2006-07	1.299	1.433	1.331	1.277	1.210	1.206	1.203	1.201	1.201	1.200	1.194	1.183
2007-08	0.929	1.750	1.619	1.644	1.629	1.601	1.603	1.608	1.613	1.635	1.642	1.635
2008-09	0.708	0.579	0.881	0.916	0.955	0.958	0.965	0.969	0.971	0.971	0.970	0.966
2009-10	0.162	1.246	1.056	1.206	1.218	1.243	1.262	1.276	1.273	1.270	1.266	1.265
2010-11	0.438	0.513	0.608	0.724	0.793	0.963	1.002	1.018	1.021	1.022	1.033	1.036
2011-12	1.342	0.913	0.910	1.074	1.077	1.109	1.130	1.146	1.155	1.158	1.163	1.159
2012-13	0.190	0.324	0.508	0.629	0.619	0.623	0.626	0.627	0.629	0.632	0.631	0.627
2013-14	1.835	1.751	1.513	1.415	1.336	1.298	1.293	1.294	1.293	1.290	1.286	1.290
2014-15	0.595	1.069	1.127	1.189	1.168	1.134	1.149	1.152	1.152	1.152	1.150	1.154
2015-16	2.029	0.867	0.692	0.683	0.680	0.709	0.713	0.715	0.716	0.717	0.715	0.710
2016-17	0.498	0.605	0.573	0.554	0.508	0.487	0.480	0.480	0.479	0.479	0.479	0.477

Table 5.16. Annual Abstracts of Mekedatu Reservoir Working Tables

	Initial Level	Inflow*	At Biligundlu		
			Obligation	Met	Excess
1	2	3	4	5	6
Year	m	Mcft	Mcft	Mcft	Mcft
1985-86	440.00	167647	139718	139718	0
1986-87	425.16	186178	151154	151154	0
1987-88	418.48	104240	89193	89193	0
1988-89	398.85	184724	137503	137503	0
1989-90	406.88	178023	158946	158946	0
1990-91	397.98	148924	148924	149665	741
1991-92	394.95	331276	177250	223593	46343
1992-93	440.00	349282	177250	297091	119841
1993-94	440.00	221838	165980	169751	3771
1994-95	440.00	384698	177250	332521	155271
1995-96	440.00	187914	165564	165564	0
1996-97	421.40	237953	176784	176784	0
1997-98	433.01	268628	177250	204718	27468
1998-99	440.00	250150	177250	198047	20797
1999-2000	440.00	264369	177250	212275	35025
2000-01	440.00	310025	177250	257968	80718
2001-02	440.00	182853	155890	155890	0
2002-03	424.61	104818	104818	123992	19174
2003-04	394.95	71139	71139	71139	0
2004-05	394.95	174938	163604	163604	0
2005-06	394.95	375111	177250	274117	96867
2006-07	440.00	249268	177250	197968	20718
2007-08	439.49	344365	177250	291312	114062
2008-09	440.00	202693	177250	177250	0
2009-10	423.46	214618	177250	177250	0
2010-11	412.79	206086	177250	177250	0
2011-12	406.45	231480	177250	177250	0
2012-13	414.34	96251	96251	105755	9504
2013-14	394.95	244277	177250	177250	0
2014-15	414.09	219740	177250	177250	0
2015-16	407.45	148746	130432	130432	0
2016-17	394.95	63302	63302	63302	0
Average	424.56	242141	157973	200187	42214

5.1.18 Reservoir flood routing

The spill way has been designed for 8,00,000 cusecs (22, 654 cumecs) and the corresponding maximum water level attained with the spillway configuration proposed is 441.20 m. Flood routing has been carried out. For details refer **Chapter 5.**

5.1.19 Tail water rating curves

Flow is a variable, usually required for hydrological analysis but, continuous measurement of flow past a river section is usually impractical or prohibitively expensive. However, stage can be observed continuously or at regular short time intervals with comparative ease and economy. Fortunately, a relation exists between stage and the corresponding discharge at the given river section, which is termed as Stage-Discharge relationship or Stage-Discharge Rating Curve or simply, Rating Curve.

A rating curve is established by making a number of concurrent observations of stage and discharge over a period of time covering the expected range of stages at the river gauging section. At many locations, the discharge is not a unique function of stage; variables such as surface slope or rate of change of stage needs to be determined to obtain the complete relationship in such circumstances. The rating relationship thus established is used to transform the observed stages into the corresponding discharges.

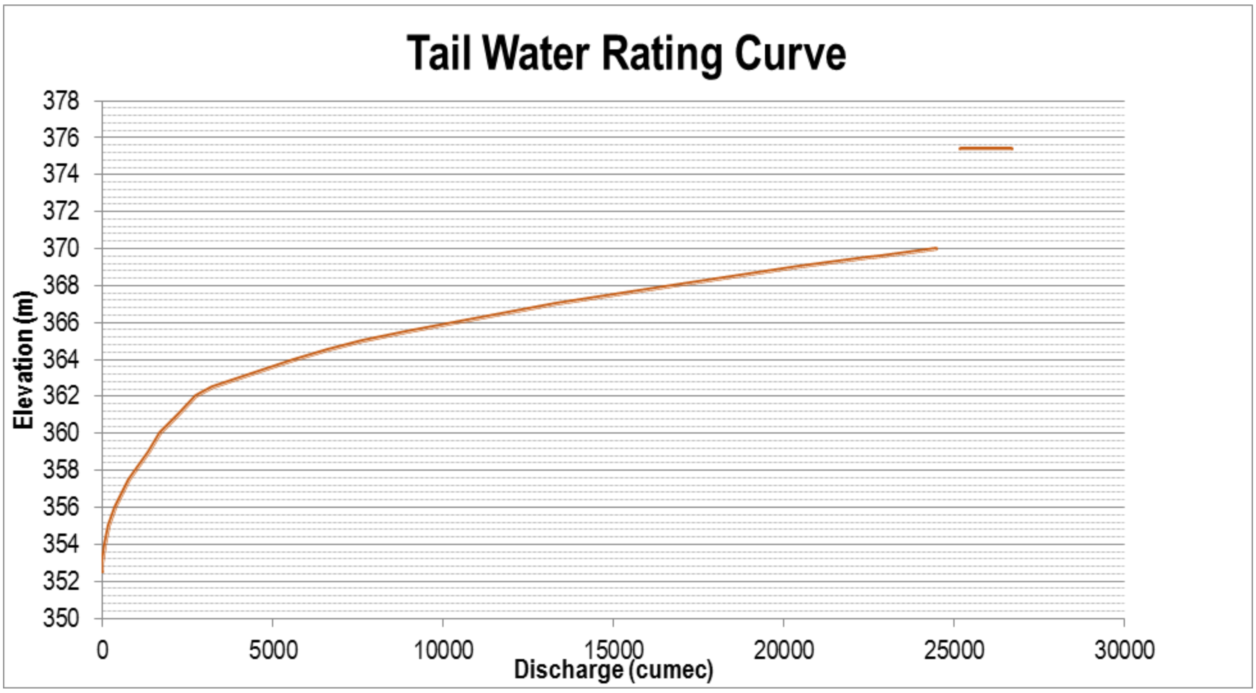


Fig. 5.6: Tail water Rating Curve at dam site

The details rating curve generated for the present study is shown in **Fig. 5.6** and also attached as **Appendix 9 Vol II**

5.1.20 Backwater Studies

The Backwater levels for 25 and 50 year floods at Mekedatu reservoir is arrived at to assess the extent of submergence at the proposed FRL of the balancing reservoir (RL 440.00 m).

IS 11123 recommends that structures that will be submerged in the backwater of a dam by a 25-year flood and land submerged by a 50-year flood be acquired. Accordingly, 25-year and 50-year floods are determined and backwater due to construction of Mekedatu reservoir is calculated.

5.1.20.1 Annual Peak Flows

Annual peak discharges for 45 years are available at Biligundlu from the CWC gauging records. The following Table shows these discharges (in cumecs):

Table 5.17: Biligundlu annual peak discharges for 45 years

Year	Discharge	Year	Discharge	Year	Discharge	Year	Discharge
1971	1235	**1982**	1558	**1993**	3279	**2004**	524
1972	2649	**1983**	2532	**1994**	1314	**2005**	1103
1973	3825	**1984**	3981	**1995**	5311	**2006**	3656
1974	2510	**1985**	1158	**1996**	2009	**2007**	1959
1975	4427	**1986**	2474	**1997**	1712	**2008**	3883
1976	979	**1987**	1216	**1998**	2730	**2009**	2702
1977	2362	**1988**	1420	**1999**	1586	**2010**	1602
1978	2373	**1989**	1595	**2000**	2023	**2011**	1472
1979	2982	**1990**	1618	**2001**	2412	**2012**	1888
1980	4562	**1991**	146	**2002**	1213	**2013**	862
1981	4370	**1992**	6688	**2003**	954	**2014**	2289
						2015	1061

Since Mekedatu dam site is very close to Biligundlu and the intermediate catchment is relatively small (less than 700 km^2), the above discharges are taken to be valid at Mekedatu.

5.1.20.2 Flood Frequencies

The flood frequencies are determined from the above data by the Gumbel method (Engineering Hydrology, K. Subramanya, 1984, pp. 212-215). The flood of a return period T is given by the equation.

$$X_T = X_m + K\sigma$$

where X_T = flood of return period T, X_m = Mean annual flood, $K = (Y_T - Y_n)/S_n$, $Y_T = -\ln \ln (T/(T-1))$, Y_n = Reduced mean in Gumbel's distribution corresponding to the record length n, S_n = Reduced standard deviation in Gumbel's distribution corresponding to the record length n, and σ = standard deviation of the annual peak flood.

Since 45 years data are available, n = 45. From the Tables, Y_n = 0.5453 and S_n = 1.148. From the peak flood data, X_m = 2345 and σ = 1372. Value of Y_T is 3.1985 for T = 25 years and 3.9019 for T = 50 years. With these values, the 25-year flood works out to 5517 cumecs and the 50-year flood to 6357 cumecs.

Similar calculations give the 100-year flood as 7192 cumecs, 500-year flood as 9120 cumecs, and 1000-year flood as 9950 cumecs.

5.1.20.3 Backwater Computation

The backwater computation was carried out using the HEC-RAS software package developed by the US Army Corps of Engineers. The software uses the standard step method and requires flow cross sections to be input for solving the problem. A total of 32 cross sections were generated from toposheets at 1 km intervals covering 32 km length of the river from the dam site, and were input to the software. Reservoir level was assumed to be at FRL (RL 440 m) and the 25-year or 50-year flood was assumed to enter at this condition. The program was then executed to determine the water levels.

For comparison, normal water levels (i.e., pre-Mekedatu dam condition) were also calculated for the two floods with the same software. The downstream boundary condition for these cases were given as the normal depth corresponding to the slope 0.0016, which is the average longitudinal slope of the river bed near the dam site.

5.1.20.4 Results

The water levels are presented in **Fig. 5.7** for the 25-year flood. It is seen that the backwater level is practically horizontal at RL 440 m from the dam up to Ch 30 km upstream. Beyond this point, the backwater level merges with the normal water level. This happens because the bed slope of the river is steep.

Fig. 5.8 shows water levels for the 50-year flood. It is very similar to the 25-year flood case. The backwater level merges with the normal water level in this case also at Ch 30 km upstream.

Hence land acquisition is necessary only up to RL 440 m.

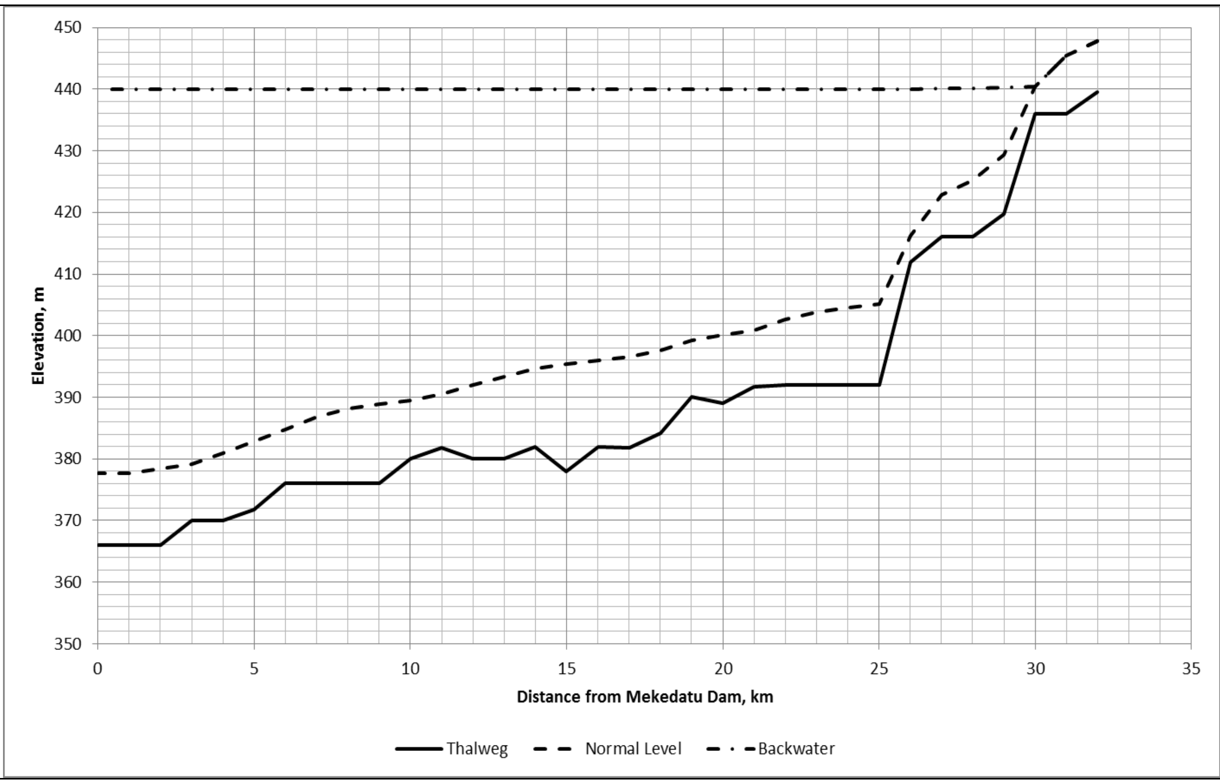


Fig. 5.7: Normal and Backwater Levels for 25-Year Flood

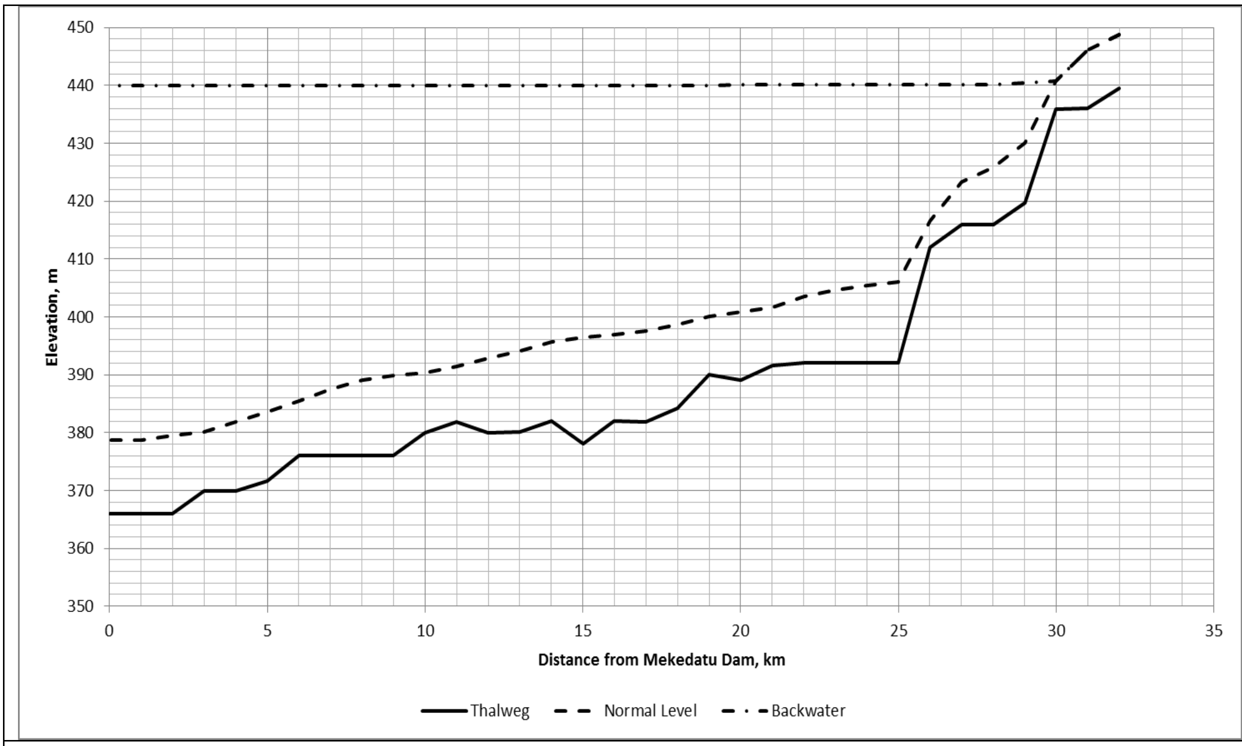


Fig. 5.8: Normal and Backwater Levels for 50-Year Flood

5.2 Simulation and performance testing of alternate plans

5.2.1 Details of the system configuration for each alternate method.

For simulation and performance, FRL from RL 410.00 m to RL 440.00 m has been considered.

5.2.2 Period of simulation and operational policies used

Period of simulation is 10 daily for 43 years. In the Operation policy (more fully described in **Annexure 4 – Hydrology Report**), first priority is given to releasing water to Tamil Nadu as per CWDT Award further modified by the Hon'ble Supreme Court of India vide its Judgemenet dated 16/02/2018. Second priority is given for supply of drinking water to Bengaluru, its surrounding areas etc in the Cauvery basin.

5.2.3 Demands, their time distribution and justification in the light of existing and proposed utilization of the system

There are only two types of demands, namely, 177.25 TMC of water to be released to Tamil Nadu according to the schedule prescribed by CWDT further modified by the Hon'ble Supreme Court of India vide its Judgemenet dated 16/02/2018 and 4.75 TMC for drinking water to Bengaluru Metropolitan Region, is surrounding areas etc at a uniform rate.

5.2.4 External constraints on the system

There are no external constraints on the system apart from the CWDT Award.

5.2.5 Criteria considered and used in performance testing of alternate plans, comparative results and final choice

Criteria considered are success in meeting the obligations to release the required quantum of water to Tamil Nadu as per Schedule and meeting the envisaged drinking water need. The comparison of the alternateives imply constructing the reservoir with FRL at RL 440.00 m which would help in achieving the objectives for which it is envisaged.

5.3 Hydrologic studies for design flood, design flood level etc

5.3.1 Design flood for safety of structure

a) Design criteria and overall approach

The overall approach is Hydrometeorological approach

b) Salient details of the studies made and final estimate

The catchment has been divided in to 15 sub catchments. The PMP has been taken from the PMP Atlas published by CWC & IMD for Cauvery basin. The Synthetic Unit Hydrographs for each sub basin are developed based on the Flood Estimation Report of CWC. The PMF from each sub catchment has been routed through reservoirs and channels to arrive at the PMF at Mekedatu.

c) Comparison of the estimated flood with the design flood of existing projects in the vicinity

PMF (for the present Mekedatu balancing Reservoir cum Drinking Water Project) considered for design is 8,00,000 cusecs. Compared to this, the design flood at KRS Dam is 3,45,868 cusecs, at Kabini Dam is 1,94,150 cusecs and at Mettur Dam is 4,56,089 cusecs.

d) Himalayan rivers

Not applicable

e) Design storm input

For design storm, 3-day PMP has been considered and details have been discussed in Annexure 4 – Hydrology Report.

f) Inundation map corresponding to MWL / FRL

Back water level computation is given in 5.1.3.2 of **Annexure 4 – Hydrology report**. Inundation map is the same as Submergence map furnished with the report.

5.3.2 Design flood for flood control component

The proposed balancing reservoir is not designed as a flood control dam

5.3.3 Hydrologic design of surface drainage

Not applicable

5.3.4 Design flood for planning construction and diversion arrangement

For river diversion during construction, the diversion flood is worked out at 5517 cumecs equilvalent of 1 in 25 year frequency. A diversion channel is proposed for 1st stage diversion and three sluices of size 3.0 x 3.0 m are proposed with a peir width of 6.0 m in the spillway portion for diversion in the further stages of construction.

5.3.5 Determination of flood levels for structure on river bank

There are no existing structures on River Bank

5.3.6 Determination of outlet levels

Refer Section 4.3, **Annexure 4- Hydrology Report** for details

5.3.7 Tail water rating curves

Refer Section 5.2, **Annexure 4 – Hydrology report** for details

5.4 Effect of project development on hydrologic regime – effect on the following

a) Impact on existing projects in the downstream of planned project

Mettur Dam in Tamil Nadu is situated on the downstream of the proposed balancing reservoir. The releases of 177.25 TMC of water to Tamil Nadu according to the schedule prescribed by CWDT further modified by the Hon'ble Supreme Court of India vide its Judgemenet dated 16/02/2018 will be stored in it for further utilization.

b) Low flows

Out of the 177.25 TMC to be released to Tamil Nadu, 10 TMC is earmarked as Environmental flows to take care of the low flows on the downstream.

c) Flood hydrology

The flood will be moderated on account of construction of this dam

d) Total run-off

Between Mekedatu & Mettur, the total run off is about 27 TMC (2 TMC upto Biligundlu and 25 TMC between Biligundlu & Mettur). The release of 177.25 TMC will therefore dominate the flow.

e) River hydraulics (short & long terms)

Since the flow will be regulated as per the Schedule prescribed by CWDT further modified by the Hon'ble Supreme Court of India vide its Judgemenet dated 16/02/2018, the river Hydraulics will be in a stable regime.

f) Sediment yields, sediment carrying capacities, aggradations & degradations at various locations

After construction of this reservoir, the sediment load will be reduced downstream. Since the bed downstream is rocky, there will not be any degradation.

g) Water quality

Since the volume of water stored in the dam is large (67.16 TMC), any pollution will be diluted and water quality will improve.

h) Water demand

The release of 177.25 TMC is meant to meet the water demand as per CWDT Award further modified by the Hon'ble Supreme Court of India vide its Judgemenet dated 16/02/2018.

Chapter 6
Hydro Geology

6.1 Hydro Geological setup

A major part of the district which is occupied by a relatively shallow layers of red sandy soil (60%), and the remaining by red loamy soil. Red sandy soil mainly occurs in Channapatna, Kanakapura and Ramanagara taluks in undulating land slopes. These soils are derived from acidic rocks, granites and granitic gneiss. These soils occur on gently sloping pediplain. They are dark brown colour with loam to sandy loam composition on the surface and sandy clay loam to clayey soils in the sub surface horizons. They are neutral to alkaline in nature. Red loamy soils generally occur on hilly to undulating land slope on granite and granite gneisses. It is mainly covered in Magadi taluk and parts of Channapatna and Kanakapura taluks.

6.2 Ground water resource availability

Groundwater studies suggests, water resources occur in weathered and jointed zones of gneisses, granites, Charnokite, Closepet granite and alluvium along river courses in unconfined or water table conditions where as it occurs in semi confined to confined conditions in fractured formations at deeper depths. The thickness of weathering in major part of the district ranges from 5-10 m and more than 10 m in rest of the district. Unconfined aquifer system is taped by dug wells and shallow bore wells. This zone extends down to 25 metres below ground level. The yield tests in dug wells show that the specific capacity is in the range of 0.64 to 4.18 lpm/mdd .The dug wells generally sustain discharge in the range of 10 to 20 m^3 /day. The yield range in bore wells is mostly less than one lps and occasionally up to 5 lps

6.3 Ground water development prospects

Chamarajanagara District

Groundwater resource estimation of the district indicates that the net ground water availability for future irrigation development is about 11930 Ham, and the balance of ground water irrigation potential is about 13826 Ha. Based on this and the present status of ground water development (i.e. through shallow dug wells and bore wells alone where the deeper aquifers are not much exploited), it is proposed that the ground water development structures viz. dug wells and dug cum bore wells and bore wells in those areas are falling under safe and semi critical category. Dug wells are the ideal structures in command areas of Yalandur taluk and Kollegal taluk. Dug cum bore wells and bore wells are suitable in the other areas. The diameter may be 5.00m to 8.00m and the depth may be 10.00 to 25.00 metres below ground level (mgbl). Bore wells may be drilled from the bottom of the dug wells up to the depth of 30.00 to 60.00 metres below ground level (mgbl) to tap weathered and fractured zone wherever it is feasible. Bore wells are possible in all topographic conditions.

It may be taken into consideration while designing the various abstraction structures; emphasis for a farm budget model can be evolved for the structure with a designed discharge of 2 to 5 lps with an irrigable command of 1.25 to 3.00 ha. The colluviums of Yalandur area also require scrutiny to estimate the total thickness and its spread over area for further development. Ground water development may also be considered on the banks of rivers and streams in Yalandur taluk in general and command areas of Yalandur and Kollegal taluks. Reference to the density of wells in cultivable lands of Kollegal and ChamarajaNagar has to be considered for further ground water development.

Ramanagaram District

Sustainability of ground water resource and its judicious use should be given prime importance while making development strategy. In critical and over exploited areas artificial recharge and rainwater harvesting measures are recommended to augment ground water resources. About 1626 ham of ground water resources is available in the district (for further development) which can create 2454 ha of additional irrigation potential. However the development is recommended only in areas categorised as safe and semi critical In such areas, potential aquifers can be located by hydrogeological surveys aided by geophysical methods. Spacing norm of 200 m between two bore wells may be strictly adhered to avoid interference

6.4 Anticipated behavior of ground water on downstream after implementation of the project

The project development and the creation of reservoir due to impounding of water u/s of dam could lead to substantial increase in the ground water table around the nearby reaches of the Reservoir which in turn benefit the people.

6.5 Quality of ground water

Chamarajanagara District

The water samples from National Hydrograph monitoring Stations (NHS) were analysed to decipher the shallow aquifer water quality. The results indicate that the water is alkaline in nature with average pH value of 8.4. The average values of other important parameters are like Ca-94.47ppm, Mg-361.09ppm, TH-

302.21ppm, Cl- 270.06 ppm, F-1.05ppm etc., which are falling in desirable to permissible class as per ''Indian standard drinking water specification'' except for Mg concentration which falls beyond the permissible limit. The nitrate and chloride contents are found more in few pockets in Chamarajanagar and Yalandur taluks. Due to intensive irrigational activities in the command area it is observed Nitrate concentrations are beyond 100 ppm. Similarly, Fluoride concentration beyond 1.5ppm is observed in the eastern parts of Kollegal taluk. Considering the ground water quality in the district for irrigation purposes it is found that the Specific Conductance ranges from 512 to 4850 (average 1668.20 m mhos/cm at 25°C), chloride is in the range of 57 to 852 ppm (average 270.06) and sodium is in the range of 6ppm to 856ppm (average 79.54) indicating low sodium type of ground water and good to permissible class of water for irrigational purposes

Ramanagaram District

Water samples are collected from selected dug wells (National Hydrograph monitoring Stations) annually for chemical analysis. The analysis results indicate that in general the quality of ground water is potable for drinking and suitable for irrigation purposes. The pH of ground water generally ranges from 7.42 to 9.09 and at certain places more than 10 indicating feeble to strong alkaline nature of groundwater. The electrical conductivity ranges from 310 to 2990 mhos/cm at 25°C. However in majority of the places it is within permissible range. High concentration of nitrates (>45 mg/lit) is observed in major parts of the district and about 44% of samples were found to be unsuitable for drinking. This may be attributed to unscientific disposal of domestic waste, natural sewage and industrial pollution.The Fluoride concentration in shallow and deep ground water is within permissible to desirable limits except at certain localities like Gademarna halli cross (2.75 ppm) and Henguru (1.85ppm) villages

6.6 Identification of rising / declining water tables

Chamarajanagara District

Out of 16 National Hydrograph Stations (NHS) located in C.R.Nagar district, the depth to water levels recorded during May-2006 was in the range of 1.42 to 6.75m bgl. The depths to water levels in the National Hydrograph Stations (dug wells) recorded during post monsoon period (November 2006) were in the range of 0.01 to 7.97m bgl. The average depth to water level during premonsoon is 4.77m and in post monsoon it is 3.47m. The major portion of the district shows 5.00m to 10.00m water level during May- 2006, as well as during November 2006. However major part of Kollegal taluk, part of C.R.Nagar and Gundlupet taluk is covered with hill ranges and dense forests and partly bad land topography. Such areas are left out for want of sufficient control over the water level data. In the remaining part, due to uneven topography, the depth to water level changes with a short distance.

The water levels in the 5-piezometer National Hydrograph Stations range from 4.60 to 36.75mbgl during May 2006 and 3.94 to 40.11m bgl during November 2006.

Consequent upon seasonal rainfall, the water levels record a rise indicating the build up of storage in ground water reservoir. During the non-monsoon period, this gets depleted due to exploitation and natural discharge. Therefore, the water levels, in general show a receding trend from December to May. The seasonal water level fluctuation for the year 2006 is available for 15 dug well National Hydrograph network stations. While sixty percent of the NH Stations have shown a rise in water levels in the range of 0.50 – 7.86 m, thirty percent of the stations have recorded a fall in water levels in the range of 1.62 – 3.67m. The seasonal water level fluctuation for the year 2006 is available for five piezometer hydrograph network stations, which is in the range from 0.66 to 16.97 m. The average water level fluctuation during 2006 is 1.00m.

The long term water level trend is analyzed for 23 NH Stations for the period from 1997 to 2006, where 15 stations have shown rising trends in the range of 0.05m/y to 0.464m/y and the average rise in water levels is 0.23m/y. Similarly falling trend were observed in 8 National Hydrograph Network Stations in the range of 0.003m/y to 0.588m/y with the average fall of 0.20m/y.. Similarly the water level trend in five piezometers in the district showed rise in water level in all the five except at Gundlupet, where falling trends were observed with1.038m/y since 1997 to 2006. The range of rise in water level in the four piezometers is 0.124 m/y to 0.649 m/y.

Ramanagaram District

It is observed from the depth to water level data that there is both rise and fall in water levels during November 2011 when compared to May 2011 water levels in dug wells .Out of 13 dug wells, water level rise is observed in 8 stations ranging from 0.02 to 4.88 m. In the remaining 5 stations water level fall is observed in the range of 0.19 to 3.22 m. The highest rise (4.88m) is noticed at Magadi station in Magadi taluk. The highest fall (3.22m) is noticed at Gonaldoddi station in Kanakapura taluk.

However, all the Piezometers have shown rise in water levels ranging from 0.5 m to 9.31 m. The highest rise (9.31 m) is noticed at Magadi station in Magadi taluk.

6.7 Proposal of conjunctive use of surface water

The present project doesn't envisage conjuctive use of surface water

Chapter 7

Design features and criteria for river valley structures

7.1 Structures and development

7.1.1 General

Detailed longitudinal sections and cross sections are prepared for the proposed Dam site. Site survey plan for a length of 200 m upstream and downstream is prepared. Available data and information has been compiled to plan and prepare the designs for project structures.

a) Reasons for choice of layout

The dam is located about 500 m u/s of the narrow reach at Mekedatu based on the evaluation of geological and geotechnical findings for alternative locations The present identified location is free from major geological defects and the requirement of grouting is expected to be minimum. A fall of 310 m is available in the river Cauvery between Shivanasamudram Anicut and State border below the proposed Mekedatu dam site. In addition, a fall of 100 m is available in the reach of common border between Karnataka and Tamil Nadu States below Mekedatu. It is possible to generate relatively cheap hydro power by utiliizing the head available between Shivanasamudram and Hogenakal falls.

b) Type of structure

The Geological and Geotechnical investigation has confirmed presence of rocks of Charnokite group, Sargur group, Peninsular gneissic complex (PGC), Closepet granite, and basic and younger intrusives. Charnokite group is represented by Charnokite. Sargur group comprises ultra mafic rocks, amphibolite, banded magnetite quartzite, occurring as small bands, and lenses within the migmatite and gneisses. Geologically, the identified location provides excellent conditions to have gravity structure since presence of good quality rock is observed at surface and hence Concrete gravity dam is recommended

7.1.2 Geology, Seismisity and foundation Conditions

The project site comprise of rocks that belong to Charnokite group, Sargur group, peninsular gneissic complex (PGC), Closepet granite, and basic and younger intrusives. Charnokite group is represented by Charnokite. Sargur group comprises of ultra-mafic rocks, amphibolite, banded magnetite quartzite, occurring as small bands, and lenses within the migmatite and gneisses. PGC includes granites, gneisses and migmatite and occur to the east and west of Closepet granite. Transformation of Peninsular Gneissic Complex into Charnokite is reported locally in the districts. Closepet granite occurs as intrusive bodies trending nearly N-S within the gneisses over a distance of 50 km and with a width of 15-20 km. The Closepet granite contains enclaves of migmatite, gneisses, quartzite and amphibolites and is reported to be of variable composition. The basic intrusives are represented by dolerite, gabbro, occasionally Norite and pyroxenite. The dolerite is dominant among the basic dykes.

The Project area falls under seismic Zone-II as per the seismic zoning map of India published in IS: 1893-1993.

The starta met with is Hard rock. Foundation treatment is proposed. Consolidation and curtain grouting is proposed to make the foundation string and reduce seepage through or from the dam foundation..

7.1.3 Alternative studies carried out for selection of site

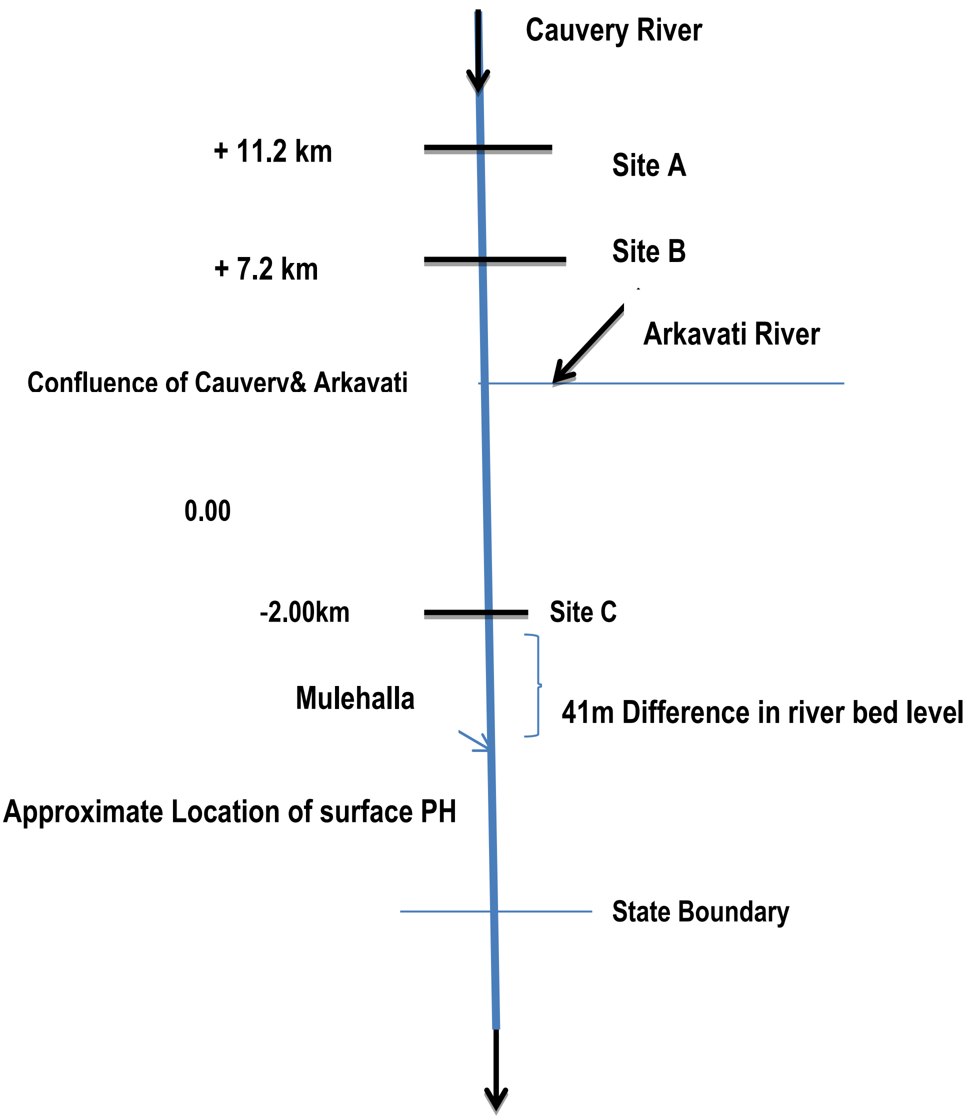
7.1.3.1 Alternate Proposals studied

As narrated in Chapter 1.9 History (Earlier proposals) three sites namely A,B and C were identified for the construction of storage dams with a storage capacity of about 180 TMC. The river bed levels at these sites are as follows:

- Site A: EL 377.95m
- Site B: EL 370.30m
- Site C: EL 361.10m

Since all the dam sites were located in gorge portion, ideal location for the construction of power house was found to be upstream of the junction at Mulehalla, a stream joining river Cauvery down stream of Mekedatu falls. There is a rapid fall of river bed level to an extent of 41m between Site C and the proposed location of power house. Though all the 3 sites A, B, and C were found to be suitable for high dam, length of the water conductor system varied considerably.

Dam Site	Approximate Distance between Dam site and Power house
Site A	15.6 km
Site B	11.6 km
Site C	2.4 km



Site A and B involved lengthy water conductor system comprising of head race tunnel, surge shaft and penstock. To create storage of 180 TMC, the submersion was found to be more when compared to C site, hence these locations i.e., Site-A and Site B were not considered for further investigations. Finally Site C was selected for detailed geological Investigation.

Initially during the year 1966 surface power house was considered. The salient features of the project as considered were as shown in **Table 7.1**:

Table 7.1: Salient features of the project as developed in 1996

No	Particulars	Details
1.	Catchment area	13,800 sq.miles
2.	Maximum flood Discharge	4,00,000 cusecs
3.	Annual yield	3,60,000 M.cft

No	Particulars	Details
4.	Average Bed level	R.L. 1185 (361.17m)
5.	Deepest bed Level	R.L. 1170 (356.6m)
6.	F.R.L	R.L. 1570 (478.50m)
7.	Gross capacity	1,81,000 M.cft (181TMC)
8.	Top of dam	R.L. 1580 (481.56m)
9.	Minimum Draw down level	R.L. 1350 (411.46m)
10.	Height of the dam	125m (400ft)
11.	Main dam length	855m
12.	Length of Spillway	168m
13.	Crest level	R.L. 1535 (467.85m)
14.	Number of Tunnels	2
15.	Length of each tunnel	1372m
16.	Normal Discharge	5,500 cusecs
17.	Number of Surge Shafts	2
18.	Diameter of surge shafts	30.5m
19.	Height of surge shafts	122m
20.	Penstocks	6 Nos.
21.	Diameter of each penstock	4.89m
22.	Length of each penstock	640m
23.	Minimum tail water level	1050 R.L.
24.	Maximum gross head	158.3m
25.	Minimum gross head	91.4m.
26.	Net rated head	131m
27.	Designed Discharge	11,000 cusecs.
28.	Continuous power	3,52,900 kW
29.	Proposed installations	6 Nos. of 1,26,000 kW

The Preliminary geological investigations were carried out by Shri K.C.C. Raju, Geological Survey of India, during Feb 1966 when exploratory drilling at the dam site was taken up. In Conclusions and recommendations it was mentioned that as the excavation involved at the surface power house site are of the order of 40m, the feasibility of an underground power house may be considered as the rock appears to be quite good.

Based on the recommendations of Shri K.C.C. Raju/GSI, instead of surface power house, an underground power house was agreed to and further investigations were carried out.

Shri A.N. Agarwal, GSI carried out geological investigations during April and May 1980. He has examined 38 boreholes drilled as on that day.

In Conclusions and recommendations, it was mentioned that reconnaissance geological studies and subsurface explorations have indicated that the site is feasible for construction of a 125 m high dam across river Cauvery.

During October 1982 Shri H.M. Dayal (Geologist Sr.) / GSI carried out studies on the result of drilling carried out for exploring the site conditions at various components of the project namely main dam, saddle dams, underground power house, penstock and tail race tunnel.

In conclusions and recommendations it is pointed out that the tail race tunnel will be excavated through fresh granite gneiss. Similar rock would be met with at the underground power house site and along the penstock tunnel.

The Advisory Sub-committee constituted by the Government of Karnataka in 1995 noted the following:

Location of Dam: C Site

Particulars	Option 1: FRL 478.00m	Option 2: FRL 440.00m
Storage Capacity	180 TMC	63.82TMC
Height of the Dam	125m	99m
Submersion area	10,000 Ha	5,445m

Considering the vast submergence of the forest and other lands and also its related impacts, Govt. of Karnataka decided to restrict the FRL of the proposed Mekedatu to EL 440.00m and consider the proposal for implementation.

Based on the decision of Government of Karnataka, Karnataka Power Corporation Ltd., (A Government of Karnataka undertaking) prepared Project report of Mekedatu Hydro Electric Project during July 1996 and submitted to Central Electrical Authority .

The installed capacity contemplated was 180 MW in the first stage and another 180MW in the ultimate stage with an annual generation of 524MU initially and 635MU ultimately

7.1.4 Choice of final layout of all major components

As explained above, based on the decision of Government of Karnataka in 1995, the decisions of the CWDT and the judgement of Hon’ble Supreme Court of India dated 16/02/2018 all the components have been worked out. Final layout consists of Concrete Gravity Dam at ‘C’ site (as earlier finalized by KPCL) with a FRL of EL 440.00 m having a gross storage capacity of 67.16TMC and an underground power house with installed capacity of 400MW (3X120MW + 1X40MW).

Details of major components are explained in subsequent sections/sub sections.

7.1.5 Design Flood and Sediment Studies - Brief

The Design flood as PMF based on the flood hydrograph is 6.73 lakhs cusecs. However spillway can discharge maximum flood of about 8.00 lakh cusecs at MWL of 441.20 m. Refer Chapter 5, para 5.1.8 and Chapter 8, para 8.2 of this report.

7.1.6 Freeboard

Freeboard is calculated as per IS 6512:1984. A freeboard of 3.576 m is provided (**Appendix 12.2 Vol II)**

7.1.7 River diversion arrangements

For river diversion during construction, the diversion flood is worked out at 5517 cumecs equilvalent of 1 in 25 year frequency. A diversion channel is proposed for 1st stage diversion and three sluices of size 3.0 x 3.0 m are proposed with a peir width of 6.0 m in the spillway portion for diversion in the further stages of construction.

7.1.8 Construction materials - Brief

Refer Chapter 15, para 15.2

7.1.9 Model studies

Since it is a high dam,the model studies as required for energy dissipation arrangements could be undertaken at pre construction/detailed design stages for confirming the theoretical studies. In addition hydraulic model studies would also be got conducted for river sluices to ascertain the provisions made for river sluices, liners and also hoist capacity proposed for operating river sluice gates.

7.2 Dam

7.2.1 Embankment Dam

Not Applicable

7.2.2 Concrete Gravity Dam

A dam across the Cauvery River is proposed near Mekedatu to store water to act as Balancing Reservoir to meet drinking water requirements and for utilizing the downstream releases to generate power. The height of the dam is 99 m. Hard rock is exposed almost throughout the dam alignment..As the rock is met at the surface itself, concrete gravity dam is proposed.

- The maximum height of the dam is 99 m.
- The catchment area at the dam site is 34,273 Sq Km.

- The maximum flood discharge is estimated to be 22,654 Cumecs.
- Ogee spillway is proposed to realize high coefficient of discharge.
- 16 gates of 15.0 m x 12.0 m are required to pass the design discharge of 22,654 cumecs at MWL. Additional number of gates to an extent of 10 % are to be provided to account for mechanical failure. As such 18 gates of 15.0 x 12.0 m are proposed.
- Radial gates are proposed with sill at a little lower than the spillway crest. This is kept 0.2 m below crest. The trunnion level is proposed at 431.90 m. The radius of the gate is 13.5 m with sufficient clearance.
- The spillway bridge is located at sufficient clearance, such that the arrangement doesn't affect the operation of the radial gates.
- Stop log gates are also proposed on upstream side of the dam. Gate grooves are proposed for all the vents in the piers. The stop log gates will be in pieces for easy operation. Two sets of stop log gates are proposed.
- Gantry crane of adequate capacity has also been provisioned.. This helps in inserting and removing the stop log gate elements.
- The total length of the dam is 734.50 m which comprise spillway of 337.00 m, power blocks of 57.0 m , NOF and key wall of 161.00 m on right flank and 179.50 m on left flank.
- As per the codal recommendation, galleries are to be provided where the height of dam is more than 10 m. For the dams where the height is much more, galleries may be in 2 or 3 tiers. In this case the height of the dam is 99 m, and galleries are proposed in 3 levels. The first gallery (drainage gallery) is proposed at RL 353.000 m in the river bed reach that runs all along it. An intermediate inspection gallery is proposed at RL 383.000 m and another inspection gallery is proposed at RL 413.000 m.
- The Dam as per Codal provisions is analyzed as Gravity section for following loading conditions:
  1. Load combination A – Reservoir Empty
  2. Load combination B – Reservoir Full upto FRL with no tail water
  3. Load combination C – Flood discharge condition
  4. Load combination D – Combination A with Earthquake condition
  5. Load combination E – Combination B with Earthquake condition

6. Load combination F – Combination C with extreme uplift(Drains inoperative)
7. Load combination G – Combination E with extreme uplift(Drains inoperative)

- The area falls under Zone II, where the basic seismic coefficient αh is 0.02. With importance factor of 3.00, the horizontal seismic coefficient works out as αh = 0.06, and for vertical component to an extent of ½ αh , i.e., αv = 0.03 is considered.
- Rocky strata is available and hence flip bucket is proposed for energy dissipation. However as this is a major structure, model studies will be conducted for its suitability and configuration before implementation.
- Free board in the dam is given to cater for the wave action and its run up. . The wave height is calculated as per IS 6512:1984 considering the maximum fetch in the submergence area. The free board works out to 3.576 m. Accordingly the top of the dam is proposed at RL 445.000 m
- The analysis of the dam is also done to determine the factor of safety against sliding. In the formula, factors like cohesion of the material at the plane is considered and coefficient of internal friction of the material is also considered. In the preliminary designs these values are assumed based on the results of other similar projects. However before finalization, its true value will be ascertained. Therefore field tests will be carried out to determine the actual values for C and Φ which shall be adopted in the final design.
- Vertical shafts and adits are proposed to facilitate access to the galleries.
- The structural design of gallery is done considering it as an opening in an infinite plane. Coefficients are used to arrive at the tensile force and required reinforcement is provided.
- As it is a high dam, instrumentation is also proposed to assess the deflection, seepage, uplift, stress, strain, etc.
- Consolidation grouting is proposed to make the foundation strong and curtain grouting is proposed to reduce seepage through the dam foundation.

7.2.2.1 Non Overflow section blocks – design criteria

The non-over flow section on the left flank is proposed for length of 179.5 m. and on the right flank is proposed for length of 218.00 m. Stability analysis of the section has been done for the conditions of loading as stated earlier

The base width proposed is 102.08 m at the maximum overflow and 94.30 m at the maximum Non overflow section. The section is checked at various levels i.e., 346.00 m, 353.00 m, 354.20 m, 384.20 m ,414.2 m, and 437.00 m where the side slope changes. The stresses developed are tabulated and enclosed. **Appendix 12.6 Vol II**

3 m thick rich concrete of M 30 grade on the u/s face of the dam is proposed to achieve imperviousness.

7.2.2.2 Spillway blocks – design criteria

The Catchment area at dam site is. 34,273 sq.kms. The maximum design flood discharge is 22,654 cumecs. Ogee profile with radial gates is proposed for disposing the flood. The flood depth considered over the spillway crest is 12 m. 18 gates of 15 m x 12 m with 14 piers of 3.5 m thickness and 3 sluice block piers of thickness 6m are proposed (**Appendix 12.1, 12.3, & 12.4 Vol II**). The total length of the spillway between its abutments is 337.00 m. Details of the spillway are in **Table 7.2.**

Table 7.2: Details of the spillway

No	Particulars	Details
a)	Max discharge	22,654 cumecs (8,00,000 cusecs)
b)	Flood lift proposed	1.20 m
c)	No. of Span	18
d)	Type of gate	Radial
e)	Crest level	428.00 m
f)	FRL	440.00 m
g)	MWL	441.20 m
h)	Top of Dam	445.00 m
i)	Thickness of piers	3.5 m and 6.0 m

7.2.2.3 Spillway Section

The base width proposed for the spillway blocks of the dam is 102.08 m. The section is checked at EL 346.00 m for the different loading conditions listed earlier. The stresses developed are tabulated and enclosed.

7.2.2.4 Transverse Contraction Joints

The total length of the dam is 734.5 m. The founding levels vary to a considerable extent. As per Codal recommendation, transverse contraction joints are provided to suit the methods of construction, materials of the dam, the foundation conditions and convenience of the location of control gates, outlet etc. for block wire construction. For block wise construction of the concrete dam, a spacing of 15 m to 25 m is recommended for concrete dams vide IS 6512-1984. In this case, spacings varying from 18 m to 25 m are proposed for transverse contraction joints sealing with PVC joint seals are proposed for arresting leakage.

7.2.2.5 Spillway Cap

Ogee shape is proposed for the spillway with u/s and d/s profile as recommended in IS 6934-1973, for high ogee overflow spillway. Piers are proposed at 18.5 m c/c with radial gates. This causes tension in the crest portion and sufficient reinforcement is provided to take care of this. The design head is 12 m. This reinforcement may be curtailed to half at a depth of 5 m below crest and discontinued from a depth of 13 m below crest.

7.2.2.6 Spillway Piers

3.5 m thick RCC peirs with grooves for stop log gates and provision for hoisting arrangements for the operation of the radial gates is proposed .

The stability analysis of the pier has been checked at RL: 428.00 m i.e. crest level. The thickness of the pier proposed is 3.5 m and for sluice pier it is 6 m.

7.2.2.7 Spillway bridge

7.5 m RCC T- Girder bridge is proposed with 15 m span. Three longitudinal girders of 0.4 m x 1.5 m and three cross girders of 0.3 m x 1.2 m are proposed in one span. The total length of spillway is 337.00 m

7.2.2.8 Energy Dissipating arrrangements

The FRL of the spillway is RL 440.00 m and MWL is RL 441.20 m with the deepest bed level at RL 346.00 m. The maximum head will be 95.20 m. The discharge considered is 22, 654 cumecs. The discharge per unit length of spillway works out to 67.22 cumecs. The tail water level works out to 372.0 m for which the water depth will be 17.60 m. The following alternatives were considered for designing energy dissipating arrangements. (**Appendix 12.5 Vol II)**

(a) Solid roller bucket

(b) Slotter roller bucket

(c) Flip bucket

(d) Conventional stilling basin

As the tail water depth is very less, Cases (a) and (b) will not hydraulically function satisfactorily. Flip bucket arrangement is more suited in this case, and the maximum throw length will be 179.00 m , with the bucket lip angle 35°. The maximum height of throw is 28.30 m. Unless there is a pond or the bed material is very hard, scour may take place in due course, and create a pond.

Case (d), needs 150.00 m of stilling basin without baffle blocks and 105.00 m with baffle blocks. The floor level of stilling basin has to be lowered by about 4.0 m tentatively at RL 348.00 m. Thick floor concrete to an extent of 5.0 m at the commencement combined with anchor bars would be provided.. This alternative is a viable arrangement and safe. However, the cost will be very high.

Hence, flip bucket is proposed with 24 m radius. The width of the bucket 30.74 m. The invert level of the bucket is proposed at RL 353.00 m so as to reduce the quantity of concrete and excavation. As a precautionary measure, it is proposed to protect the bed in the near reach of dam on the downstream with a rich concrete mat of 30.00 m length to absorb the impact.

Since it is a high dam,it is proposed to conduct hydraulic model studies to validate and confirm the final design.

7.2.2.9 Training Wall

The RCC Training wall is designed for earth pressure by considering the following combination of loadings.

Case A: No water in the River

Case B: Case A + Earth quake

Case C: Back fill submerged up to 50%

Case D: Back fill submerged up to 50% + Earth quake

Case E: Sudden draw down condition

The stability analysis has been done considering the permissible stresses both in compression and tension, vide IS 12720:1993 for structural design of spillway training walls and divide walls.

7.2.2.10 Foundation Levels

The foundation levels proposed for various blocks in the Non Over Flow section and Over Flow section (Spillway) are furnished in **Table 7.3.**

Table 7.3: Details of Non Over Flow section and Over Flow section (Spillway)

A) N.O.F - Left Flank

No.	Block	Ch:		Length	Component Total length =179.5m	Foundation level in m	Nature of soil at FNL
		From	To				
1.	Key wall	82.5	102.5	20		428.00	
2.	1A	102.5	127.5	25		420.00	
3.	1	127.5	152.5	25	Non overflow section, .	405	HR
4.	2	152.5	177.5	25		390	HR
5.	3	177.5	202.5	25		380	HR

No.	Block	Ch: From	Ch: To	Length	Component Total length =179.5m	Foundation level in m	Nature of soil at FNL
6.	4	202.5	227.5	25		375	HR
7.	5	227.5	247.5	20		370	HR
8.	6	247.5	262.0	14.5		350	HR

B) Spillway

No.	Block	Ch: From	Ch: To	Length	Component Total length =337m.	Foundation level in m	Nature of soil at FNL
1.	6	262.0	269.75	7.5	Overflow section - Spillway ,	346	HR
2.	7	269.5	288	18.5		346	HR
3.	8	288	306.5	18.5		346	HR
4.	9	306.5	325	18.5		346	HR
5.	10	325	343.5	18.5		346	HR
6.	11	343.5	362	18.5		346	HR
7.	12	362.0	380.5	18.5		346	HR
8.	13	380.5	401.5	21		346	HR
9.	14	401.5	442.5	21		346	HR
10.	15	422.5	443.5	21		346	HR
11.	16	443.5	432.0	18.5		346	HR
12.	17	432.0	480.5	18.5		346	HR
13.	18	480.5	499	18.5		346	HR
14.	19	499	517.5	18.5		346	HR
15.	20	517.5	536	18.5		346	HR
16.	21	536.0	554.5	18.5		346	HR
17.	22	554.5	573.0	18.5		346	HR
18.	23	573.0	591.50	18.5		346	HR
19.	24	591.5	599	7.5		346	HR

C) N.O.F - Right Flank

No.	Block	Ch: From	Ch: To	Length	Component Total length =218.00m	Foundation level in m	Nature of soil at FNL
1.	24	599	610.5	11.5	overflow section NOF section	346	HR
2.	25	610.5	628.5	18		350	HR
3.	26	628.5	646.5	18		360	HR
4.	27	646.5	665.5	19	Power sluice	370	HR
5.	28	665.5	684.5	19		370	HR
6.	29	684.5	703.5	19		370	HR
7.	30	703.5	727	23.5	Non overflow section	395	HR
8.	31	727	752	25		410.5	HR
9.	32	752.0	777	25		410.5	HR
10.	33	777.0	802	25	NOF	422.5	HR
11.	Key wall	802	**817** **Total**	**15** **734.5**	Key wall	430	

7.2.2.11 Gauge Well

A gauge well is proposed at Ch :277.50 m in block no 6 to measure the depth of water in the reservoir at any time. The gauge well will be abutting the upstream side face of the dam.The inner diameter of the gauge well is 0.6 m. The top level of the gauge well will be at the top level of the dam i.e.RL: 445.000 m.

7.2.3 Opening through dam

River sluices are provided in block Nos. 13,14,15 which function as construction stage diversion and as scouring sluices subsequently to release water to the downstream side whenever necessary. Three vents of 3.0 x 3.0 m are proposed with pier thickness of 6.0 m. **Appendix 12.7 & 12.8 Vol II)**

Power sluices is provided from in block Nos. 27,28,29 which function to release water to the power house. Two vents of size 5.6 m x 5.6 m and one vent of size 6.5 x 6.5 m are proposed. **Appendix 12.9 Vol II)**

7.2.4 Various conditions of MWL, TWL, Drainage, Earthquake etc

7.2.4.1 Gates, type, size and hoist arrangements

18 nos of Radial gates of 12 m height are proposed for the spillway with trunnion level at 431.90 m. The gate seat level is 427.78 m. Sufficient clearance is ensured between the spillway bridge and the gate. Rope drum hoist arrangement is proposed for the radial gates. Provision of stop - log gates is also made in the spillway. The details of spillway radial gates, stop logs and reverse sluice gates and relating hoists etc. are presented in **Appendix 12.10, Vol II**

a) Galleries

As it is a high dam, galleries are proposed at three different levels viz, Drainage gallery at RL 353.00 m , Intermediate inspection gallery at RL 383.00 m and Inspection gallery at RL 413.00 m. The three galleries are interconnected vertically and slope of 1 in 1000 is proposed horizontally. The size of the galleries are 1.6 m x 2.4 m. Refer **Appendix 12, Vol II**.

7.3 Barrage and Head Regulator

Not applicable

7.4 Canals

Not emnvisaged in the present proposal.

7.5 Canal Structures / Gates etc.

Not applicable

7.6 Power house

As already indicated in the foregoing chapters, there exists substantial elevation difference between the Project site location and the State border which could be utilized for generating power from the obligatory releases to be effected to. Hence, in the present proposal, power component has also been considered for arriving at the total project cost.

7.6.1 Power Intake

The intake structure is housed in the three power blocks of the dam in block Nos.27,28,29. Three numbers of steel penstock pipes, two numbers of 5.6 m diameter (circular) and one number of 6.5 m diameter (circular) are embedded in the power blocks. The centerline of the penstock pipes is fixed at RL 383.00 m considering the MDDL as RL 395.00 m to fulfill the submergence criteria as per IS stipulations. The Invert level of the Intake is fixed at RL 372.80 m. The height of the Power blocks is around 75 m from the deepest foundation level. A semicircular type trash rack is envisaged in front of Intake. No anti-vortex arrangement of each penstock opening is necessary in this arrangement of Power Intake.

Necessary provisions for locating the service gates to regulate the flow to each of the penstock pipe and its hoisting arrangement has been made. Provision for emergency gate is not made since there is a Main Inlet Valve (MIV) for each generating unit in the power house. In the power intake structure, Two vertical lift roller Service gate of size 5.6 m x 5.6m and 1 No. of vertical lift roller service gate of size 6.5 m x6.5 m have been proposed. These are operated with the help of individual rope drum hoists located on a platform supported on suitable structural steel frame at the top of the dam. Three Nos. of semi circular trash rack of height 25.25 m between EL 398.25m and EL 372.80m are also envisaged in front of the penstock openings of intake to avoid entry of any debris to the penstocks. RCC breastwall is proposed above EL 398.25m

The hydraulic calculations pertaining to submergence of the entry required below water level, bell mouth, hydraulic design of trash rack, structural design of trashrack, weight of hydraulic gates and hoist capacity is enclosed in **Appendix-15.1, Vol II**

7.6.2 De-silting arrangements

Not applicable.

7.6.3 Power channel

Not applicable.

7.6.4 Tunnel (s), Pressure shaft(s)

3 nos.of steel penstock pipes, (2 nos. of 5.6 m dia. and 1 no. of 6.5 m dia.) which are embedded in the power blocks and run horizontally for a distance of around 75 m before taking a 90º bend, to form the pressure shafts dropping down to RL 296.50 m. All the three pressure shafts are total length of around 203 m and are steel lined with cement concrete backfilling. Each of the 2 Nos 5.6 m diameter pressure shaft carry a design discharge of 113 cumec and the 6.5 m diameter pressure shaft carries a design discharge of 151 cumec. The total design discharge conveyed by the three pressure shafts is 377 cumec. The water in the pressure shaft will have a velocity of 4.6 m/sec. The 6.5 m diameter pressure shaft bifurcates into a 5.6 m diameter branch and a 3.25 m diameter branch near the power house to feed the 120 MW and 40 MW turbine-generator units in the power house respectively. The other two pressure shafts of 5.6 m diameter directly enter the power house to feed the other two turbine-generator units of 120 MW.

The centerline of the penstock at entry in the intake is kept at RL 383.00 m and the centerline of horizontal portion of pressure shaft at entry to the power house is at RL 296.50 m. The steel penstock is encased with cement concrete 1000 mm thick. The vertical pressure shaft and a horizontal pressure shaft will have backfill concrete lining thickness of 600 mm around the steel liner. Thickness of steel lining has been worked out considering rock mass participation based on rock quality and strength parameters with due consideration for suitable rock participation.

The calculation pertaining to economic diameter of embedded penstock / pressure shaft, Hydraulic losses through the system and steel liner design for external and internal pressure are enclosed in **Appendix 15.2. Vol II**

7.6.5 Balancing reservoir

This is a balacing reservoir. For details refer **Chapter-8.**

7.6.6 Forebay

Not applicable.

7.6.7 Penstock and surge shaft

No Upstream Surge Shaft / Surge Tank is required as the short length of water conductor system comprisies embedded upper horizontal penstock, vertical pressure shaft and lower horizontal pressure shaft is around 275 m and hence the ratio of Length (L) to Head (H) is less than 4. Hence there is no necessity of surge shaft for this water conductor system. However the water conductor system is designed for the pressure rise and checked for negative pressures (as per hydraulic gradient line/ water hammer pressures) due to sudden closing and gradual opening of valves.

However a suitable arrangement in the form of Surge Chamber Cavern is provided to cater to transient condition in the downstream circuit which consists of the the power house, draft tube tunnel, tail race tunnel which is around 2150 m long and the tail race outlet.

Based on the preliminary transient analysis, a Surge Chamber of size 77.5 m (L) x 22 m (W) and 46 m (H) is envisaged. The draft tube tunnels of individual generating units from the power house enter the Surge Chamber at RL 289.00 m and RL 292.00 m for 120 MW units and 40 MW unit respectively. Individual gates are provided to control flow from each draft tubes. A gate operating platform is provided inside the Surge Chamber. Based on the transient analysis for the downstream circuit carried out using WHAMO, developed by USACE, the maximum surge level in the surge chamber is fixed at RL 315.00 m. The minimum surge level is fixed at RL 292.50 m. Required rock supporting measures in the form of grouted rockbolts and shotcrete (SFRS) are provided for the surge chamber cavern based on the rock mass properties available.

The results pertaining to transient analysis of the downstream circuit is enclosed in **Appendix-15.3 Vol II**.

7.6.8 Underground Power house

For the laidout underground power complex sufficient rock cover is available. In general, the granite gneiss with Closepet granite and charnokite rocks will be present up to invert level. The granite gneiss rock is good tunneling and underground power house cavern medium.

The foliations in rock striking almost N-S to NW-SE and dipping towards west and intersected by two sets of joints requires rock bolting during arch excavation. It is suggested to align the longitudinal axis of the power house E-W to ensure the optimum stability It is expected that, during power house excavation, good to very good, self supporting rock will be met. The invert level of power house is below the river bed; hence seepage could be expected during excavation.

It is proposed to house the four generating units, 3 units of 120 MW capacity each and one unit of 40 MW in the underground power house located in the rock mass on the right bank of the Cauvery River. The underground power house has a provision for service bay and control room bay, along with unit bays. The width of the power house cavern is fixed as 22 m. The overall dimensions of the powerhouse cavern including service bay and control room building is 139 m (L) x 22 m (W). The dimensions of service bay is 30 m (L) x 22 m (W). The size of control room / switch gear room is 25.5 m (L)x 22 m (W). The crown of the power house cavern is at RL 328.50 m, the height of the power house cavern is 42 m upto draft tube invert level at RL 286.50 m. The Power House is proposed to be provided with shotcrete and rock bolts at the crown of the power house. The operating floor and service bay level is fixed at RL 309.00 m. The generator floor is at RL 304.50 m. Turbine floor is provided at RL 300.00 m. The MIV floor is at RL 293.00 m. Provision has been made in the powerhouse complex to accommodate the control room, the battery room, the switchgear room, the utility room, the DG room and an office with toilet facilities, etc. Four draft tubes emerge out of the underground power house at the bottom those lead into the surge chamber. A ventilation tunnel of 6.0 m diameter is provided at the crown of the underground power house which also connects the Transformer Cavern and surge chamber. Cable shaft is also proposed from the transformer / bus duct upto the outdoor GIS Building and pothead yard. A D-Shape access tunnel of 7.0 m size is provided to meet the power house at the level of operating floor / service bay i.e., RL 309.00 m. A rock mass gap of 40 m is left between the power house cavern and transformer cavern for stability for the openings / caverns. Required rock supporting measures in the form of grouted rock bolts and steel fibre shotcrete (SFRS) are provided for the Power house cavern based on the available rock mass properties.

A transformer cavern is provided to house 4 nos. 3-Phase Transformers catering to the 3 generating units of 120 MW each and one generating unit of 40 MW. The power generated from the generating units of underground power house is connected to the transformer in the transformer cavern through 4 nos. bus ducts of sizes 6.0 m (3 nos. D-shape) and 5.0 m (1.0 No. D-shape) and of lengths 40 m each. The length and width of transformer cavern are 66 m and 16 m respectively. The height of the transformer cavern is 19 m. A rock mass gap of 30 m is left between transformer cavern and surge chamber cavern to provide the required stability for the openings/ caverns. Rock supporting measures in the form of grouted rock-bolts and shotcrete (SFRS) are provided for the transformer cavern and the interconnecting tunnels like the busducts, draft tubes and escape tunnels, based on the available rock mass properties .

7.6.8.1 Rock Supporting Measures for Under Ground Structures (Caverns and Tunnels)

The design of rock supporting measures for caverns like power house, transformer and surge gallery are based on the geological and geotechnical inputs. At and around the project site, Archean granite forms the country rock, which is a coarse grained, porphyritic, slightly foliated rock mass. However, the dominance of fine to medium grained, massive, banded and foliated pink / grey granite at the site, resembling the peninsular gneiss, is also noticed. Granite is intruded by charanockites and thus contain within them tongues and asophyses of the charanockites formations. Based on these inputs it is evident that Power house cavern, Transformer cavern and surge gallery caverns are located in good, competant rock. The parameters for proposed rock supports are enclosed in the designs enclosed in this chapter. Class-I, Class-II and Class-III initial supports based on RMR classification and Barton ‘Q’ are considered for rock supporting measures. Mainly grouted rock bolts and steel fibre shotcrete (SFRS) is envisaged as the initial rock supporting measures for all rock openings.

The calculations pertaining to rock supporting measures for underground structures are enclosed in **Appendix-15.4 Vol II.**

7.6.8.2 Tail race tunnels

Two nos. **Tail race tunnels** of finished size 9.5 m dia, Horseshoe Shaped finished size of 9.5m dia take off from the Surge Chamber. The tailrace tunnels followed by a tail race channel terminates in a weir overfall structure with its crest at RL 302 m. The lengths of the tail race tunnels & Tail race channel depends upon the location of the location of the junction with the river bed level at RL 302.00 m. Lengths of each of tail race tunnel is around 2150 m. These tail race tunnels will be designed as pressure tunnels.

The calculations pertaining to hydraulics of tailrace outlet in enclosed in **Appendix-15.5 Vol II.**

7.6.8.3 Switch yard / Pothead yard

The out door GIS and pothead yard is proposed at RL. 385 m. XLPE cables from the transformer cavern are routed from through the ventilation tunnel of 6.0 m size, D-shape and 6.0 m diameter (circular) cable shaft to GIS building. The generated power is evacauated from the pothead yard through dedicated double circuit 220 kV transmission lines upto the receiving substation of KPTCL.

7.6.8.4 Access tunnel, ventilation tunnels, escape tunnel, adits

The three caverns namely, Power house cavern (PH), Transformer cavern (TC) and Surge Gallery cavern (SG) are excavated through the proposed ventilation tunnels of size 6.0 m D-Shape. The ventilation tunnels are connected to the crowns of all these caverns for excavation of caverns. The portal for ventilation tunnel is proposed at RL 360.00 m. The total length of ventilation tunnels is around 1200 m. Suitable approach road is provided to the ventilation tunnel portal.

Main access tunnel of size 7.0 m size, D-shape and length of around 833 m, and it provides access to Power house, Transformer and surge gallery caverns. For movement of equipment and maintenance, the portal for main access tunnel is proposed at RL 365.00 m. The size of Main access tunnel is increased to 10 m (W) x 7 m (H) between Power house cavern and Transformer cavern for ease of movement of fully assembled 3-phase transformer from Transformer Cavern to Service bay in PH cavern.

Escape tunnel of 4.0 m size, D-shape interconnecting the power house, transformer cavern and surge gallery is envisaged for easy escape of personnel in operation stage during case of any contingencies like fire etc. The total length of escape tunnel is around 70 m.

For the excavation and insertion of steel ferrules in the vertical pressure shaft as well as lower horizontal pressure shaft, a 6.0 m size, D-shape adit to pressure shaft bottom is envisaged. Once the construction of pressure shaft is completed, suitable length of concrete plug will be provided. This adit takes off from main access tunnel. The total length of adit to the chamber at the pressure shaft bottom is around 410 m. Suitable approach road to the top of pressure shafts are provided.

An adit to tail race tunnel of size 6.0 m size, D-Shape is proposed at mid point length of the tail race tunnel to reduce the construction time of the tail race tunnel. The portal for this adit is proposed be established at RL 365.0 m. The total length of the adit to tail race tunnel is around 750 m.

7.6.8.5 Power house Gates

The details of the gates and stop logs for power intake, draft tube and tail race are presented in **Appendix-12.10 Vol II.**

7.7 Instrumentation

i. Instrumentation for the Concrete Dam

a. Control survery targets and alignment targets

b. Plumb lines in the dam and foundation.

c. Seepage measurement wiers.

d. Uplift and pore pressure meters.

e. Stress and strain meters etc

Details presented in **Appendix 12.11 Vol II.** The instrumentation details for dam blocks is presented in **EIT-1328X-WRE-XX-STR-A037**

ii. Instrumentation for caverns

a. Tape Extensometers - for convergenece closure measurements

b. Bore hole extensometer (Single and Multiple) - for measuring movement of rock surrounding cavern and relative movement of joints, fissures etc.

c. Load Cells - for measuring thrust, anchor forces, horizontal and vertical loads,

d. Piezometer - for measuring water pressure in rock, lining or at interfaces.

iii. Instrumentation for tunnels

a. Tape Extensometers - for convergenece closure measurements

b. Bore hole extensometer (Single) - for measuring movement of rock and relative movement of joints, fissures etc.

c. Load Cells - for measuring thrust, anchor forces, horizontal and vertical loads

Chapter 8 Reservoir

8.1 Fixation of storage and reservoir levels

8.1.1 Dead storage

As per the standard practice, the Dead Storage is fixed at 10 % of the Total storage. However, the dead staorage is fixed as 7.70 TMC corresponding to the MDDL of 395.0 m.

Observation of sediment flow in the River has been carried out by CWC at their gauging station in Biligundlu. After analyzing the probable accumulation of sediment which may accrue at the end of 50 years as per the relevant IS Code, it is seen that about 3.00 TMC will be lost in this period.

8.1.2 Low water level

In order to optimize power potential , MDDL has been fixed at RL 395.0 m as against the new zero elevation of RL 370.48 m.

8.1.3 Full reservoir level

The Full Resevoir Level is fixed at RL 440.00 m

8.1.4 Maximum water level

Maximum Water level is RL 441.20 m

8.1.5 Maximum Back Water level at FRl & MWL and its effect.

Maximum back water level is almost same as FRL. Refer Sub-section 5.1.20.3 & 5.1.20.4 of this report and Section 5.1.4.2 of **Annexure 4 – Hydrology report**. Backwater effect / FRL will reach upto 30 km on the upstream of the dam.

8.1.6 Saddles present along the rim of the reservoir

There are no saddles along the rim of the reservoir

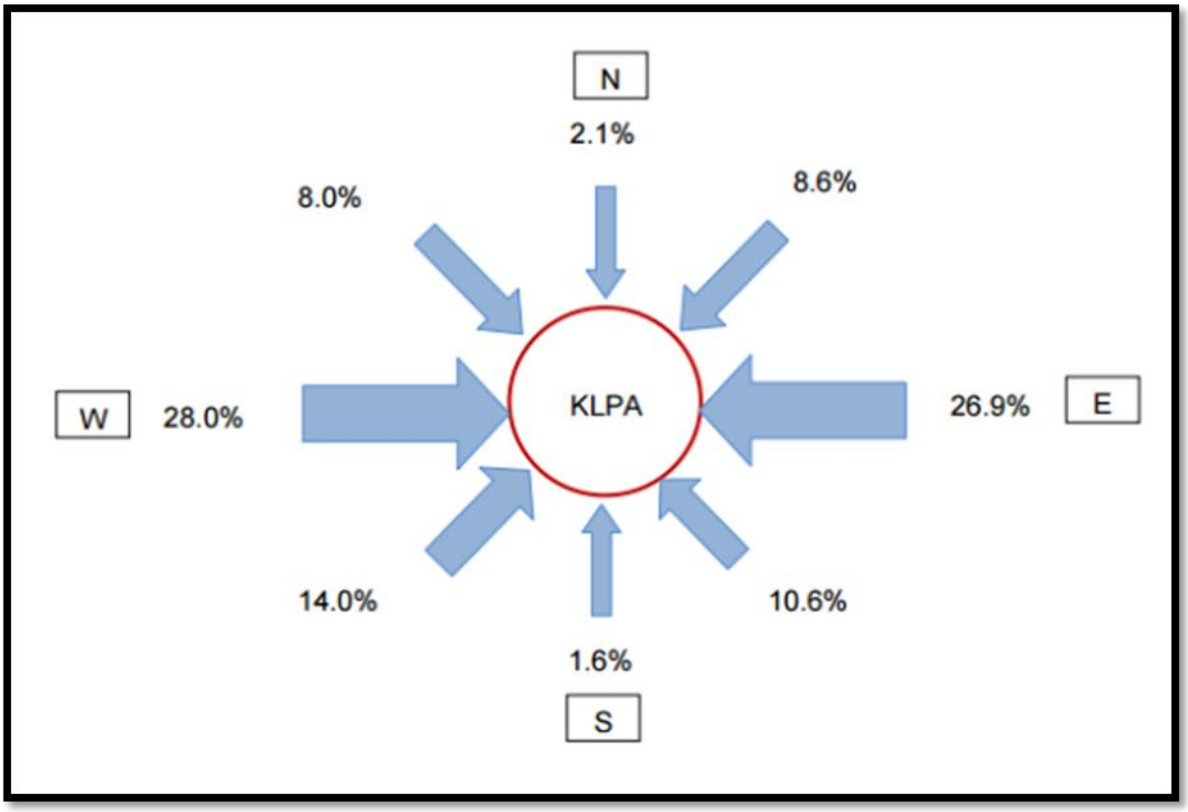
8.1.7 Fetch

Effective fetch computed is as per IS 6512 – 1084 and the length of the effective fetch is 2.00 km. Maximum fetch will be 4.70 km.

The design wave height will be 2.630 m. The provided free board upto spillway pier top is about as 3.60 m. Hence, the top of the dam is proposed at 445.00 m.

8.1.8 Direction of wind velocity

It is seen from the wind rose data collection from the Indian Meteorological Department (IMD) at Bangalore that the wind direction is mostly moving from east to west. In the morning i.e., 08.30hrs, the wind is towards west during May to September and east during November to February. Whereas, in the evening i.e, 17:30 hrs, the wind blows towards west during June to September and in November to March. Hence, it can be taken that the wind generally blows towards west. The strongest winds (>19 kmph) are observed in the months from June to August.



8.2 Sedimentation data and studies

It is necessary to study the sediment data before finalizing the planning and implementation of a Reservoir which is proposed to be used for providing drinking water and balancing purposes. In this connection , it is pertinent to note that storage reservoirs built across rivers tend to loose their capcacity over the years on account of deposition of sediment. The sediment accumulation in a reservoir is progressive which reduces its active capacity thereby affecting the capacbilty to provide required quantum of water for use through passage of time.

The accumulation of sediment near the dam will affect the future functioning of water intakes which in turn affects decision regarding location and elevation of various outlets (in case it is an irrigation project). The reservoir may also face problems of rise in flood levels in the head reaches which will definetly affect the assessed submergence area in question.

Before planning of a new project, it is necessary to view the sedimentation as an additional factor and study its effect and evaluate the performance of the reservoir.

8.2.1 Planning of new Storage reservoir

Before planning of any new storage reservoir, it is necessary to assess the seriousness of the sediment problem and classify it as insignificant , significant or serious. This is usually done by comparing the expected average annual volume of sediment deposition with the gross capacity of the reservoir. In case, ratio is greater than 0.5% per year, the problem is usually considered serious and special care needs to be taken in estimating the sediment yield from the catchment andmitigate its effect to the extent possible.

In case it is less than 0.1% per year, the problem is insignificant and changes in reservoir capacity can be neglected for study of reservoir performance.

For cases falling in between these two limits, the problem is considered significant and requires further studies.

This project being a balancing reservoir based hydro power project supplying power to a grid its full service time has been taken as not less than 25 years, feasible service time as not less than 17 years. (As per IS: 12182-1987)

8.2.2 Rates of sedimentation

Before fixing the capacity of reservoir it is necessary to compute the sediment load and its characteristics for predicting the probable sediment distribution in the reservoir below the normal FRL.

The measurement of sediment load/ estimation is done by any one of the following methods

a. Sedimentation surveys of reservoirs with similar catchment characteristics or
b. Sediment load measurements and its characteristics of the stream

In case of the Cauvery river on which the proposed Hydropower project is envisaged, the sediment load measurements have been carried out by CWC at its gauging station at Biligundlu from year 1973 – 2017, which lies on the downstream of the proposed ‘C’ site. As such, for working out the capacity at various FRLs and probable sediment load calculation, the said data has been considered as the basis. The sediment rate at Biligundlu will be 0.075 Thousand cum/sq.km while in the projects lying on the same river like Hemavathy, Harangi, Kabini, KRS on the upstream and Mettur on the downstream of the proposed C site, the rate of sediment is as under. For calculation purpose, the rate of sediment at Biligundlu is considered for the proposed 'C' site as both sites are not far off from each other.

A comparative statement is indicated below:

Table 8.1: Average rate of sedimentation (Thousand cum/Sq.Km) in various reservoirs of Cauvery basin

No	Name of the Reservoir	Average rate of sedimentation in Thousand cum/Sq.Km
1.	Hemavathy	0.903
2.	Harangi	2.081
3.	Kabini	0.300
4.	KRS	0.115
5.	Mettur	0.242
6.	At Biligundlu	0.075

(Source : Compendium on silting of reservoirs in India- 2015, Water and reservoir sedimentation Directorate , CWC)

8.2.3 Sedimentation fraction expected

The following are the sediment fraction expected in the reservoir as per the available data at Biligundlu.

- Medium and Coarse fraction
- Fine fraction

8.2.4 Quantity of sediment

As per observations at the guage site maintained by CWC, the quantity of sediment accumulation in an year will be 0.075 thousand cum / Sq Km of the area.

The estimated 50 year sediment at Biligundlu = 0.075 * 50 (years) * 23920 Sq. Km {i.e.,CA of Biligundlu - (CA of Kabini + CA of KRS}

= 89700 Thousand cum

= **89.7 MCM or 8970 Ha-m**

The estimated 100 year sediment at Biligundlu = 0.075 * 100 (years) * 23920 Sq. Km {CA of Biligundlu - (CA of Kabini + CA of KRS}

= 1,79,400 Thousand cum

= **179.40 MCM or 17940 Ha-m**

8.2.5 Type and shape of reservoir

The reservoir envisaged is a balancing reservoir with a gross capacity at 67.16 TMC and is of semi fan shape. It stretches upto a length of around 31.8 km and has a maximum width of 6.8 km and spreads along the main river and its tributaries (Arkavathy and Shimsha).

8.2.6 Sediment studies

As indicated in 8.2.2 above, the rate of sedimentation including the probable volume of sediment accumulation in 50 years have been worked out based on the sediment data available at Biligundlu.

8.2.7 Methodology

Boreland and Miller (1958) classified the distribution pattern of sediment in a reservoir into four standard types. The data showed that a definite relationship between the percent of total reservoir depth to the percent of total reservoir sediment volume existed for each of the four different reservoir types based on physical shape. The type of the reservoir is defined by plotting the reservoir depth (ordinate) against capacity (abscissa) on logarithmic coordinates. This curve plots as a straight line, although some reservoirs may have a shape resulting in two straight lines. The reciprocal of the slope of the line indicates the reservoir type. Curves showing a rapid increase in capacity with depth indicate large basin type reservoir, whereas a small increase in the relationship indicates gorge type reservoirs. The classification on this basis is given in the **Table 8.2.**

Table 8.2: Reservoir types for sediment distribution

m	Reservoir Type	Standard Classification
1-1.5	Gorge	IV
1.5-2.5	Hill	III
2.5-3.5	Flood Plain Foot Hill	II
3.5-4.5	Lake	I

Two methods have been suggested for approximate determination of the sediment distribution with elevation:

- The area increment method, and
- The empirical area reduction method, particularly applicable to large multipurpose reservoirs.

In the present study, Emperical Area reduction method is adopted.

8.2.7.1 Determination of 'm' value

The reservoirs are classified into four types, namely, (IV) gorge, (III) hill, (II) Flood plain-foot hill, and (I) lake, based on the ratio of tbe reservoir capacity to the reservoir depth plotted on a log-log scale. Refer Fig.

From figure, The present reservoir is classifies as Type III - Hill.

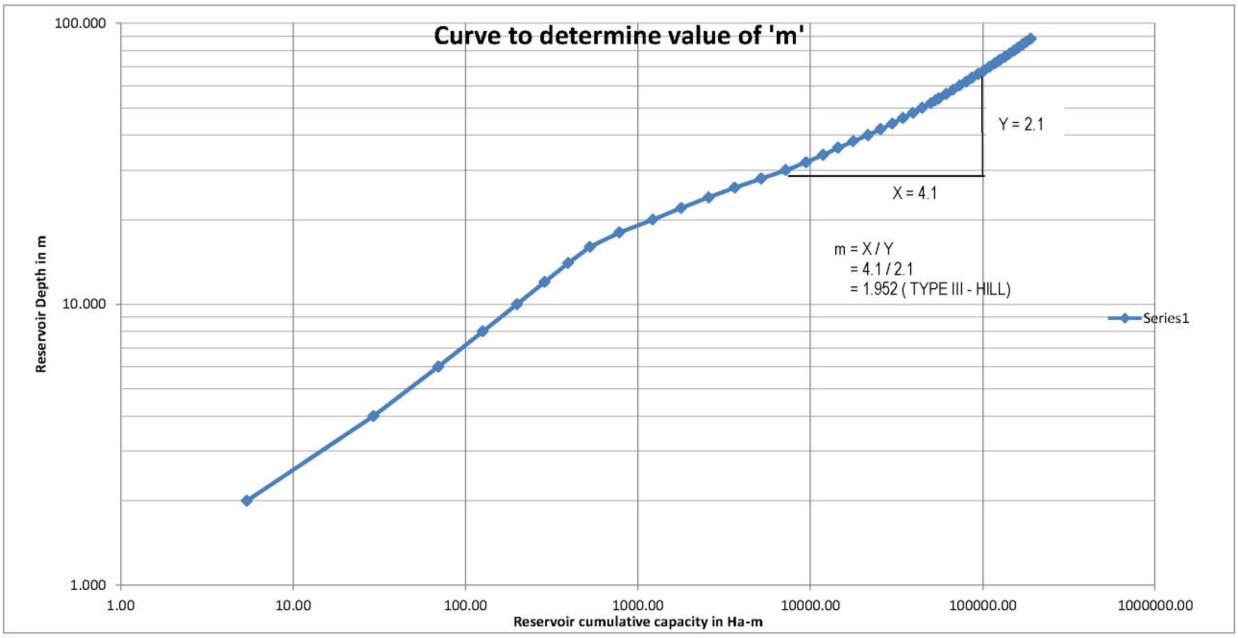


Fig. 8.1:Curve to determine valve of 'm'

8.2.7.2 Determination of New Zero Elevation

This method is used to determine the newzero elevation 0, directly without trial and error process. Two parameters f (p) and f' (p) as explained below are made use of:

$$f(p) = \frac{1 - V(p)}{a(p)} \qquad \ldots(3)$$

$$f'(p) = \frac{S - V(pH)}{H\,A(pH)} \qquad \ldots(4)$$

where

$f(p)$ = a function of the relative depth of reservoir for one of the four types of theoretical design curves,

$V(p)$ = relative volume at a given elevation,

$a(p)$ = relative area at a given elevation,

$f'(p)$ = a function of the relative depth of reservoir for a particular reservoir and its anticipated sediment storage,

S = total sediment in the reservoir in hectare metres,

$V(pH)$ = reservoir capacity at a given elevation in hectare metres,

H = the total depth of reservoir for normal water surface in metres, and

$A(pH)$ = reservoir area at a given elevation in hectares.

8.2.7.3 Empirical Area reduction Method

The method was developed by Borland and Miller (1958) from analysis of sediment distribution data obtained from surveys of 30 reservoirs. They prepared area design curves for the four standard types of reservoirs with relative sediment area as ordinate and relative depth as abscissa, the area under the curve being unity in each case. The curves could be represented by the equation,

$$A_p = C\ p^m (1 - p)^n$$

where

Ap = Relative sediment area at depth h,

p = Relative depth = h/H,

h = Depth of water level measured from the original stream bed level, and

C, m and n = Constants.

The four standards curves were used to compute sediment distribution in reservoirs and the method was termed as empirical area reduction method. It may be noted that the method gives only the distribution of sediments in the reservoir at different elevations; the total sediment accumulation for a given period has to be estimated separately. The values C, m and n for different types of reservoir are as below in **Table 8.3**

Table 8.3: The values C, m and n for different types of reservoir

Type	C	m	n	Equation of area design curve
I	3.4170	1.5	0.2	$A_p = 3.417p^{1.5}(1-p)^{0.2}$
II	2.3240	0.5	0.4	$A_p = 2.324p^{0.5}(1-p)^{0.4}$
III	15.8820	1.1	2.3	$A_p = 15.882p^{1.1}(1-p)^{2.3}$
IV	4.2324	0.1	2.5	$A_p = 4.232p^{0.1}(1-p)^{2.5}$

The stepwise procedure for computation is as below:

(i) Determine the type of the reservoir on the basis of value of M from Table 8.1.

(ii) Determine the relative depth for each increment at each value of h.

(iii) Select as a first approximation a NZE (an elevation upto which the reservoir is expected to be filled up completely by sediment). Sediment area at and below this elevation will be equal to the original reservoir area. Sediment areas for each depth increment above the assumed NZE would be obtained by finding, K = A_o/A_p and multiplying K by the A_p value at each h.

(iv) After computing the sediment areas the incremental sediment volumes can be computed as explained earlier. If the cumulative sediment volume does not tally with the anticipated sediment accumulation in the reservoir, the second approximation for the NZE would have to be made.

Refer **Appendix 10 Vol II** for Determination of New Zero elevation at RL 440.00 m and Detailed Sediment analysis using Emperical Area reduction Method.

8.2.8 Sedimentation in the reservoir after 50 years

After 50 years, The Sedimentation accumulation will be **8970 Ha-m** working out to a loss of about 3 TMC.

8.2.9 Revised Area Capavity Curve after Sedimentation

The revised area capcity curve after sedimentation i.e after 50 years is as indicated in **Fig. 8.2** / **Appendix 11 Vol II**

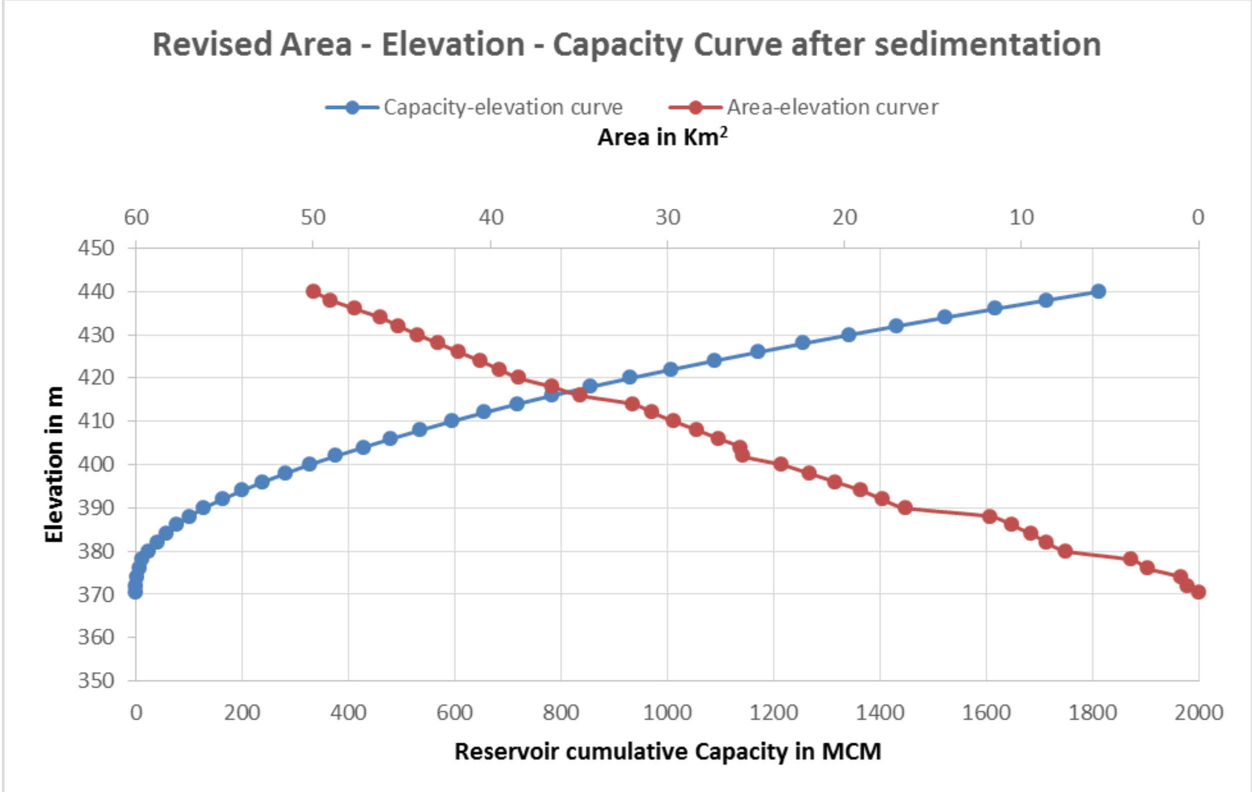


Fig. 8.2: Revised Area- Elevation - Capacity Curve after sedimentation (50 years)

8.3 Life of reservoir in years with basis

The sediment accumulation as per the analysis indicates that the sedimentation rate in the proposed reservoir is low and as per the above, the sedimentation after 50 years will be about 3 TMC which works out to 0.08% per year.

8.4 Capacities

8.4.1 Capacities (Mcum)

The capacity of the proposed reservoir before sedimentation at FRL 440.00 m is 67.16 TMC (1901.97 MCM).

8.4.2 Water tightness of the reservoir

All the parameters as required and if any for designing the water tightness of the reservoir would be considered during implementation stage.

8.5 Effect on sub soil water table in the adjoining areas

The resultant ponding of water due to storage in the proposed balancing reservoir will help in energizing and improving the sub soil water table in the adjoining areas.

8.6 Reservoir rim stability

Slopes are found to be stable and that there are no possibility of any slope failures in the reservoir formation area.

8.7 Area of submergence in Ha at FRL 440.00 m

The total submergence area at FRL 440.00 m = 4996.00 Ha.

8.8 Land acquisition, property submerged and rehabilitation

8.8.1 Land acquisition

The proposed project involves land acquisition im view of submergence and for seating of dam, construction of Intake canal , Underground power house, tail race tunnel and approach roads / utility corridor/bridges. The acquisition comprises of forest lands and revenue lands.

No	Purpose	Extent (Ha)	Type of land
1	Submergence Area (FRL 440.0 m)	5160.71	Wildlife forest - **4821.66 Ha** Reserved Forest- **196.57 Ha** Revenue land- **142.48** Ha
2	Dam Seating, Intake tunnel, Underground power house and tail race tunnel	66.64	Wildlife
3	Approach road and utility corridor (13.4 km, ROW 60m)	14.60	Wildlife
4	Colony	25.64	Revenue
	Grand Total	**5267.59 Ha**	Wildlife , Reserved and Revenue lands
	Area under Wildlife	4879.02 Ha	
	Area under Reserved forest	198.31 Ha	
	Area under Revenue land	190.26 Ha	

8.8.2 Details of properties

About 300 buildings are proposed to be acquired which comes under the submergence.

8.8.3 Details of Oustees

About 500 families involving a population of around 2000 are likely to be displaced.

Chapter 9
Irrigation Planning

This project is conceived as a power project and a balancing reservoir in order to generate power and as well as regulating / allowing the required quantum of water as per CWDT award, no irrigation component has been envisaged.

Chapter 10
Command area

This project is conceived as a power project and a balancing reservoir in order to generate power and as well as regulating / allowing the required quantum of water as per CWDT award, there will be no commanding area.

Chapter 11
Flood control

Flood control is not a part of the present proposal.

Chapter 12
Drainage

Since the present proposal is for construction of a balancing reservoir and not for irrigation purposes, this is not a part of the report.

Chapter 13
Power

13.1 Power aspect of the project

The present proposal of construction of a balancing reservoir primarily addrsses the following issues.

The proposed project is envisaged to address the following Objectives:

- The Storage capacity in the State of Karnataka is not enough to take care of the allocation made by the Hon'ble Tribunal and as modified by the Hon'ble Supreme Court of India vide its judgement dated 16.02.2018. In view of the same, there is a need for creating additional storage at Mekedatu to ensure utilisation of the allocated waters by the State of Karnataka (which will not be used for the irrigation purpose)
- To ensure timely release of the required quantum of water to Tamil Nadu on monthly basis (in a normal year) as per the orders of the Hon'ble Tribunal and as modified by the Hon'ble Supreme Court of India vide its judgement dated 16.02.2018.
- To harness incidentally 400 MW of power (650.28 MU of renewable energy annually at 90% dependable year) by utilizing fall in the natural bed profile of the Cauvery River upto the State border from the monthly releases to be made as per the orders of the Hon'ble Tribunal and as modified by the Hon'ble Supreme Court of India vide its judgement dated 16.02.2018..

After meeting the requirement of releases as per the CWDT award further modified by the Hon'ble Supreme court of India on 16/02/2018, the flows will be optimally made use of to generate power to the extent possible by utilizing the difference in bed level between the project site and the State border.

Thus, the primary objective of the present project being regulating and releasing the flows to Tamil Nadu (as per CWDT Award further modified by the Hon'ble Supreme court of India on 16/02/2018) and meeting the drinking water needs of Bengaluru Metropolitan region, its surrounding areas etc in the Cauvery Basin. Incidently, the proposal further envisages utilizing the elevation difference between the project site and the State border to generate power and as such, power components are also included as a part of the present proposal.

The justification for implementation of the project needs to address both the primary objective and the consequent power generation aspect.

a) Justification for primary objective

As per the studies and the results obtained for utilisation of available water flows after preparing the working tables as a part of study of Hydrology, it is seen that all the parameters as indicated below are met with by the project.

- The releases as per the CWDT Award further modified by the Hon'ble Supreme Court of India on 16/02/2018 at 177.25 TMC is fulfilled.
- Drinking water requirements for Bengaluru Metropolitan Region and surrounding areas can be met with the additional allocation of 4.75 TMC.

b) Justification for generating power

As indicated above, power can be generated by taking advantage of the available elevation difference in the bed fall of the river between the project site and the State border. While regulating the releases from the reservoir, the flows and the available head are utilized for generating power.

Once the balancing reservoir is constructed (keeping in view the objective), a head of 138 m is created between the reservoir level and river bed level at State border beyond which releases to Tamil Nadu State take place. It is prudent and justified to use this quantum of releases and the available head to generate Power.

13.1.1 Present Installed capacity

The project is situated in State of Karnataka which is in Southern Region. Present installed capacity in the region and state are shown in **Table 13.1**.

Table 13.1: Installed capacity in southern Region (Figures: In MW)

Sector	Thermal				Nuclear	Hydro	RES (MNRE)	Grand Total
	Coal	Gas	Diesel	Total				
State	19,433	792	288	20,513	0	11,838	521	32,872
Private	12,125	5,322	474	17,921	0	0	34,958	52,879
Center	14,225	360	0	14,585	3,320	0	492	18,397
Grand Total	45,783	6,474	762	5,3019	3,320	11,838	3,5971	104,148

Table 13.2: Karnataka State (Fig in MW)

Sector	Thermal				Nuclear	Hydro	RES (MNRE)	Grand Total
	Coal	Gas	Diesel	Total				
State	5,020	0	128	5,148	0	3,600	155	8903
Private	1,959	0	25	1,984	0	0	12,756	14740
Center	2,829	0	0	2,829	698	0	0	3527
Grand Total	9,808	0	153	9,961	698	3,600	12,911	27170

Note: Figures are in MW as on 31-10-2018 and include allocated share in joint and Central Sector (Source: Executive Summary published by CEA -October-2018)

13.1.2 Present and projected Status of Utilization of Power:

Category wise Energy consumption from 2013 onwards projected based on 2012 and CAGR is as follows:

Table 13.3: Utilization of power (Fig in MU)

FY Year	LT Domestic	HT Domestic	LT Commercial	HT Commercial	LT Industry	HT Industry	Agriculture	Bj / Kj	Others	Total
2013	8657	186	2584	3406	1817	8112	16328	578	3699	46,182
2017	11986	228	4082	5029	1998	11421	19536	824	4934	60,038
2022	18002	293	7230	8188	2251	17517	24444	1283	7073	86,281

Source: Study report by C-Step for Hon'ble KERC

13.1.3 Power Scenario in the State of Karnataka

The installed Capacity as on 31.10.18 is 27170 MW including allocation from Central and joint sectors. The category wise capacity is as furnished in 13.1.1 above. The energy drawn from SR grid in MU in the year 2017-18 is 67,635 MU.

As per 19th Electric Power Survey Committee report of the CEA the demand projections for Karnataka are as follows(Source:NEP-18):

Table 13.4: Energy(In MU)

Year	2016-17	2021-22	2026-27
Energy Requirement in MU	66,146	85,932	110,368

Table 13.5: Peak Demand(Fig: In MW)

Year	2016-17	2021-22	2026-27
Peak demand in MW	10,895	14,271	18,481

To meet the demand growth addition of Generation capacities is essential.

13.1.4 Shortages

The shortages in energy and Peak demand required, met and deficit / surplus are as follows for the year 2017-18 (Source: CEA -Annual Report -2018).

Table 13.6: Energy (Fig: In MU)

Sector	Required	Available	Shortage	Shortage in %
State	67869	67701	168	0.2
Sothern Region	320248	319642	606	0.2

Table 13.7: Peak Demand (Fig: In MW)

Sector	Required	Available	Shortage	Shortage in %
State	10,857	10,802	56	0.5
Southern Region	47385	47,210	175	0.4

The all India average shortage in energy is 0.72% and peak demand is 2.0% for the same period.

13.1.5 Future plans of power development

Future plans of power development from different sources in the State/region:

i. **State Sector(KPCL):**

Table 13.8: State Sector Projects

No.	Particulars	Capacity in MW	Status
1	Combined Cycle Power Plant (Gas based) at Yelahanka	370	Expected commissioning: 18-19
2	Shivasamudram Run off the river scheme.	200	DPR prepared.
3	Sharavathy Pumped Storage Scheme	2000	DPR under preparation.
4	Godhna TPP	2x800	Coal allotment and environmental clearance required.
5	Edlapur	1x800	Proposed to be shifted to RTPS mill reject area. MOEF clearance awaited.

(Source: Monthly progress report of the SRPC for the month of September -2018.)

ii. Details of the projects proposed and state share from these projects during 12th and 13th plan periods are furnished in PCKL website as per which state share is 11,752MW. Only Jurala HEP (117MW) and Additional unit at Ghataprabha (1x20MW) are hydro power projects among these projects.

13.1.6 Integrated operation of the system

Integrated operation of the system and present status of utilization in the state as well as in the region.

A. Hydro Thermal mix

i) All India level

For flexibility in operation of the grid Thermal hydro mix in generation plays an important role. Initially Thermal hydro Mix was is the range of about 50:50 in the year 1962-63 and the same has been reduced to about 13.6% in installed capacity during the year 2016-17. (Source: NEP-18 published by CEA)

ii) At State level

Earlier entire state demand was met by Hydro resources. With the commissioning of Thermal Power Plants in Raichur during 1980s, Hydro thermal mix started changing and it was around 60:40 in favour of hydro. However, with capacity addition in RTPS, BTPS, YTPS, UPCL, Jindal, etc the hydro thermal mix has been reduced to about 30:70(Excluding NCE capacity) (Source: Generation sheet dated 31.10.18 of SLDC/KPTCL)

B. Renewable energy targets

Further, GoI set a target of capacity addition of 175GW from renewable energy sources mainly from solar and wind in order to reduce the carbon footprint in the power sector. Karnataka grid at present has an installed capacity of 12,546MW from NCE projects out of which solar and wind contributes about 5154MW and 4731MW respectively. It is noted that these are variable sources of power and hence safe and reliable operation of the grid becomes important.

C. Flexibility

NEP-18 has noted that flexibility solutions of hydropower include

a) accommodating large variations in residual demand (to counter variability of RES, as sun does not always shine and wind does not blow constantly),

b) providing increasing ramp rates in real time, caused by sudden changes of generation

c) offsetting unexpected variations in production due to forecast errors in the intra-day markets or in the form of balancing power or ancillary services.

Considering all the above, it is envisaged in the National Electricity Plan-18 to accord **foremost priority** for **Hydro**, Gas and Nuclear based capacity addition due to their inherent advantages towards a **Low Carbon Growth Strategy**.

Considering the above, there is an urgent need for addition of capacity of 400 MW hydro power plant in Mekedatu, which is renewable in nature, from the point of view of safe and reliable operation of the grid in addition to augmenting the capacity required for improving the power position.

13.1.7 Fitment of the scheme in planning of power' development of the State/region.

The project proposes to utilize the releases from the dam to meet the award of the tribunal. Considering this water releases will follow the pattern as given by Tribunal. Considering this it is easy for forecasting the generation on day ahead basis apart from weekly, monthly basis. Hence, it could be scheduled during peaking, and scheduled for balancing the renewable energy also. Further, it is near to the load centre i.e., Bangalore and hence absorption of energy would be easy.

13.1.8 Energy generated from the project, firm power, seasonal power and total power:

Energy generated from the project, firm power, seasonal power and total power arrived in brief are as follows:

- Energy generated from the project.
- Total Energy generated from the project in 90% dependable year (2012-13) is 650.28 MU.
- Firm Power : From the ten daily power and energy potential studies (**Appendix 15**, **Vol II**), it is seen that in the 90% dependable year viz 2012-13, the maximum power output achievable is 307.84 MW (1st Oct 2012 to 10th Oct 2012).
- Monthly/seasonal power (90% dependable year).

13.1.9 Project cost and cost of power generated

At the present estimated cost per MW and cost per unit of energy, the project is most attractive from the economical considerations also.

It is noted that the average cost of supply for the year 2014-15 is Rs 5.43 per unit of energy on all India level. ***(Source : Annual report-18 of CEA.)***

Generic Tariff approved by Hon'ble KERC for renewable energy resources varies from Rs 3.0 to Rs.5.0 for the year 2018 as detailed below:

Table 13.9: Tariff for renewable energy

No.	RE Sources	Control period	Approved Tariff (Rs. Per Unit)
a)	Wind	1 Year from 01-04-2018	3.45
b)	Solar(MW scale)	1 Year from 01-04-2018	3.05
c)	Solar(SRTPV) Without subsidy	1 Year from 01-04-2018	3.56
d)	Solar(SRTPV) With subsidy	1 Year from 01-04-2018	2.67
e)	Bio-Mass	3 Years from 01-04-2018	i) 5.55 for water Cooled ii) 5.35 for Air Cooled
f)	Mini-Hydel	3 Years from 01-04-2018	3.95
g)	Co-Gen	3 Years from 01-04-2018	3.59

Details of tariff estimated for hydro projects, under 50,000 MW hydro initiative has been furnished in the Annual report of CEA for the year 2018. As per this detail, hydro projects with an energy content of about 500mu to 700 mu, have an estimated tariff varying from Rs.1.5 per unit to Rs 5.0 per unit of energy.

Cost of energy from thermal power plants is much higher at about Rs. 4.0 to Rs.5.0 per unit. Present cost of energy of BTPS is Rs.4.55 per unit and that for RTPS is Rs.3.99 per unit . ***(Source: Executive Summary -03 (2018) published by CEA)***. Average tariff of Gas based plant is much higher considering the present gas prices. Energy charges itself works out to about Rs.5.0 per unit.

(Example - Source: Order dated March 21, 2018 passed by Uttarakhand Electricity Regulatory Commission in respect of Gas plant of M/s Gama Infra prop Pvt Ltd.). Similar trends could be seen in this region also. Prices vary between Rs.3.62 per unit to Rs.7.49 per unit for gas based plants in private sector. ***(Source: Executive Summary -03 (2018) published by CEA)***.

Considering all the above aspects, the present proposal of installing 400MW hydro power plant at Mekedatu is most attractive and merit consideration for taking up on utmost priority.

13.1.10 Transmission system

3 nos. 220 kV lines (1 double circuit + 1 single circuit) are envisaged for evacuating 400 MW Generation from Makedatu Project. The nearest 220 kV substation is TK Halli which is approximately at 40 km from the project site. The existing transmission lines from TK Halli to Somanahalli can be considered for Loop in Loop out connection at Makedatu. The load centers of TK Halli, Mysore and parts of Bangalore can be supplied from Makedatu and hence load centers proximity is good.

The first 10 km (approx) of the route length of 40 km passes through forest area of eco sensitive zone. It is proposed to lay 220 kV UG EHV Cables from plant GIS to a distance of about 10 km passing through eco sensitive zone and for balance 30 km over head transmission line is proposed. A Pot head yard will be provided for terminating cables to transmission line.

The final planning of transmission line, selection of substation etc will be carried out by KPTCL who have been intimated regarding the requirement.

GIS switch yard on surface is proposed with 4 unit modules, 4 line modules, 1 bus coupler module and 2 PT modules. The SLD and switch yard layouts are furnished in drawing, Vol III.

13.2 Assessment of power benefits of the proposed project

13.2.1 Nature of project

Karnataka Government proposes to build a dam across Cauvery River near Mekedatu. It is a storage based project with its main objectives comprising:

The proposed project is envisaged to address the following Objectives:

- The Storage capacity in the State of Karnataka is not enough to take care of the allocation made by the Hon'ble Tribunal and as modified by the Hon'ble Supreme Court of India vide its judgement dated 16.02.2018. In view of the same, there is a need for creating additional storage at Mekedatu to ensure utilisation of the allocated waters by the State of Karnataka (which will not be used for the irrigation purpose)
- To ensure timely release of the required quantum of water to Tamil Nadu on monthly basis (in a normal year) as per the orders of the Hon'ble Tribunal and as modified by the Hon'ble Supreme Court of India vide its judgement dated 16.02.2018
- To harness incidentally 400 MW of power (650.28 MU of renewable energy annually at 90% dependable year) by utilizing fall in the natural bed profile of the Cauvery River upto the State border from the monthly releases to be made as per the orders of the Hon'ble Tribunal and as modified by the Hon'ble Supreme Court of India vide its judgement dated 16.02.2018.

13.2.2 Stage of development and effect of future u/s or d/s development

Existing projects near the proposed Mekedatu Project

The following are the existing Power Projects upstream of Mekedatu Project.

a) Shivanasamudram Power House (42 MW)

b) Shimsha Power House (17.2 MW)

c) Mini Hydel Schemes

upstream of Mekedatu Project viz i. Shivanasamudram Run of the River Power Project with Installed Capacity of 200 MW to utilize the head between EL 614.5m and EL. 440.0m.

A Power Project was also contemplated earlier downstream of Mekedatu Project in the common boundary of Karnataka and Tamil nadu i.e., Hogenekal Project with FRL of EL 305.0 m.

13.2.3 Hydrology ,sedimentation studies and criteria for fixing up the FRL and MDDL

The Hydrology, sedimentation studies and and criteria/optimization studies for fixing up FRL and MDDL etc., is explained in Chapter-5, Chapter 8 respectively.

13.2.4 Mode of operation of Reservoir

Mode of operation of reservoir is already explained in Chapter-8.

13.2.5 Long term water power studies depending upon nature of the project

As explained in Chapter 8 "Reservoir", FRL of the reservoir is proposed at RL 440.0 m and MDDL at RL 395.00 m. Tail water level is considered at RL, 305.00 m to suit the proposed FRL of the Hogenakal Power Project. Thus, maximum gross head of 138.0 m is available for power generation from this Project.

The parameters have been considered in carrying out the Power Potential Studies are illustrated in **Table 13.10.**

Table 13.10: Parameters have been consider for Power Potential Studies

No	Parameters	Details
i.	Full Reservoir Level (FRL)	RL 440.0 m
ii.	Maximum Draw Down Level (MDDL)	RL 395.0 m
iii.	Minimum Tail Water Level	RL 302.0 m
iv.	Weighted Reservoir Level	RL 425.0 m
v.	Operating Tail Water Level	RL 305.0 m (All Units Working)
vi.	Maximum Gross Head	138.0 m
vii.	Minimum Gross Head	90 m (All Units Working)
viii.	Losses in water Conductor system	3 m
ix.	Maximum Net Head	135 m
x.	Minimum Net Head	87 m
xi.	Rated Net Head	120 m
xii.	Combined efficiency of Generating Units	90%

The detail friction losses are explained in Chapter-7.

The working tables have been prepared for Mekedatu reservoir with FRL of RL 440 m and MDDL of RL 395 m. The daily gauged data for the Cauvery River from the year 1974-1975 to the year 2016- 17 maintained by CWC / Government of India at Biligundlu have been collected and utilized. Based on the daily inflow data, 10 daily inflows have been worked out and the same are made use of for the Mekedatu Reservoir Operation Tables. The working tables considers the Obligation of release of water to Tamil Nadu as per CWDT Award further modified by the Hon'ble Supreme Court of India on 16/02/2018, water supply to Bangalore Metropolitan region, its surrounding areas etc in the Cauvery Basin. Evaporation loss have been considered and explained in detail in Hydrology – Chapter – 5.

It is also brought out in Chapter 8 that although the results are shown for all the years for which data is available, viz., from year 1974-1975 to the year 2016-2017, results from 1974-1975 to 1983-1984 may not be a true representative since utilization of waters from Hemavathy, Kabini and Harangi Projects were not stabilized and fully developed during that period. **Therefore, for power potential assessment, working tables for the year from 1984-1985 to the year 2016-2017 have been utilized.**

Based on the above working table, ten daily flows released to Tamil Nadu at Biligundlu has been assessed and furnished vide **Appendix 15.6. Vol II**

As per the CWDT Award further modified by the Hon'ble Supreme court of India on 16/02/2018, following monthly flows during Lean Season should be ensured:

Table 13.11: Lean season flows

Month	Feb	Mar	Apr	May
Flow, TMC	2.5	2.5	2.5	2.5

From the working tables furnished in the Hydrology chapter, it is seen that the above obligations have also been met.

Graphical representation of maximum mean and minimum flow pattern are shown in **Appendix 15.7 Vol II** Unrestricted power and unrestricted annual energy have been worked out for each of the years of the above period. Details are furnished vide **Appendix 15.8 & 15.9 Vol II**. From the above, it is seen that unrestricted annual energy varies from 382 MU to 3040 MU. Further, the power studies have also been carried out for installed capacities varying from 300 MW to 500 MW with increment level of 25 MW. Detailed ten daily powers and energy potential computation for the above period for various installations have been enclosed as **Appendix -15.10(1) to 15.10(33) Vol II.**

13.2.6 Unresticted energy generation

Unrestricted energy generation from the year 1984-85 to 2016-17 is furnished in the **Table 13.12**

Table 13.12: Unresticted energy generation

No.	Year	Unrestricted Energy in MU	No.	Year	Unrestricted Energy in MU
1	1984-85	2374	18	2001-02	1221
2	1985-86	1179	19	2002-03	782
3	1986-87	999	20	2003-04	430
4	1987-88	559	21	2004-05	988
5	1988-89	848	22	2005-06	2291
6	1989-90	965	23	2006-07	1814
7	1990-91	904	24	2007-08	2661
8	1991-92	1939	25	2008-09	1473
9	1992-93	2719	26	2009-10	1267
10	1993-94	1465	27	2010-11	1094
11	1994-95	3040	28	2011-12	1161
12	1995-96	1300	29	2012-13	650
13	1996-97	1201	30	2013-14	1430
14	1997-98	1791	31	2014-15	1275
15	1998-99	1732	32	2015-16	815
16	1999-00	1866	33	2016-17	382
17	2000-01	2210			

The summary of average annual generation in MU for the period from the year 1984-1985 to the year 2016-2017 and the annual plant load factor for various installations are tabulated in **Table 13.13.**

Table 13.13: The summary of average annual generation in Mu (1984-2017)

Installed Capacity in MW	Average Annual Energy in MU	Annual Plant Load Factor (%)
300	1039.80	39.6
325	1077.82	37.9
350	1111.55	36.3
375	1141.34	34.7
400	**1167.26**	**33.3**
425	1189.71	32.0
450	1209.25	30.7
475	1225.75	29.5
500	1240.54	28.3

The graphical representation of average annual energy in MU V/s Installed capacity in MW is depicted in the **Error! Reference source not found.**

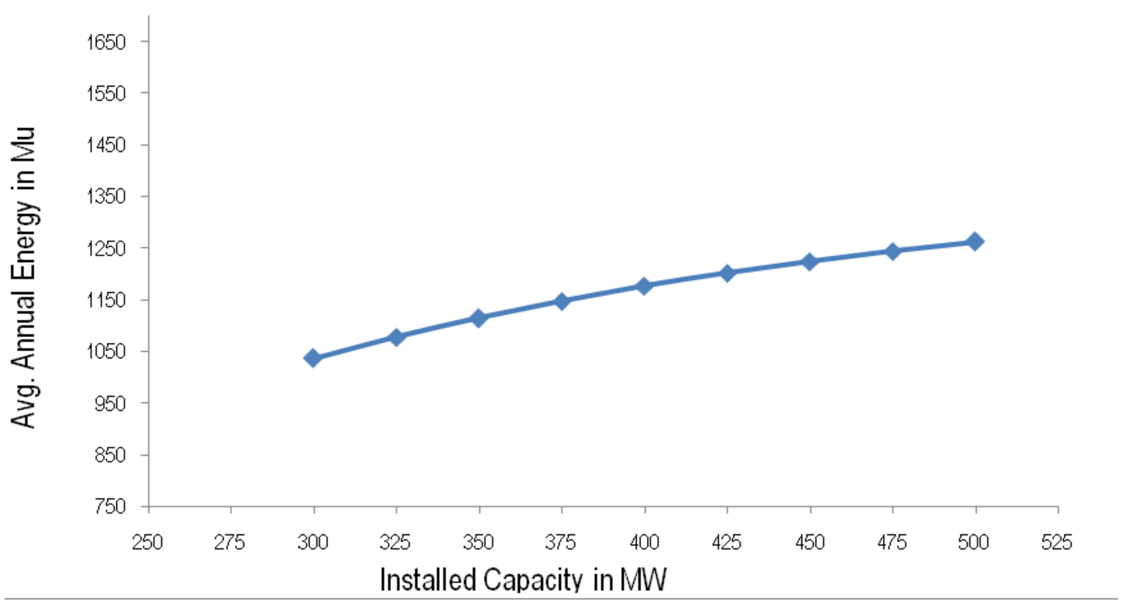


Fig. 13.1: Graphical representation of average annual energy in MU V/s Installed capacity in MW

Incremental Energy: Incremental additional energy (Delta KWH) for an incremental additional capacity of 25MW(Delta MW) has been calculated and shown in **Table 13.14**

Table 13.14: Incremental energy for incremental addition of capacity

No	Installed Capacity (MW)	Annual Energy (Mu)	Incremental Energy Mu / MW
1	300	1039.80	
2	325	1077.82	1.52
3	350	1111.55	1.35
4	375	1141.34	1.19
5	400	1167.26	1.04
6	425	1189.71	0.90
7	450	1209.25	0.78
8	475	1225.75	0.66
9	500	1240.54	0.59

Graphyical representation of incremental addition of energy for incremental addition of capacity is shown in **Fig. 13.2**

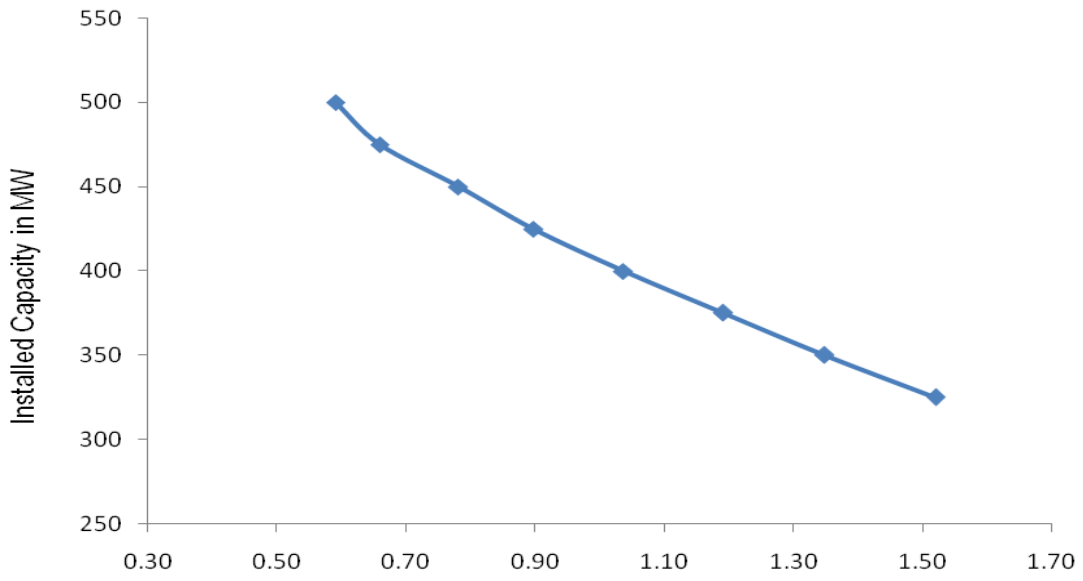


Fig. 13.2: Graphical representtaion of incremental energy for incremental addition of capacity

Karnataka State is facing acute shortage of Power and Energy. Therefore, in order to mitigate the above shortages to the extent possible, an installed capacity of 400 MW with Annual Plant Load Factor of 33.3% has been considered as the optimum Installed Capacity for this Project. Average Annual Energy Generation is estimated at 1167.26 MU.

Ten daily power potential and corresponding energy for installed capacity of 400 MW for the year 1984-85 to 2016-17 are furnished vide **Appendix- 15.11 and 15.13 Vol II.**

Details of average monthly Power / Energy Generation for the period 1984-85 to 2016-17 are as given in

Table 13.15: The summary of average monthly Power/Energy generation in Mu (1984-1985 to 2016-17)

Month	Days	Average Power in MW	Average Energy in MU	% Load Factor
Jun	I	75.93	18.22	18.98
	II	71.79	17.23	17.95
	III	84.94	20.38	21.23
Jul	I	253.44	60.83	63.36
	II	249.63	59.91	62.41
	III	267.44	70.60	73.55
Aug	I	319.44	76.67	79.86
	II	310.54	74.53	77.64
	III	324.75	85.73	89.31
Sep	I	275.21	66.05	68.80
	II	294.72	70.73	73.68
	III	294.62	70.71	73.66

Month	Days	Average Power in MW	Average Energy in MU	% Load Factor
Oct	I	239.86	57.57	59.96
	II	230.72	55.37	57.68
	III	219.75	58.01	60.43
Nov	I	211.48	50.76	52.87
	II	191.98	46.07	47.99
	III	190.23	45.66	47.56
Dec	I	128.10	30.74	32.03
	II	105.21	25.25	26.30
	III	79.81	21.07	21.95
Jan	I	42.21	10.13	10.55
	II	32.35	7.76	8.09
	III	30.54	8.06	8.40
Feb	I	17.28	4.15	4.32
	II	19.01	4.56	4.75
	III	19.53	3.75	3.91
Mar	I	16.82	4.04	4.21
	II	16.06	3.85	4.01
	III	18.40	4.86	5.06
Apr	I	15.34	3.68	3.84
	II	25.87	6.21	6.47
	III	22.06	5.29	5.52
May	I	21.23	5.09	5.31
	II	24.98	6.00	6.25
	III	29.25	7.72	8.04
Average		**132.51**	**1167.26**	**33.77**

Note: Installed Capacity of 400 MW is considered for working out Load Factor

13.2.7 Studies for Optimization of Storage

As explained in Chapter-8: Hydrology and Results of Mekedatu Reservoir working tables, it is seen that, fixing of FRL at RL 440.00 m is necessary to meet the obligation of release of water to Tamil Nadu as per CWDT Award further modified by the Hon'ble Supreme Court of India on 16/02/2018, & to meet the water supply need of Bangalore Metropolitan region, its surrounding areas etc in the Cauvery basin as per the additional allocation of 4.75 TMC.

From Sedimentation consideration, MDDL of EL 395 m has been adopted.

Storage Capacity of Mekedatu Reservoir is as follow:

Gross Storage at EL 440 m: 67.16 TMC (1902 MCM)

Dead Storage at EL 395 m : 7.7 TMC (218.06 MCM)

Live Storage : 59.46 TMC (1683.90 MCM)

13.2.8 Annual and month-wise design energy

A. Optimization of Installed Capacity and unit-size studies.

As explained in para (ii), optimum Installed Capacity has been considered as 400 MW. 90% Dependable Energy year has been calculated for IC: 400 MW as shown in **Table 13.16**

Table 13.16: Annual design energy

Observed Series		Rank	Descending Order		Probability of Exceedance
Year	Annual Energy in Mu		Annual Energy in Mu	Year	
1984-85	1514.27	1	1769.17	2000-01	2.94
1985-86	1124.23	2	1719.79	1999-00	5.88
1986-87	930.18	3	1719.30	2007-08	8.82
1987-88	559.45	4	1714.71	2005-06	11.76
1988-89	768.96	5	1644.56	1998-99	14.71
1989-90	936.16	6	1625.25	2007-08	17.65
1990-91	859.32	7	1619.29	1991-92	20.59
1991-92	1520.51	8	1592.62	1994-95	23.53
1992-93	1663.69	9	1563.71	1984-85	26.47
1993-94	1324.78	10	1557.61	1997-98	29.41
1994-95	1543.42	11	1387.62	2006-07	32.35
1995-96	1143.75	12	1346.26	2008-09	35.29
1996-97	1196.50	13	1322.87	1993-94	38.24
1997-98	1576.65	14	1304.24	2013-14	41.18
1998-99	1604.75	15	1244.22	2001-02	44.12
1999-00	1671.58	16	1221.38	1996-97	47.06
2000-01	1727.90	17	1209.32	1995-96	50.00
2001-02	1195.55	18	1200.60	2009-10	52.94
2002-03	750.04	19	1155.75	1985-86	55.88
2003-04	429.61	20	1141.59	2014-15	58.82
2004-05	976.52	21	1102.89	2011-12	61.76
2005-06	1654.32	22	1002.26	2004-05	64.71
2006-07	1350.42	23	982.52	2010-11	67.65
2007-08	1563.01	24	942.76	1989-90	70.59
2008-09	1296.37	25	936.18	1990-91	73.53
2009-10	1203.38	26	865.92	1986-87	76.47
2010-11	990.26	27	815.42	2015-16	79.41
2011-12	1096.89	28	774.96	1988-89	82.35
2012-13	**650.28**	29	756.04	2002-03	85.29

Observed Series		Rank	Descending Order		Probability of Exceedance
Year	Annual Energy in Mu		Annual Energy in Mu	Year	
2013-14	1273.64	30	**650.28**	2012-13	**88.24**
2014-15	1225.62	31	559.45	1987-88	91.18
2015-16	815.42	32	429.61	2003-04	94.12
2016-17	382.23	33	382.23	2016-17	97.06

90% dependable energy works out to 650.28 MU

Graphical representation of Annual Energy for the year 1984-85 to 2016-17 for IC.400 MW are shown in **Fig. 13.3**

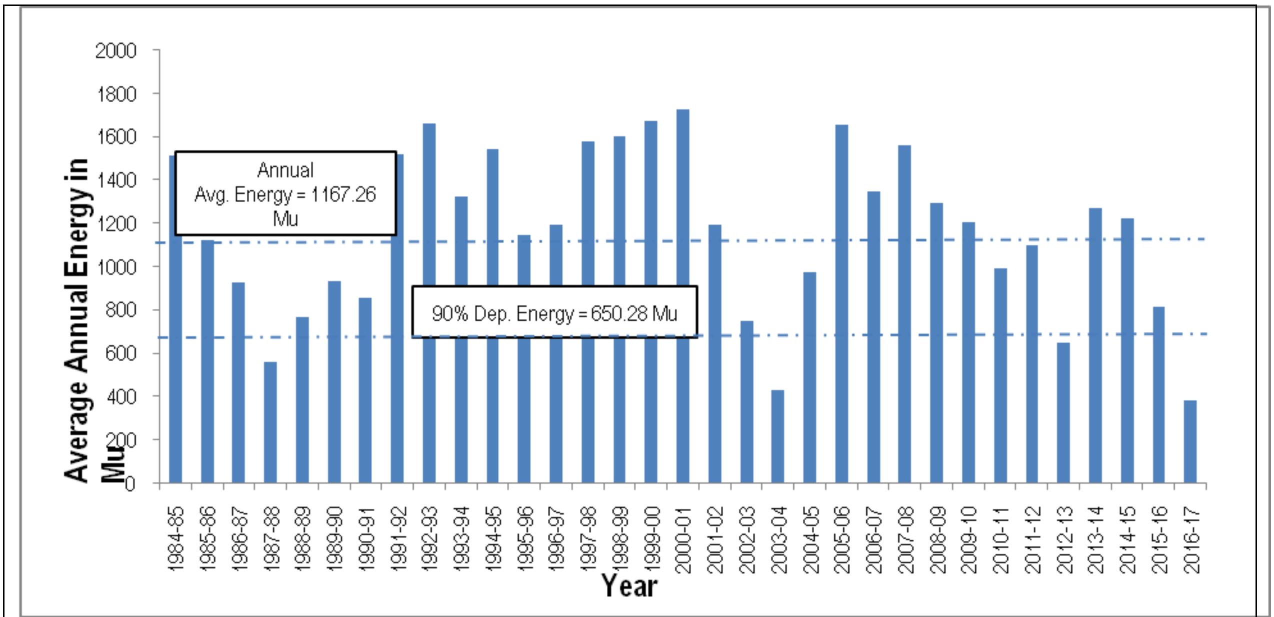


Fig. 13.3: Graphical representation of Annual Energy for the year 1984-85 to 2016-17

Month-wise Energy for Installed Capacity of 400 MW for the 90% Dependable Energy Year (Year 2012-13) is shown in :**Error! Reference source not found.** and graphical repsentation is shown in **Fig. 13.4.**

Table 13.17: Month wise design energy for 90% Dependable (Year 2012-13)

Month	Jun			Jul			Aug		
	I	II	III	I	II	III	I	II	III
Energy in MU	4.45	4.42	4.39	33.54	23.60	22.60	28.37	36.60	16.06
Month	Sep			Oct			Nov		
	I	II	III	I	II	III	I	II	III
Energy in MU	32.13	59.47	28.11	73.88	37.22	16.94	29.56	20.45	20.72
Month	Dec			Jan			Feb		
	I	II	III	I	II	III	I	II	III
Energy in MU	36.30	22.13	15.21	10.22	8.30	6.46	5.04	13.32	7.08
Month		Mar			Apr			May	
	I	II	III	I	II	III	I	II	III
Energy in MU	4.60	4.86	3.67	4.34	4.35	2.99	2.90	2.99	3.01

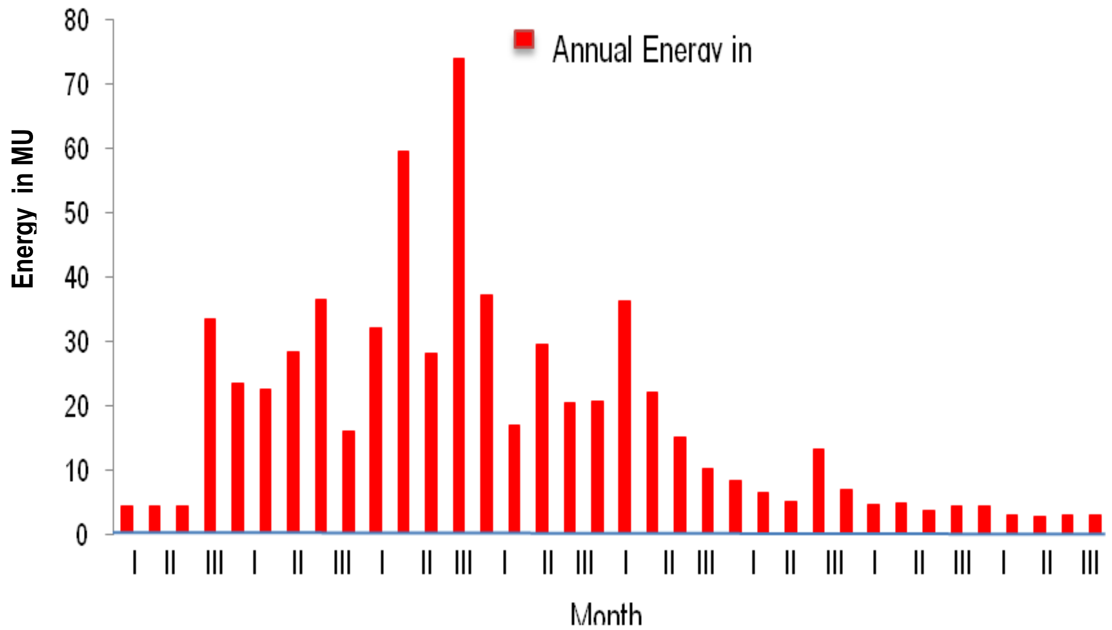


Fig. 13.4: Graphical representation of month-wise design energy for 90% Dependable (Year 1987-88)

B. Design Energy

As explained above, 90% Dependable Energy (Gross) works out to 650.28 MU. From the ten daily power and Energy potential studies (Appendix 15), it is seen that in the 90% Dependable Year namely 2012-13, maximum power output achievable is 307.84 MW (1st OCT 2012 to 10th OCT 2012). Firm power is calculated as 20.95 MW.(Based on Average of lean season flows in 90% dependable year).

The design energy (annual) of 650.28 MU has been used for calculating the Tariff is shown **Table 13.18.**

Table 13.18:Calculation of design energy (annual) of 650.28 MU at 90% Dependable year 2012-13

Month	Average MW	Average MU
June	18.41	13.25
July	107.89	79.74
Aug	110.51	81.03
Sept	166.27	119.71
Oct	175.70	128.04
Nov	98.24	70.73
Dec	100.35	73.64
Jan	33.88	24.98
Feb	37.79	25.44
March	17.79	13.14
April	16.22	11.68
May	11.98	8.90
Total		**650.28**

C. Seasonal Energy

Firm discharge has been calculated considering the average of flows during the lean season (February to May) in a 90% dependable year.(2012-13). Firm power and firm energy has been calculated based on the firm discharge calculated. Firm discharge works out to 27.28 cumecs and Firm Power works out 20.95 MW.

The secondary energy is the difference between the average annual energy and the firm energy. In other words, it is the energy generation in excess of the firm energy in any year by the installed capacity.

The Month wise availability of firm power, seasonal power, firm energy and seasonal energy for the year 2012-13 are given in **Error! Reference source not found.**

Table 13.19:Month-wise availability of power and energy for the year of 1987-88

Month	Average Monthly Power	Monthly Firm Power	Monthly Seasonal Power	Average Seasonal Energy	Monthly Firm Energy	Monthly Seasonal Energy
	MW	MW	MW	Mu	Mu	Mu
Jun	18.41	18.41	0	13.25	13.25	0
Jul	107.89	20.95	86.85	79.74	15.58	64.15
Aug	110.51	20.95	89.47	81.03	15.58	65.44
Sep	166.27	20.95	145.23	119.71	15.08	104.63
Oct	175.70	20.95	154.66	128.04	15.58	112.46
Nov	98.24	20.95	77.20	70.73	15.08	55.65
Dec	100.35	20.95	79.32	73.64	15.58	58.05
Jan	33.88	20.95	12.84	24.98	15.58	9.40
Feb	37.79	20.95	16.75	25.44	14.08	11.36
Mar	17.79	17.79	0	13.14	13.14	0
Apr	16.22	16.22	0	11.68	11.68	0
May	11.98	11.98	0	8.90	8.90	0
			Total	**650.28**	**169.13**	**481.15**

D. Conclusion

To utilize the release of 2.5 TMC per month during the period from the month of Feb. to May to cater to the environmental consideration, an Installation of smaller unit of 40 MW has been contemplated, as part of the total Installed Capacity.

Proposed configuration of Installation of Generating units at this project would be 3 x 120 MW + 1 x 40 MW=400MW.

13.3 Power house and equipment

13.3.1 Criteria for selection of type of power house

Under Ground Power House is proposed since the terrain on both banks of river is very steep rendering grading for a surface Power house uneconomical. The geology is suitable for tunneling and construction of underground caverns, to house the generating units and associated equipment.

13.3.2 Criteria for selection of location of power house and alternatives considered

The site had been selected based on earlier reports. KPCL had identified 3 sites at the stretch of river naming them as A,B & C and had recommended site 'C' as the best choice. The same site is proposed in this DPR.

13.3.3 Dimensions

- Power house cavern = 83520 (L) x 22000 (W) x 42000 (H)
- Transfomer Cavern = 77987 (L) x 16000 (W) x 19500 (H)
- Repair bay and Control block = 56270 (L) x 22000 (W) x 14000 (H)
- Surge Gallery = 77500 (L) x 22000 (W) x 47000 (H)

13.3.4 Number of units

Installed Capacity proposed is 1 unit of 40 MW and 3 units of 120 MW.

13.3.5 Turbine

Turbines are Vertical Axis Francis Turbines with a rated head of 120 meters and rated output of 45.5 MW and 136.1 MW to give 40 MW and 120 MW at Generators Terminals. (Generating units shall have 10% continuous overload capacity above nominal rating).

13.3.6 Generator

Type	Vertical Shaft Salient Pole Synchronous, Semi Umbrella or Pendent type
Rated Output	Unit 1-45 MVA / Units 2 to 4-135 MVA(Nominal rating)
Power Factor	0.9 lag
Frequency	50 Hz
Phases	3
Speed	333/187.5 rpm (To match turbine speed)
Rated Terminal Voltage	11-15.75 kV
Cooling	Totally Enclosed closed circuit air cooled by water

13.3.7 Transformer

Each Generator will be provided with a 3 phase 11 kV / 230 kV step up transformer as follows

Particulars	Parameters
Voltage Ratio	11 KV / 230 KV
MVA rating	50 / 150 MVA
Vector group	Ynd1 (HV neutral solidly grounded)
Cooling	OFWF
Tap changer	On load +/-10%
Impedance	10%/12.5%

13.3.8 Power house cranes

2 nos. 225 T / 15 T EOT Cranes will be provided in the Power House cavern.

13.3.9 Switchgear

Type of Switch gear is GIS above ground. 220 kV, 40 kA short time rated. The size of GIS building and pot head yard together is 21.5 m X 72 m.

13.4 Power plant head and flow

Particulars	Parameters
Minimum Net Head at MDDL	87 m
Maximum Net Head at FRL	135 m
Rated net head	120 m
Design net head	120 m
Maximum discharge at MDDL	520.07 cumec for 400 MW
Minimum discharge at FRL	22 cumecs for 26 MW
TWL Min / Max / Maximum under flood	RL 302.0m / RL 305.00m / RL 315.00m

13.5 Transmission arrangement

3 nos. 220 kV lines (1 double circuit + 1 single circuit) are envisaged for evacuating 400 MW Generation from Makedatu Project. The nearest 220 kV substation is TK Halli which is approximately at 40 km from the project site. The existing transmission lines from TK Halli to Somanahalli can be considered for Loop in Loop out connection at Makedatu. The load centers of TK Halli, Mysore and parts of Bangalore can be supplied from Makedatu and hence load centers proximity is good.

The first 10km (approx) of the route length of 40 km passes through forest area of eco sensitive zone. It is proposed to lay 220 kV UG EHV Cables from plant GIS to a distance of about 10 km passing through eco sensitive zone and for balance 30 km over head transmission line is proposed. A Pot head yard will be provided for terminating cables to transmission line.

The final planning of transmission line, selection of substation etc will be carried out by KPTCL who have been intimated regarding the requirement.

GIS switch yard on surface is proposed with 4 unit modules, 4 line modules, 1 bus coupler module and 2 PT modules. The SLD and switch yard layouts are furnished in drawing, Vol III.

13.6 Power Generating Equipment

13.6.1 Installed capacity

Installed capacity is 1X40 MW and 3X 120 MW = 400 MW

13.6.1.1 Turbine

a) Type of Turbine

The optimum installed capacity of the project as per power studies is 400 MW consisting of 1 unit of 40 MW and 3 units of 120 MW. The rated net head arrived at is 120 meters. For this rated head and output, vertical Francis turbines are best suited.

b) Unit Ratings

Number of units and unit ratings are selected to minimize the number of units and at the same time limiting the unit size so that the part load generation is possible to absorb the lean flows also. The minimum mandatory discharge to be maintained is 25 to 27 cumecs. The power output for this discharge at 120 m head is around 27 MW. Considering that a Francis Turbine can be run at minimum load of 70% of rating the unit rating is to be around 38 MW to be able to run at the minimum flows. To meet this requirement, it is proposed to install one small unit of 40 MW. The optimum installed capacity is 400 MW. It is also required to limit unit size to around 120 MW for avoiding too large turbine and generators which will give rise to transportation and handling problems. Based on all these considerations installation of 1X40 MW+3X120 MW is proposed.

c) Operating Heads and Outputs:

Design head, maximum head and minimum head for turbines:

Operating heads of turbines are arrived at as follows:

FRL of Reservoir = 440.00 m

MDDL of reservoir = 395.00 m

Minimum tail water level with

40 MW unit at 50% discharge = 302.0 m

Normal Tail water level with

All 4 units rated flow = 305.00 m

Maximum gross head = 440.0 – 302.0 = 138.0 m

Minimum gross head = 395.0 - 305.0 = 90.0 m

Design gross head = 90.0 + 2/3 x (138.0 – 90.0) = 122.0 m

Losses in water conductor system

For design flow of around 380 cumecs = 3.0 m

Design net head = 122.0 – 3.0 = 119.0 m

Hence design head is fixed at 120.0 m.

Minimum net head = MDDL - Loss in water conductor - Maximum tail water level

= 395.0 –305.0-3 = 87.0 m

Maximum net head = Maximum gross head – Losses = 138 – 3 = 135 m

Hence Design head, maximum head and minimum head are fixed at 120.0 m, 135.0 m and 87.0 m respectively. The range of heads are within operating range of Francis Turbines.

d) Specific Speed and Synchronous Speed

For rated head of 120 m, the range of specific speed is 150 to 210 metric units.

The speeds within the range are selected as follows.

i) For 40 MW unit

For specific speed of 170, turbine speed will be Speed = Ns*h^1.25/(Tkw)^0.5

Where Ns is specific speed= 170, h is head=120 m and Tkw is turbine rating in kW= 40000/Geneff = 40000/0.96.

Speed = 170*120^1.25/(40000/0.96)^0.5 = 330.7

Nearest synchronous speed of 333 rpm is selected.

For 333 rpm, the specific speed will be = 333*(40000)^0.5/120^1.25 = 171.14 Mkw units. Since silt is not high and one speed higher is selected which will reduce the cost.

The specific speed in meter-HP units is 171.14 / 0.86 = 199. As per IS 12800, fig.1 for head of 120 m the specific speed recommended is 200. Hence it is in order.

ii) For 120 MW units

Speed = 170*120^1.25/(120000/0.96)^0.5 = 190.9

Nearest synchronous speed of 187.5 rpm is selected.

For 187.5 rpm the specific speed will be = 187.5*(120000)^0.5/120^1.25 = 166.9.MkW units.

The specific speed in meter-HP units is 166.9 / 0.86 = 194.0. As per IS 12800, fig.1 for head of 120 m the specific speed recommended is about 200. Hence it is in order.

e) Runner diameter

The runner diameter for the selected speed is calculated as follows

i) For 120 MW unit

As per Warnick runner dia =

(26.2+0.211*Ns)*(h)^0.5/N = (26.2 + 0.211 *167)*120^0.5 / 187.5 = 3.60 m

As per USBR runner discharge dia = 84.47*ǿ*h^0.5/n

ǿ= velocity ratio = 0.0233* Ns^2/3= 0.0233*167^2/3

Runner dia = 84.47*0.0233*167^(2/3)*120^0.5/187.5= 3.5 m

Runner diameter d_3 of 3.9 m is selected based on above and 10% higher to accommodate overload margin.

As per USBR runner proportions, maximum outside diameter of runner will be 1.2 times = 1.2*3.9 = 4.68 m

ii) For 40 MW unit

As per Warnick runner dia = (26.2+0.211*Ns)*(h)^0.5/N

= (26.2 + 0.211 *171)*120^0.5 / 333= 2.05 m

As per USBR runner discharge dia = 84.47*ǿ*h^0.5/n

ǿ= velocity ratio = 0.0233* Ns^2/3= 0.0233*171^2/3

Runner dia = 84.47*0.0233*171^(2/3)*120^0.5/333= 2.0 m

Runner diameter d3 of 2.1 m is selected based on above and with margin for overlaods

As per USBR runner proportions, maximum outside diameter of runner will be 1.2 times = 1.2*2.1 = 2.52 m

All other dimensions of spiral casing, draft tube and unit bay size are calculated based on the selected runner diameter.

f) Setting of Turbine

The setting of the turbine with respect to minimum tailrace level has to be less than the maximum allowable to limit cavitation damage to the runner. Based on the specific speed selected and maximum head cavitation factor (Critical sigma) is calculated and based on the Critical Sigma setting of the runner centerline is determined as follows. However final setting level will be decided as per recommendations of the successful turbine bidder.

i) For 40 MW unit

As per Warnick, Sigma = (Ns)^1.64/ 50227, where NS is in Metric-HP Units

= 199^1.64/50227 = 0.116

As per IS 12800, fig. 3A, Sigma for specific speed of 199 is 0.11

Sigma as 0.12 is selected.

Required submergence = ha – hv- sigma* head

Where ha is atmospheric pressure at site elevation = 9.99 m, hv= vapor pressure = 0.35 m and head = 120 m

Submergence = 9.99 – 0.35 -0.12*120 = -4.76 m

Turbine center line = Min TWL – 4.76 – 0.15* runner dia = 302 - 4.76 – 0.15*2.1 = EL 296.925 m

Turbine center line as EL 296.925 m is selected

ii) For 120 MW Unit

As per Warnick, Sigma = (Ns)^1.64/ 50227. Where NS is in Metric -HP units = 194^.64/50227 = 0.112

As per IS 12800, fig. 3A, Sigma for specific speed of 193 is 0.11

Sigma as 0.12 is selected.

Required submergence = ha – hv- sigma* head

Where ha is atmospheric pressure at site elevation = 9.99 m, hv= vapor pressure = 0.35 m and head = 120.0 m

Submergence = = 9.99 – 0.35 -0.12*120 = -4.76 m

Turbine center line = Min TWL – 4.76 – 0.15* runner dia = 302-4.76 – 0.15*3.9 = EL 296.65m

Turbine center line as EL 296.5 m is selected.

g) Speed and Pressure Raises

Runaway speed at rated head as per USBR = Rated speed *0.65*Ns^0.2

Runaway speed at rated head for 40 MW unit = 333*0.65*170^0.2 = 604 rpm

Runaway speed at maximum head for 40 MW unit = (Max H/rated H)^0.5* Runaway speed at rated speed = (132/120)^0.5 * 604 = 633.5 rpm

Runaway speed at rated head for 120 MW unit = 187.5*0.65*167^0.2 = 337.9 rpm

Runaway speed at maximum head for 40 MW unit = (Max H/rated H)^0.5* Runaway speed at rated speed = (132/120)^0.5 * 337.9 = 354.3 rpm

The pressure raise and speed raise on full load throw off will be within 35% and 45% respectively as per standard practice.

h) Efficiencies:

Turbine efficiency at rated head and rated load will be 93% and generator efficiency will be better than 97%. The overall efficiency of the plant will be 90%.

i) Turbine Parameters

Turbines are Vertical Francis type with adjustable guide vanes. The main parameters of turbines are as follows

No.	Parameter	Description
1	Type of Turbine	Vertical Francis
2	Maximum Net Head	135 m
3	Min Net Head	87 m
4	Rated Head	120 m
5	Rated out put	40 MW for unit1 / 120 MW for unit 2,3 and 4 at Generator terminals

No.	Parameter	Description
6	Min. Tail Water Level	EL 302.00 m
7	Max. Tail Water Level	El 305.00 m
8	Center line of Turbine (Indicative)	EL 296.5 m
9	Permissible Pressure Rise	< 35 % of maximum gross static head
10	Speed Rise	Less than 45.% of rated speed
11	Runaway speed withstand duration	Not less than 15 minutes with cooling water supply "ON"
12	Runner dia.	2100 / 3900 mm (Indicative)
13	Rated speed	333 / 187.5 rpm (Indicative)
14	Minimum turbine efficiency at rated load and rated head	93 %

j) Turbine Maintenance

There is no high silt content in water. Hence special arrangement of runner removal requirement is not envisaged.

k) Major components of Turbine

a) Spiral Case

The Spiral case will be designed for the maximum internal pressure and built of fabricated construction & embedded in the concrete and sectionalised as necessary for handling and shipment. Design and fabrication will be in accordance with ASME, Section VIII, Division 1. The design shall be such that under pressure test of 1.5 times the maximum over-pressure, the stresses shall not exceed 2/3 of the Yield Strength and an allowance of 2 mm (at least) shall be considered for corrosion and abrasion resistance. The maximum stresses due to most severe operating conditions shall not exceed 1/3(one third) of the yield point or 1/5 (One fifth) of the ultimate strength of the materials. Spiral case will be provided with one tapping with valve for drain pipe, one for air release/ vacuum breaking and one set of stainless steel pipes for pressure gage and flow meter as required.

b) Stay Ring

The stay ring will be of fabricated construction & embedded in the concrete and sectionalised as necessary for handling and shipment. Design and fabrication will be in accordance with ASME Section VIII– division 1. The stay vanes shall be designed and shaped to direct the water flow with a minimum head loss and to eliminate vibrations. An over thickness of 2 mm (at least) shall be considered for corrosion and abrasion resistance. It shall be designed to withstand the spiral case pressure test as well as all the external loads exerted by the turbine and the concrete structure. The construction will be from boiler quality steel plates designed to bridge the throat of spiral casing and to transfer the weight of the entire unit to the foundation with hydraulically profiled stay vanes. The upper ring will carry the main turbine cover and pit liner and the lower ring will be provided with heavy base plate extended to carry the pivot ring and foundation ring. The two rings will be rigidly tied together by the stream lined vanes which lead the water smoothly to the guide vanes. The foundation ring (discharge ring) will be of welded or cast steel construction and heavily ribbed to maintain circularity.

c) Runner

The turbine runner blades will be made of cast stainless steel or welded stainless steel material conforming to ASTM A-743 having 13% chromium and 4% nickel and properly stress relieved. The vanes will be polished and stream lined. The vanes, crown, skirt, upper labyrinth seal and lower labyrinth seal all will be machined integral with the runner. Drilled holes will be provided in the crown to drain water and reduce hydraulic thrust.

The runner shall be designed to withstand safely the stresses due to operating at runaway speed under conditions of maximum head with no load on the generator.

The runner shall be accurately balanced statically in the shop to meet balance quality grade 6.3 of ISO 1940-1, latest edition.

d) Turbine shaft and shaft seal

Shaft will be made out of best Siemens Martin forged open hearth carbon conforming to BIS or ASTM A668.The shaft will have adequate diameter to operate safely in combination with Generator. Turbine shaft will be directly connected to generator by means of suitable coupling.

The shaft seal will be provided above the runner and below the guide bearing. The seal will be either labyrinth type or carbon ring seal. The shaft seal will have cooling/sealing arrangement from cooling water system and will be suitable for raw water after filtering. A maintenance seal of inflatable rubber will be provided below the shaft seal to facilitate servicing or adjustment of main seal without dewatering the draft tube. Seal will be of design which can be easily dismantled and replaced and supplied with clean water so that water pressure will keep away dirt from the seal. The shaft will have sleeve in 2 halves bolted to shaft at the seal area so that the ware out of shaft does not take place and the sleeve can be replaced when worn out.

e) Guide vanes and guide vane operating mechanism

Guide vanes will be of steel conforming to 13% chromium and 4% nickel and each guide vane will be with integral stems and trunions and will be supported in self-lubricated bearings / bushings. The gate axial adjustment between head cover and bottom ring will be by adjustable self lubricated bush thrust bearing on the upper stem. Seals will be provided for preventing leakage of water.

The guide vane operating ring of rigid construction will transfer the motion of servo motor to individual guide vanes through the connecting links. The ring will be provided with suitable bearing and renewable guides. Shear pin or breaking links will be provided in alternate connecting rods which will break or shear when any vane movement gets blocked and protects rest of the mechanism. Such failure of shear pins will give alarm and will not cause progressive failure of adjacent shear pins.

Guide vanes will be operated by servomotor for which the pressurized oil is supplied from independent OPU for each unit.

f) Bearings

The bearing will be rigidly supported on the turbine head cover with individual pad adjustment and designed to permit axial movement of the shaft. The bearing will be split vertically into two or more sections for facilitate dismantling and the mating sections will be doweled securely. Bearing will be designed to operate at all speeds including runaway speeds with out damage. The bearing will be capable of operating at run away speed for 5 minutes without cooling water supply. Bearings will also be capable of operating at 115% speed continuously, for 30 minutes at lower speeds upto 10% speed and for 15 minutes at runaway speeds. The maximum operating temperature will be 70 deg. C for metal and 55 deg C for oil. Instrumentation for monitoring and protections consisting of RTD’s, dial thermometers, alarm and trip contacts either from scanner or from thermostat/dial will be provided. Alternative bearing types of shell type, self lubricating with out oil will be considered during implementation stage depending on merits.

g) Pivot Ring

Pivot ring will be made of fabricated steel plates adequately ribbed. Pivot ring will consist of self lubricated bushes for lower stems of guide vanes and renewable stainless steel liners below the guide vanes.

h) Top Cover

Top cover will be of welded steel plate construction and with stainless steel liners in the area of guide vanes in the closed position. The bushes for guide vanes will be self lubricating type. The top cover will be designed for withstanding the up-thrust from runner. Arrangement for draining the leakage water from top cover will be provided by pumps/ siphon.

i) Turbine Pit liner

Turbine pit liner will be fabricated from structural steel conforming to equivalent of IS 226 / 2062. Provision will be made to mount the guide vane servomotors in the pit liner. A circular mono rail with chain block in the pit liner to handle shaft seal and servomotor will be provided.

j) Draft Tube

The draft tubes will be elbow type with embedded steel liners. The liners will extend to where the water velocity does not exceed 2 m/s. The draft tube will be a double conduit with a central pier for 120 MW units.

k) Governors

The Electronic Governors will be of digital version and designed to ensure stable operation of the Generating unit. They will be designed to be substantially immune to noise, transients and stray magnetic fields as per IEC. Electronic governor will be of modular design, facilitating easy and quick fault detection and rectification. The governor will have features of settable speed droop, position controller, load controller and speed controller to cater for start/ stop, synchronizing and loading of the unit.

Each turbine will be controlled by a digital electronic-hydraulic governor with proportional integral and derivative (PID) adjustable response and feedback to cater to the functions of start/stop, synchronising, speed/load control while on grid, over speed protection and respond to changes in system frequency and /or load. The governor will accept and process frequency and load signals and will activate hydraulic servomotors, which operate the guide vanes to control turbine speed and output. The governor is required to control the turbine safely and effectively during starting, stopping, off-line and on-line operation and to respond effectively and safely to emergency conditions all within constraints imposed by the Project electrical and hydraulic systems.

The nominal design pressure of the governor hydraulic system shall be minimum 10 % more than the maximum system operating pressure.

(i) Speed control for start up and synchronizing and block loading.

(ii) Steady State, Small transient, Large transient control of machine

(ii) Isolated grid operation if required

(iii) Manual and Automatic control.

(iv) Over speed detection.

(v) Adjustable speed droop control

(vi) Load control/position control selectable with settable load limiter

(vii) Joint control feature for the 4 units

The digital control system of governor will out put the appropriate current / voltage signal which will be interfaced to hydraulic proportional control valves. The proportional control valves will allow the required oil flow through the servomotors of guide vane to position them. The governor control will achieve the guide vane closing time to limit the speed raise and pressure raise with in limits in all transient operating conditions. The governor will function as a closed loop control system with PID control having speed, position and load as measured input parameters, guide vane position as manipulated variable and speed or load as the controlled variable. Toothed wheel speed signal generator with speed sensor or PMG will provide the turbine speed input, and load transducer will provide the load input to the governing system functions. Governor panel will have the required indications of speed, load, flow, position, etc. Control modes of position or load will be selectable and whenever the unit goes to isolated grid operation governor will automatically change over to speed control.

The microprocessor used in turbine controller will have high resolution. 100% redundancy shall be provided for Control Unit. Time tagging and time synchronisation feature shall be provided. Signals from PT shall be taken to the Governor via signal isolator for frequency governing of unit (Main).

Few of the important features governor will have are:

Flow measurement: Necessary software shall be in built in the governor by taking reference of flow from flow meters and display of the same shall be made available on the Micro Terminal. Provision shall also be made for remote indication of flow.

FGMO/RGMO: Free governing mode of operation (FGMO) shall be available in all the units. Further, Restricted governor Mode of Operation (RGMO) will also be possible as required under IEGC. It shall be possible to change as per the requirement prevailing duirng implementation.

Power supply: Power supply for the governors shall be fed from Battery and Battery Charger to be provided exclusively for Governor

Man Machine Interface: The governor shall be provided with control switches/indicators and analog position indicators for local control. The remote control and indication shall be provided with digital technology using touch screen display. The MMI used shall display the following:

a. Data such as speed, opening, setting etc.
b. Local//remote control of governor.

c. Auto/Manual control
d. Switching from one control mode to another.
e. Setting of parameters used for speed & power control.
f. Diagnostics.

It shall be possible to obtain display of measured values, set values, trends and binary input/output status signals. The MMI used shall have minimum 15” X 15” display. Necessary hub for connecting MMI to station SCADA shall also be provided.

13.6.1.2 Performance requirements

a) Stability: The governor system shall be capable of controlling in a stable manner, the speed of the turbine at all power outputs between zero and maximum power output when the generating unit is operating isolated, or the power output when the generating unit is operating in parallel with other generators.

I) Following rejection to zero of any load within the capability of the governed unit, speed shall be returned to the set point as may be modified by speed droop or regulation.

II) During idling of the turbine, the governor shall automatically maintain the rotational speed of the turbine ensuring steady state operation of the system.

III) The governor shall be designed considering the unit running as synchronous condenser.

b) Speed Droop/ Regulation: The permanent speed droop/ regulation shall be capable of adjustment to values between ‘0’ percent and ‘10’ percent for free governing mode of operation, i.e., the unit has to accept load whenever there is decrease in the system frequency and vice versa at a rate depending on the set droop. The speed versus generator output curve shall be substantially linear over the full range of generator output. Free governing mode of operation shall be available in all control modes.

c) Temporary Speed Droop: The temporary speed droop control shall be capable of controlling the movement of the servomotor without any hunting. The governor parameter, temporary speed droop, percentage and decay time constant shall be set so as to allow stable operation. The temporary speed droop adjustment on the governor shall provide a wide range.

d) Sensitivity: The sensitivity of the governor offered shall be 0.01%.

e) Dead Band: The speed dead band at rated speed shall not exceed 0.02%.

f) Dead Time: For a step load change of more than 10% of the turbine, the dead time of the governor shall not be more than 0.20 seconds.

g) Range of Speed Changer Adjustment: Speed control under auto mode shall cover the range from 85% rated speed at no load and minimum speed regulation to 110% rated speed at maximum speed regulation. The speed changer when arranged for remote operation shall be capable of providing a 100% change in power setting in any selected time. This equipment is to be designed for the future addition of automatic generation control.

h) Governor Time Adjustment: The minimum time and maximum time limits will be adjustable. Time adjustment shall be made by taking into account Speed and Pressure rise limits.

i) Speed oscillations: It shall not exceed +/-0.15% of rated speed.

i) Remote Management: The design of the governor shall be compatible for remote control management under SCADA system.

Architecture: Architecture of the governor will be fully consistent with the advanced control system and the associated software. The communication from the governor to the DCS(SCADA) will be fully transparent from the user point of view through digital link. The software will be protected against electrical failures using internal battery.

Governor will be designed for single stage closing.

Oil Pressure System

The final control elements for positioning of guide vanes will be hydraulic oil servo motors through directional valves. The required oil pressure and oil flow will be provided unit wise by the Governor Hydraulic system consisting of an oil sump, a set of oil pumps, accumulator, oil filters, proportional control valves, servomotors, logic elements etc. Accumulator will be provided with nitrogen or air cushion depending on the oil pressure chosen. There will be 2 pumps with one running and other as stand by. The standby pump will be automatically switched on upon failure of the pump in service. A set of smooth operating un-loader valves, non-return valves and safety valves will be provided to regulate the oil pressure. Pressure switches will be provided for loading/un loading of pumps and for stand by pump starting. Pressure switch will also be provided for alarm and trip at desired values. The oil pressure system of each unit will cater to operation requirements of guide vanes and MIV. The governor oil pressure receiver, pipe work and valves will all be designed in accordance with recognized pressure vessel standards. Since MIV is provided in the power house cavern itself, single oil pressure system is proposed. Present trend is to use higher oil pressure system. If pressure of 60kg/sq.cm pressure is specified, it allows smaller vaqlves, pressure tank, piping's, and servomotors. For higher oil pressure, piston type accumulator with Nitrogen bottles will be used.

13.6.1.3 Generators

Generator will be of salient pole type synchronous Generators each with 0.90 pf lag, 50Hz, l1kV suitable for coupling directly to Vertical Francis turbine, complete with coolers, deluge water fire extinguishing system and other associated equipments as required. The manufacturer can select the generator voltage based on economics in the range of 11 to 15 kV. The insulation will be class 'F' and the temperature rise at rated MVA will be limited to 80 degrees centigrade. Duplex type resistance temperature detectors will be provided in windings to monitor the temperature. The generator will have air cooled ventilation system using air-water heat exchangers placed around the stator frame. Generator will be of conventional type with a combined thrust and guide bearing located above the rotor and a guide bearing located below the rotor. A high pressure oil injection system will be provided to have an oil film between the thrust pads and collar, when starting and stopping the units. The important parameters of Generator will be as follows:

Type	Vertical Shaft Salient Pole Synchronous
Rated Output at rated votage.	40MW /45MVA And 120MW/ 135 MVA(Nominal)
Maximum continous 10% Overload capacity at rated votage.	44MW/50MVA And 132MW /150MVA
Power Factor	0.9
Frequency	50Hz
Phases	3
Speed	333/187.5 rpm (To match turbine speed)
Rated Terminal Voltage	11-15.75 kV
Range of frequency	+3%/- 5%
Range of Voltage variation	+/- 10%
Runaway speed	to match with turbine runaway speed
Short circuit ratio	1.10 (minimum)
Stator winding connection	Star
Generator earthing	Star point earthed through distribution transformer
Stator and Rotor insulation	Class ‘F’
Temperature rise	Limited to class B
Cooling	Totally Enclosed closed circuit air cooled by water

i) Stator

The stator core is made of low carbon silicon alloyed laminations insulated and varnished on both sides with low loss factor.

The winding will have epoxy rich resin non hygroscopic insulation. Type of winding will be coil or bar type. The generator insulation will be Class ‘F’ with temperature rise limited to that corresponding to Class ‘B’ so that generator will have possibility of overloading for short durations. As hydro station will be operated under varying conditions the intent of specifying higher insulation class is to have winding life of 35 years or more.

To achieve radial air ducts the core is divided into axial packets of laminations. The cooling air ducts will be formed by strips fixed to the support laminations. The distribution of spacers will be to get uniform transfer of pressure as well as smooth flow of ventilation air.

To facilitate transport the stator frame could be made in segments and assembled at repair bay.

ii) Generator Rotor

The rotor comprises of a welded steel rotor center (outside serves as a yoke) and magnetic poles bolted on the periphery of salient pole type with damper windings on face of the pole. Rim will be made up of laminated tensile steel. Rim plates are assembled on to the spider. Spider will be provided with the brake track at the bottom. The field winding will be strip on edge copper with Class 'F' insulation.

The shaft will be designed for critical bending and torsional stresses. The natural frequencies of oscillation are kept away from exciting frequencies in operation.

iii) Bearing Bracket

The upper bracket consists of a central hub housing combined guide and thrust bearing and of lattice laminated steel beams resting on the upper part of the stator frame. The bracket supports the complete vertical loads of the generator through combined guide and thrust bearing located in it. The load is transferred to stator frame and from there on to lower sole plates embedded in concrete.

The lower bracket supports the lower guide bearing and brakes / jacks. The bracket has steel plate arms resting on sole plates embedded in concrete.

iv) Bearings

The combined thrust and guide bearing will be located in the upper bracket. Thrust bearing will have babbit metal lined pads resting on spring mattress. Pad stoppers will be placed at suitable locations. Thrust bearing will be designed to support the total weight of rotating components of turbine and generator and also the maximum hydraulic thrust of the runner. The bearing will have oil sump cooled by water circulation in plug in type oil coolers. The guide bearings will be with babbit metal lined pads, self circulation type with plug in oil coolers.

Bearings will be designed to operate at all speeds including runaway speeds with out damage. The bearing will be capable of operating at run away speed for 5 minutes without cooling water supply. Bearings will also be capable of operating with cooling water at 115% speed continuously, for 30 minutes at lower speeds upto 10% speed and for 15 minutes at runaway speeds. The maximum operating temperature will be 70 degrees for metal and 60 degrees for oil. Instrumentation for monitoring and protections consisting of RTD's, dial thermometers, alarm and trip contacts either from scanner or from thermostat/dial will be provided.

Thrust pads will be provided with high pressure oil system with HP pump for providing soft starting and stopping.

v) Brakes and Jacks

Generator will be provided with air-operated brakes to bring the rotary parts of the generator and turbine to stop from about 15% of rated speed during normal operation. The brakes will also be suitable for application at higher speed during emergency shutdown of the unit, in order to bring the rotor to rest at faster rate. The brakes will operate automatically/ manually from local control panel/unit control board.

vi) Generator on line diagnostic monitoring

The following on line monitoring instruments will be provided

a) Bearings and shaft vibration monitors
b) Partial discharge measurement and analyser
c) Air gap monitoring to continuously monitor dynamic behavior of rotor and stator structure
d) Generator shaft current monitor

vi) Synchronous Condenser Operation

Unit shall be capable of operating in Synchronous condenser mode to provide Reactive Power support system whenever required. All necessary embedment for additional runner / labyrinth cooling, compressed air inlet for suppressing water below runner etc will be provided. Mode selection features in control and protection system will also be provided. However the required additional air compressor, air tank and associated piping other than embedment will be provided at a later date.

vii) Static Excitation System:

The excitation system will be solid state, bus fed excitation system for the generator exciter and voltage regulator function and will be suitable for parallel operation of the generators with the grid. The voltage regulator function of modern solid-state excitation system is an integral part of the system and will use digital control elements with microprocessor-based control. The voltage regulator function should provide automatic and manual control of generator output voltage over a range of at least ±10%. Reactive droop compensation equipment will be provided to ensure equal distribution of reactive load between parallel units.

Synchronous condenser mode of operation will be facilitated by selection in Excitation system.

The excitation power will be tapped through excitation transformer, which will be connected to the bus generator terminals. The excitation transformers will be dry type with cast resin insulation.

The system will include excitation transformer, AVR, field suppression equipment, field circuit breaker, field flashing equipment, etc. The ceiling voltage of the excitation system will be at least 190% of the normal field voltage and response ratio will be at least 1.9. The excitation system shall have the following features.

i. Maximum and Minimum excitation limiter
ii. Resistive / Reactive drop Compensators
iii. Voltage / Frequency limiter
iv. Over Current limiter.
v. Power System Stabiliser

Excitation system will have auto mode and manual mode of operation. In manual mode system will function as Excitation current controller continuously variable from 60% to 130%. Manual control set point will follow auto channel output continuously so that transfer from auto to manual mode is bump less. .

13.6.1.4 Generator- Transformer Connections

Generators can be either directly connected to step up transformer or through a medium voltage circuit breaker in between. This would be required when the Generator Transformer is to be back charged to avail auxiliary supply during long periods of no generation is at plant. This condition is not envisaged in Makedatu requiring additional Generator Circuit Breaker. Generators will be connected directly to generator transformers through bus ducts in the bus duct gallery at invert level of 304.5 m.

A. Bus duct

While bus ducts are the requirement they can be either be segregated phase bus ducts or isolated phase bus ducts. For the current rating of 8000 amps isolated phase bus ducts are to be provided for 120MW generating unit. 40MW Generating unit is provided with 2700Amps non-segreated phase type busduct. The Bus duct will be provided with required tap offs for LAVT, excitation transformer and dry type auxiliary transformer inside the bus duct gallery. Adopter chambers will be provided at ends.

a) Bus Enclosure

The bus enclosure will be made of non-magnetic material such as aluminium alloy. The bus duct will be designed for indoor installation with a dust, vermin and weatherproof construction. Between phases of segregated phase bus ducts, if metal barriers are provided, they shall be same as that of bus duct enclosure material and if insulated phase barriers are provided, they shall be of non-hygroscopic insulating material such as fibre glass.

The inside of the bus enclosure will be given a matt finish of black colour paint to facilitate heat dissipation so that the hot spot temperature of the enclosure will not exceed 70ºC, including the heat released by the current transformers.

b) Enclosure Joints

For continuous type of design, successive sections of enclosures will be connected by providing circular bonding enclosures with adequate overlap and welding the same to the main enclosure at site.

Terminal Enclosures and Flanges

Phase terminal enclosures will be provided with flanged ends with drilling dimensions to suit the flanges at equipment on which it is terminating.

(a) The terminal enclosures will be of non-magnetic material and will be insulated from the body of other equipment. These enclosures will be separately connected to station earth bus.

(b) The star point of the generator will be formed in the generator neutral side terminal enclosure after the current transformers are mounted over the bus conductor of individual phase. A single bus duct of required length and rating and flange connections at either end will be provided on the star side of the enclosure to connect the single bus duct to neutral earthing cubicle.

c) Conductor Material of Bus

The material of the conductor will be Aluminium alloy designed to carry the rated current under normal site operating conditions without exceeding the temperature rise. Also the temperature of the bus conductor will not exceed 250ºC while carrying the specified short circuit current for one second when a fault occurs at the operating temperature. The section of the bus conductors will be tubular shape.

13.6.1.5 Main Inlet Valves (MIV)

The main inlet valve is required for isolating the turbine from water conductor and penstock during emergencies and maintenance. Each unit will be provided with a MIV. The MIV will be of double/ single servo disc type butterfly valve of required size as per inlet pipe, assembled and fully tested at works and designed to open under balanced conditions and to close against maximum discharge during emergency.

The inlet valve will be designed to operate and seal properly under pressure during all operating conditions and during transient water hammer conditions.

The diameter of valve will be about 2200 mm for 40 MW unit and 4.3 m for 120 MW units and will be designed for the expected pressure rise up to 135 % of maximum head i.e. pressure of 178 m. Butterfly valves are better suited for these duty parameters and hence butterfly type of main inlet valve is proposed.

The inlet valves will be located immediately upstream from each of the spiral case, to which they will be directly connected via a downstream dismantling joint

The opening of valve will be by oil pressure and closing will be by counter weight.

Materials of construction for major components of valve will be as follows:

Body Cast steel A 216 Gr WCC / Fab A 515 Gr 60 / 70

Disc Cast steel A 216 Gr WCC / Fab A 515 Gr 60 / 70

Trunions Cast steel A 216 Gr WCC / Forged

Seal EPDM rubber 75 Shore A

Piping Fabricated A 515 Gr 60 / 70

The valves will be provided with a hydraulically operated by-pass valve of suitable design for balanced opening of valves. The same will be suitable for automatic operation in sequential order while draining or filling of the penstocks. The by- pass valve will have manual operation facility also. It will have two manual guard valves- one each on the upstream and downstream side of the bypass valve. Guard valves will be directly mounted on a boss section on main piping thus eliminating any nozzle connection between main piping and guard valve. Design of the valve will be such as to take care of cavitation and erosion damage. The by-pass assembly will be provided complete with dismantling joints to facilitate installation and relative movement.

13.6.1.6 Surge Protection and Voltage Transformer Cubicle

The lightning arrestor or surge protection and voltage transformer (SPVT) cubicle will consist of surge protection equipment and voltage transformers. The surge protection equipment would comprise of lightning arresters with suitable discharge characteristics to suit the generator insulation level in parallel with suitably rated capacitor for smoothening the rate of rise of impulse voltage. The LAVT cubicle will be connected by means of tapping the bus duct. The voltage transformers will be in sets of one for each phase, star connected, dry type units with draw out features. The VTs for metering and protection shall be as indicated in the single line diagram. The SPVT or LAVT cubicles are located in the bus duct gallery. 4 sets of VTs will be provided, 2 sets for protection of 3P class, 1 set for AVR of 0.5 class and 1 set for metering of 0.5 class. The burden ratings will be adequate to take the relay and meter loads as per scheme.

13.6.1.7 Neutral Grounding Transformer Cubicles (NGT)

Generators are grounded through Neutral Grounding Transformer and loading resistor combination. A Neutral Grounding Cubicle consisting of NGT and NGR will be located in Generator floor. The single bus duct after star formation of Generator terminals will be terminated at NGT cubicle connecting generator neutral to NGT. Other end of NGT will be connected separately to station earth mat. The loading resistance in the secondary of NGT provides the resistance earthing.

13.6.1.8 Supervisory Control and Data Acquisition System

Supervisory Control And Data Acquisition system (SCADA) for control and monitoring of the plant will be provided. SCADA system is located in central control room at RL 319.0 m of control block. 100% plant control, monitoring and data acquisition functions of plant will be performed from SCADA at control room. It will be designed based on the Distributed Control System(DCS) configuration philosophy.

An integrated system combining process control & substation control proposed is to be provided, using the IEC 61850 standard. Protection & control devices will exchange information with the automation system using IEC 61850 substation communication protocol. The Distributed Control & Monitoring system for plant control is proposed to be configured in to two categories:

De-centralized DCS with Local HMI: The individual De-centralized unit proposed to be installed near the respective Generating Unit acquiring all types of field device/instrument inputs from field through hard wiring required for sequential operation, control, monitoring (including alarms) on real-time, operator displays, performance monitoring & other functions. De-centralized DCS shall act as centralized DCS when selected to ‘Local Control Mode’ & perform in different modes of operations using HMI. De-centralized DCS shall co-ordinate with Centralized DCS installed in Control room through communication cables when selected in ‘Remote Control Mode’. The de-centralized control unit shall act as a bay controller when controlled from control room.

Centralized DCS with Work stations & LVD: A centralized unit shall be multiprocessor based DCS to be installed at centralized control room of the station. The DCS shall acquire all the required inputs from De-centralized DCS of all individual Unit simultaneously & control, monitor, operation of the Units in sequential way shall be performed from the centralized DCS. The Work stations console shall comprise of Operator, Engineering, Server, Historian station consoles, alarm, Event record printer and dedicated laser/inkjet printer for the system, GPS time synchronizing module connected in LAN, etc. Large Laser Display wall, work stations shall be located in the Control room and wired to centralized DCS modules.

The automation system shall have an open architecture and shall be able to interface with other communication protocols like IEC 61850, DNP, SNTP, etc. There shall be built-in provision to connect to TCP/IP LAN & IEC104 protocol for external data transfer (Load dispatch center). It shall have IEC 60870-104 protocol for transferring values along with time stamp to Load Dispatch Centre (LDC).

The SCADA system will be complete with all primary sensors, cables, analyzers/ transmitters, monitors, system hardware/ software and peripherals etc. to monitor/ control the parameters for control, protection, annunciation, event recording for different equipments/systems.

The machines will be controlled on auto and manual modes through PLC based Unit control Board. A complete scheme for fast and delayed protection will be implemented in the UCB with various lockout relays, interlocks, timers etc.

UCB will have facility of auto and manual synchronizing of the units.

The system architecture proposed is shown in “SCADA” drawings-Volume-III

13.6.1.9 Main Step up Transformer

Three-phase transformer will be used to step up the generated voltage of 11 kV to 220 kV transmission voltages. Since there is no transportation difficulties assembled (Without Oil, radiators, conservators) 3 phase transformers are proposed to be transported to project site. Transformer for 40 MW unit will be of 50 MVA and for 120 MW unit will be 150 MVA, three phase, OFWF type of cooling, 50Hz. The transformers will be equipped with on load tap changer on high voltage winding. The terminations suitable for connecting with 11 kV isolated phase bus duct on LV side for 120MW Generating unit and 220 kV XLPE Cables on HV side. 11kV treminals for Generator transformer for 40MW unit shall be suitable for non-segregated phase bus duct. The transformers will be located inside the Transformer cavern at EL 309 m. The transformers will also be provided with deluge type water spray (HVWS) fire extinguishing system. Transformers will be provided with fire protection wall and emulsifier fire protection system. One soak pit will be provided below each transformer that will be connected to common oil sump. Transformers will be installed on rail tracks and it will be possible to remove one transformer at a time.

The important rating parameters of Generator Transformers will be as follows:

No.	Particulars	Parameter
1.	No. of windings	Two
2.	Step-up / Step-down	Step-up
3.	System frequency	50 Hz
4.	Rating KVA (without the spare cooler in service)	
	a) 11 KV winding (LV)	1,50,000 / 50,000
	b) 220 KV winding (HV)	1,50,000 / 50,000
5.	Voltage rating KV	
	a) LV winding	11
	b) HV winding	220
6.	Tappings	
	a) Tap changing	On-Load
	b) Taps to be provided on	HV
	c) Tapping range	+10% to –5%
	d) No. of steps	In steps of 1.0%
7.	Winding connections for three phase	
	a) HV winding	Star
	b) LV winding	Delta
	c) Neutral	Effectively earthed
8.	Terminals a) LV Terminals	 12 kV bushings to suit Isolated phase busducts/ non-segreated bus duct
	b) HV Terminals	245 kV OIP condenser type bushing to be housed in oil immersed cable box.
	c) HV Neutral (Neutral points of all star points to be brought out through bushing for solid grounding)	36 KV bushing.
9.	Type of insulation	
	a) HV winding	Graded
	b) LV winding	Uniform
10.	Type of cooling	OFWF
11.	Impedance voltage at normal tap	12.5 % /10%
12.	Insulating medium	Mineral oil of EHV grade conforming to IEC 60296
13.	Vector grouping as per ISS HV-LV winding	Ynd_1

13.6.1.10 Temperature rise

The temperature rise shall not exceed the following values above the reference ambient temperatures indicated below, while the transformer is delivering the full rated KVA on all the windings with spare cooler cut off.

No.	Part	External cooling medium-Water
1	Windings (measured by resistance method)	45°C
2	Top oil (measured by Thermometer)	40 °C
3	Cores, metallic parts and adjacent materials	Temperature shall in no case reach a value that will damage the core itself, other parts or adjacent material.

The hottest spot winding temperature shall not exceed 980C.

(Temperature rise values are less than BIS specified limits and same are proposed to be adopted to have longer life of the equipment)

Insulation levels for the transformer windings:

(All are withstand values)

Insulation class of windings kV rms	Highest system voltage kV rms	Separate source power frequency withstand voltage kV rms	Induced over voltage withstand voltage kV rms	Rated lightning impulse withstand voltage Chopped/full wave kV peak
11 (LV)	12	28	22	90
220 (HV)	245	38	460	1050

Insulation levels for Bushings(Withstand values without any negative tolerance)

Bushings used with terminals of	Rated voltage of bushing KV (RMS)	Dry and Wet power frequency withstand voltage KV (RMS)	Dry standard lightning impulse withstand voltage KVP
LV	12	28	90
HVN	36	70	170
HV	245	460	1050

Short circuit test: Short circuit test on one of the generator transformer may have to be conducted if valid test certificates for similar transformers are not available.

It is proposed to provide Generator Transformer with following monitors which may enable timely preventitive action as required to minimize the down time for maintenance during forced breakdowns.

a) On-Load Tap Changer monitor- To monitor temperature / timing sequence/ tap position/ motor load and current.

b) Dissolved/Evolved Gas analyser - To monitor Hydro and Cabon monoxide

c) On line spectroscopy - to monitor Methane/Ehtylene/Ethane.

d) PD Monitor- To monitor partial discharge activity in insulation.

13.6.1.11 220 kV XLPE Cables between Transformers and Gas Insulated Switch Yard

The broad technical specifications of 220 kV, 400 Sq.mm, single core, Copper conductor XLPE insulated, lead sheathed cable system complete with accessories and spares etc., proposed are as follows:

13.6.1.11.1 Quantities of material required

The following table gives the brief summary of the quantities of materials required and a brief description of each item.

Item		Quantity in set	General description
a)	Cable	13 Lengths of cables (Approx total length 1300 mtrs. plus 10% extra for variations)	220 kV single core, 400sq.mm XLPE insulated lead sheathed single core copper cable
b)	Out-door end Pot head	13	245 kV out door sealing end complete with insulating support etc., and terminal connector.
c)	Transformer Terminal end	13	245 kV Oil immersed in- door type sealing ends along with necessary accessories.
d)	Grounding Switches	13	245 kV rated grounding switch attached to each out door pot head complete with flexible copper braid.
e)	Link boxes	13	Single pole link box for indoor and outdoor terminating ends
f)	Cable cleats and accessories	Lot	Cable cleats, clamps, cable racks including rack supports, fixing bandage with necessary hardwares and other accessories for “Horizontal arrangement” of cables along with scaffoldings, sealing and support structures
h)	Special tools and tackles	Lot	As required

13.6.1.11.2 Locations

The 220 kV cables covered in this specification are required for transmitting power from the transformers at powerhouse (From Transformer Yard) to the GIS

The single core, XLPE insulated, extruded lead sheathed with extruded high density polyethylene over sheathed cables shall be terminated at one end in the oil immersed cable box at the unit transformer having rating of 150 MVA/50MVA, 3 Phase, 11/220 KV and the other end shall be terminated with the out door sealing end to be installed in the GIS Yard. A cable cum ventilation duct of 6 mtrs. (wide) x 6.5 mtrs. (height) is proposed for laying the cable. One length out of the thirteen will be used as a spare cable. The cables will be installed from terminal to terminal without resorting to cable splices to avoid in between joints along with other necessary measures in order to ensure a satisfactory installation. Suitable type temperature monitoring system will be provided.

13.6.1.11.3 Standards

The construction of the cable will generally conform to IS 7098 (Part-8) and tests as per IEC-62067-2001.

IEC-62067	Power cable with extruded insulation and their accessories for rated voltage above 150 kV – Test methods and requirements.
IEC-60949	Calculation of thermally permissible short circuit currents, taking into account non-adiabatic heating effects.
IS: 7098(Part-3)-93	Cross-linked polyethylene insulated, thermoplastic sheathed cables 66 kV to 220 kV.

13.6.1.11.4 Operating Conditions of the Cable:

No.	Particulars	Parameters
1.	The r.m.s. rated voltage at power frequency, between two phase conductors	U = 220 kV
2.	Maximum r.m.s. voltage at power frequency, between two conductors for which the cable and its accessories are to be designed.	U_m 245 KV
3	R.M.S. rated voltage at power frequency, between the conductor and the earth or the metallic sheath	U_o= 127 kV

No.	Particulars	Parameters
3.	Number of phases	3
4.	System frequency (Hz)	50 +3% /-5%
5.	Basic impulse level (KVP)	1050
6.	Power frequency withstand voltage (kV rms)	460
7.	System earthing	Effectively earthed (solidly grounded)
8.	Transformer rating to which the cables are proposed to be connected.	3 Phase, 11/220 kV Generator Transformer of 150 MVA /50MVA
9	Maximum fault level and its duration.	> 40 KA for 1 Sec.
10	Dynamic withstand capacity	100 KA
11	Total Relay and Breaker operating time.	90 – 120 mili seconds.
12	Tests	As per IEC-62067- 2001 with latest amendments
13	Maximum operating conductor temperature	90 Deg.C
14	Maximum conductor temperature under short Circuit for 1 Sec	250Deg.C

13.6.1.11.5 Design Stress and Insulation Thickness

The recommended design stress values for insulation thickness are:

Design stress a.c.	10 kV/mm
Design stress impulse	40 kV/mm

The higher of the two values of the insulation thickness will be adopted but not less than the nominal value of 24.00 mm.

13.6.1.11.6 Dielectric Stresses

The 220 kV cables shall be designed for continuous operation at a maximum line to earth system voltage of 127 kV. The maximum dielectric stress at insulation at the conductor surface shall be 9.01 KV/ mm.

Electrical Characteristics: The cable system shall be capable of withstanding 125% of the normal voltage value for a period of one minute and 140% of the normal voltage for a duration of 5 seconds under the condition of sudden load rejection by the generating units.

13.6.1.11.7 Grounding Switch

The conductor will be grounded for safety by a grounding switch. It is proposed to adopt side mounted, cantilever type version so that the grounding arm action is in line with the pot head structure (90o to the outgoing line). The grounding switch will be used for grounding the cable circuit during maintenance. These switches shall have the following electrical characteristics:

No	Particulars		Parameters
a)	Rated Voltage		245 kV
b)	Rated frequency		50 Hz
c)	BIL		1050 KVP
d)	Power frequency with stand voltage		
	i)	Dry	460 kV(rms)
	ii)	Wet	460 kV(rms) for 10 sec
e)	Rated short time withstand		Min. 40 KA (rms)

The grounding will be with manual and motorized operating mechanism, locking device to lock the switch in either open or closed position. A flexible copper braid connecting the switch blade to the switch base and flexible braid connection between line terminals of the grounding switch and 245 kV sealing end will also be provided.

13.6.1.11.8 Cable end Terminations

The cable end termination will be of outdoor type on one side (GIS end) and of indoor type on the other side (transformer end) suitable for 220 kV, 400 Sq. mm copper conductor, lead sheathed XLPE cable and conforming to the relevant IEC. The outdoor type sealing end shall be suitable for installation in polluted atmosphere and shall be completely weather proof. The sealing ends shall withstand the power frequency, impulse and cable testing voltage after installation as specified. The cable and accessories shall withstand all thermal and mechanical stresses under steady state and transient operating conditions.

13.6.1.11.9 Spare Cable

One standby 220 kV cable will be provided with all accessories. The spare cable will be used to replace any one of the other twelve cables of four units if required and will be installed in such a manner as to permit rapid replacement and reconnection of the faulty circuit without exposing workmen to dangerous situations. The spare cable will be terminated in an outdoor sealing end in the GIS Yard in a manner similar to that of main cables. The cable will be terminated into an indoor sealing end at the transformer side end, on a movable 'dolly'. The spare cable shall be sufficient in length so that it can be used on any of the transformer for replacement of a damaged cable.

13.6.1.11.10 Supports, Hardwares and Accessories

The supporting structure for the GIS yard will be fabricated from galvanised steel material. Wall rack supports, brackets, cable cleats, clamps, fire barriers, fixing bandage, miscellaneous accessories and hardware required for the assembly of the cable support system will be provided.

13.6.1.12 Gas Insulated Switch Yard

Conventional Air insulated open switch yard will require large amount of space and with the steeply sloping land in the area will need excessive grading excavation. In view of this Gas Insulated Switchyard on surface is proposed. GIS building of size 45m X 10m will accommodate 220 kV Double bus with 4 unit bays, 2 PT bays and 4 line bays. Generator transformers will be connected to GIS by 220 kV XLPE insulated copper conductor cables. The cable termination will be dry type and will have a disconnecting link with GIS for easy isolation of cable during any testing. The GIS arrangement proposed is shown in Drg No. **EIT-1328X-WRE-XX-STR-A082**

An EOT crane of 5 T capacity will be provided in GIS building for handling GIS modules. A local control cabinet for each circuit will be connected to its breaker, CTs, PTs, isolators and provide local control, protection and metering. All the local control cabinets will be connected to a central control panel.

The SF-6 gas pressure in the GIS is monitored to give an alarm when pressure is low. Gas filling equipment will be provided.

Rated voltage, kV	up to 253
Power-frequency withstand voltage 1 min kV	460
Power-frequency withstand 1 min. across open contacts kV	530
Lightning impulse withstand voltage, kV	1050
Lightning impulse withstand across open contacts kV	1200
Rated frequency Hz	50
Rated continuous current Amps-	1000
Rated short-time withstand current kA / s	40kA for 3 s
Rated withstand impulse current kA	100
Circuit-breaker	
Rated breaking current kA	40

Rated making current, kA	135
Drive type	spring
Rated operating sequence	O - 0.3s - CO - 1min or CO - 15s - CO

The SF6 gas insulated metal enclosed switchgear will be totally safe design against inadvertent touch of any of its live constituent parts. It should be designed for indoor application for the prevailing metrological conditions. All parts of the switchgear should be three phase enclosed for 220kV GIS. The metal-enclosed gas insulated switchgear, including the operating devices, accessories and auxiliary equipment forming integral part thereof, will be conforming to IEC- 62271-203/IEC-62271-200 publications.

13.6.1.13 Main Electrical Connection and Scheme

The overall Electrical connections and scheme are shown in “Single Line Diagram” **Drg No. EIT-1328X-WRE-XX-STR-A081/A084**

13.6.1.14 Control and Protection Equipment

Electrical protection system consisting of 'state-of-the-art' numerical multi functional relays and static discreet relays for sensing the faults and high speed tripping relays for tripping functions will be provided for isolation of affected equipment during faults and abnormal operating conditions.

The configuration and protection philosophy of the system will be as follows;

A) Two sets (As main 1 and main 2) of numerical multifunction generator protection relay each catering to all major generator protections and some numerical discreet relays as back up and for catering to those functions not provided by numerical relay will form the generator protection. The tripping functions for generators will be grouped into 4 groups as follows.

i) Emergency trip function to trip GCB, Field circuit breaker and turbine for complete isolation of generator on serious faults.

ii) Electrical shut down function to trip GCB and Field circuit breaker to electrically isolate the generator and keep the machine running at rated speed on such electrical faults not requiring turbine trip.

iii) Controlled action shut down function to trip the turbine first and then GCB and FCB after closure of guide vanes to provide tripping with out sudden load throw off on such mechanical faults like bearing temperature very high etc.

iv) Immediate action shutdown function to close MIV also

B) Two sets (As main 1 and main 2) of numerical multifunction relays for transformer protection catering to over all differential, over fluxing and restricted earth fault, over current and earth fault will form transformer protection. All transformer protections will trip the 220kV side breaker in addition to tripping the generator. The overall differential protection will cover generator, transformer and UAT.

Protection functions will be as follows:

a) Generator

The following protections will be provided for the generator in each main 1 and main 2

- Differential protection
- Stator earth fault protection 95% and 100%
- Loss of field protection.
- Negative phase sequence current protection
- Back up Impedance Protection
- voltage restrained over-current back-up protection
- Rotor earth fault protection.
- Reverse power protection
- Over voltage protection
- Under voltage protection
- Overload alarm./ thermal over load protection
- Under / Over frequency with df/dt functions
- Inadvertent Energisation (Dead Machine) Protection
- Pole slipping Protection
- Local Breaker Backup

(b) Step-Up Generator Transformer

The following protections will be provided for step up generator transformers:

i) Transformer Differential protection

ii) Over all Differential protection covering Generator, Transformer and UAT

iii) Over-current

iv) Earth fault current

v) Restricted earth fault

vi) Over fluxing protection

vii) Local Breaker Back up

viii) Buchholz, oil and winding temperature alarm/trip.

(c) Transmission line Protection

Each transmission line and Bus coupler will be provided with two numerical distance relays as main 1 and main 2. Distance relays will have minimum 4 forward zones and one reverse zone distance elements for each of phase and earth faults. Relays will have phase segregated tripping to enable single phase auto re closing if required. Separate df / dt relays will be provided for tripping in case of grid isolation.

(D) Bus protection and Local Breaker Back up protections

Numerical low Impedance differential bus bar protection for both bus-1 nad 2 will be provided for quick isolation of bus faults. The bus bar protection will be with distributed architecture with individual bay control units. Each bus zone will have a check zone for security.All 220 kV breakers will be provided with Local breaker back up protections for backing up failure of any intended breaker tripping on protection trip command.

Wherever main 1 and main 2 protections are provided for same equipment they will be of different makes to ensure 100% fail safe feature. All numerical relays will be inter connected and compatible to SCADA having IEC 61850 parallel redundancy protocol.

The protection scheme is as shown “Protection Single Line diagram”

(E) 220 kV Cable Protections

Each unit cable set will be provided with cable differential protection

General Notes: Wherever Main-1 and Main-2 relays are specified, it shall be from two different manufacturers. Further, Two separate DC souces DC1 & DC2 shall be used for protection wherever it is specified with a provision for change over

13.6.1.15 Turbine auxiliaries and other mechanical auxiliaries

a) Cooling/Service Water System:

Cooling water is required for the following:

i) Generator air coolers;

j) Generator guide and thrust bearings;

k) Turbine guide bearing;

l) Generator transformers cooling;

m) HVAC air handling and chilled water;

n) Turbine shaft sealing;

o) Governor oil sump.

Open system is envisaged since the silt in raw water is not high requiring a closed system .

The cooling water systems shall be provided on unit basis for each of the unit. The cooling water systems shall be designed with adequate capacity to maintain the plant within specified operating temperature limits. Water flows shall be determined based on requirement of turbine, generator and auxiliaries.

Each unit will be provided with 1 working and 1 stand by cooling water pump taking suction from draft tube. A common suction header will be formed inert connecting all 4 units suction pipes through gate valves. Gate valves will be normally in closed condition and will be opened whenever inter-connection is required. It will be necessary to filter the water supply to the shaft seal. The supply of water through shaft seal shall be maintained even when the turbine is not operating. Water supply to shaft seal need to be filtered by passing it through hydrocyclone filters. The degree of filtration shall match with the component design.

The outlet from all heat exchangers (warm water) are conncted to common header and led to draft tube away from the point of suction.

The system will be complete with valves, strainers, pressure and flow indicators etc.

The system proposed is as shown in "COOLING WATER SYSTEM SCHEMATIC**" Drg No. EIT-1328X-WRE-XX-STR-A076**

b) Drainage and Dewatering System:

The unit dewater system is required for the following purposes:

- To partially dewater the unit to just below the draft tube inspection platform level in order to inspect and carry out minor maintenance on the submerged turbine parts and water passages from this platform.
- To completely dewater the unit during annual major maintenance works when the main turbine parts must be replaced or whenever required during emergencies.

Dewatering required safe and effective isolation of the turbine downstream of the main inlet valve and upstream of the draft tube gates.

One pressurized wet sump will be provided for dewatering. The bulk of the water to be pumped is contained between the draft tube outlet and the draft tube gate.

The draft tube drain lines originate at the side of the draft tube, downstream of the elbow. The dewatering sump is separate, but under the same gallery as the drainage sump and contains the two submersible pumps. The top of the sump is equipped with a main access, pump removal hatches and valve activating stems. The entire sump is designed to withstand tail water pressured thereby eliminating any risk of flooding.

Before unit dewatering can be initiated it will be necessary to ensure that the unit is isolated from:

- Full penstock static head by closing and locking off the inlet valve upstream of the unit
- The tailrace river water downstream

Draft tube gates are provided to permit isolation of the unit from tail water conditions, since these gates are not designed to be subjected to full penstock static pressure nor for closure against a differential head, it is mandatory that the inlet valve, and its associated bypass valve, be locked in a closed position before installation of the draft tube gates is attempted.

Once the inlet valve is closed, the water pressure in the draft tube depends upon the tail water elevation. The draft tube gates can then be installed under balanced conditions, that is, with the same water pressure on both sides of the gate. It should be noted that this pressure balance must be restored before the draft tube gate is opened, by refilling the draft tube and turbine up to the prevailing river level. A bypass between the tail water tunnel and the draft tube is provided to facilitate this refilling.

Independent drainage and dewatering pumping system shall be provided which will be common to both the units. The drainage and dewatering system shall permanently and automatically ensure the discharge to the outside of all the effluents collected in the plant.

The dewatering system will be used to dewater the turbine and draft tube for accessing the runner and other underwater parts during routine maintenance and also during emergencies caused by abnormal inflows.

The drainage system shall handle all leakage and drains from all the equipment within the power station. The main flows and volumes to be handled by the systems shall account for permanent drainage of all floors, turbine shaft seals cooling system, fire fighting water, emptying of a unit waterways, emptying of the draft tube and downstream waterways.

Dewatering and drainage pumps will be of submersible type so that, in the event of partial flooding, the pumps will continue to operate to dewater the power station. The pumps shall operate automatically based on the rising and falling water level in the sump.

The turbine dewatering system pits will be designed to enable dewatering of the turbine within four hours time. This system will act as back up to the drainage system in the event of emergency in-flows. Suitable arrangement for interconnection of both dewatering and drainage pit by gate shall be provided.

Normally, the pumps shall operate automatically based on the rising and falling water level in the sump. Both systems will have pump-motor sets controlled by level float switches. Pumps of each system will be connected to an independent common outlet and discharged to the tailrace.

For draining the penstock u/s of MIV, a globe valve will be provided at the reducer between penstock and MIV and connected to draft tube for emptying the penstock.

The dewatering and drainage system is as shown in “DRAINAGE & DEWATERING SYSTEM SCHEMATIC” **Drg No. EIT-1328X-WRE-XX-STR-A078**

HVAC System

The ventilation system for the underground powerhouse must provide sufficient airflow through the complex to satisfy the following basic requirements:

- Provide adequate ventilation for personnel
- Remove heat generated by mechanical and electrical equipment
- Provide smoke exhaust ventilation in case of fire to minimize the circulation of smoke and products of combustion and assure safe evacuation of plant personnel and access for firefighting personnel and equipment

The size of the ventilation system depends on the rate at which the air is to be renewed. In the proposed system fresh air will be taken from the cable duct and used air will be forced out through a ventilation shaft duct located adjacent to the powerhouse.

The prime sources of heat are from the generators, bus ducts, fan motors and the electrical cubicles on the turbine floor. The distribution of air will be proportional to the needs of the various areas. In general, the galleries at the lower level will not be ventilated through air ducts; wall fans located adjacent to the equipment in these areas will provide sufficient air circulation.

Three sets of fresh air fans will be provided near the surface GIS which supply air through ventilation duct mounted in cable shaft. The air-admission fans will be complete with air filters etc. Evaporative cooling air handling units for supplying cold air to all areas other than control room and chilled water based air conditioning for Control and relay room will be provided..

Smoke Exhaust

A common smoke exhaust system, which extends through the main access tunnel, is connected by ductwork to the powerhouse and transformer gallery. Exhaust fans for the smoke exhaust systems are located at the main access tunnel portal. Dampers in the ductwork allow exhaust air to flow from the powerhouse cavern in case of fire.

Battery Room Ventilation

The battery room will be provided with an independent ventilation exhaust system discharging directly into ventilation shaft.

The HVAC scheme proposed is shown in "VENTILATION & AIR CONDITIONING SCHEMATIC" **Drg No. EIT-1328X-WRE-XX-STR-A080**

13.6.1.16 Power House EOT Crane:

The power house cranes are to be sized and designed for placing machinery during the installation of the turbine, generator, main inlet valve and associated equipment. When installation is complete, the cranes will be used for routine and major maintenance of the machinery.

The capacity of crane is determined by the weight of the heaviest component to be handled i.e. the generator rotor. For the 32 pole 135 MVA generator the estimated rotor weight is around 370 tons. With 15% margin the capacity of main hoist required will be about 450 tons and auxiliary hoist will be about 30 tons for powerhouse. Two cranes of 225 tons capacity is proposed which will be operated in tandem during rotor lifting.

The crane will be of electrically operated overhead type. The crane shall travel from service bay to last unit in the generator floor. Control of crane shall be from the operator's cabin..

13.6.1.17 Compressed Air System

Compressed air system will be provided to meet the compressed air requirements of units and auxiliary plant items. It will be a central system supplying the needs of all TG units and any other plant items requiring compressed air. The system will have high pressure and low pressure system for governing and generator brakes and for maintenance shaft seal and general maintenance respectively.

High Pressure Air System

High pressure compressed air is required for the governor air-oil accumulation and generator braking/jacking systems. This system is common to all units and comprises two air–cooled compressors, on "duty" and one "standby" which feed the main air receiver tank. This air tank contains a sufficient quality of compressed air to supply to total air required for all units without any contribution from the air compressors. The compressed air system will be located at turbine floor level under the erection bay in a separate room.

Low Pressure Air System

The low-pressure air system provides compressed air for the maintenance tools and instrumentation. Low-pressure air is supplied from the main air receiver via a pressure-reducing valve set at the required pressure. Since the low pressure system is connected to the main air receiver which replenishes automatically, the required quantity of low pressure air has no significant impact on the selection of total system equipment and cost of the installed resources. Hose stations with quick connect couplings are located on the service air header at each unit, in the erection bay, service area, drainage gallery and at other strategic locations in the powerhouse and transformer gallery. Instrument air is dried and filtered to improve the reliability and prolong the life of the equipment.

The system will comprise compressors each with an intake filter, after-cooler, non return valve and isolating valve, delivering to receivers with a pipe reticulation system to suit the equipment. The operating air compressors will be arranged for leading and backup duties and the duties will be interchanged periodically to equalise running hours. Operation of compressors will be automatic under pressure switch control.

Compressed air system scheme proposed is as shown in "COMPRESSED AIR SYSTEM SCHEMATIC" **Drg No. EIT-1328X-WRE-XX-STR-A074.**

Oil Handling

Two separate oil-handling systems are planned one to service the bearing lubricating oil and the other to service the governor oil. The systems are separated because of the high degree of filtration and purity necessary for the governor oil. The systems include oil purification and treatment equipment, oil storage facilities and separate supply and return piping headers to the units. The storage room is located in the level 309m of control block. .

The oil room contains oil purification and treatment equipment, separate oil storage tanks, and separate supply and return piping systems. The oil room layout will take into consideration the requirements for fire protection. The oil storage tanks and purification equipment will be surrounded by containment sumps. Fire doors at the entrances, fire dampers on ventilating ducts and water deluge sprinkler system will be provided.

Four pipe headers (a supply and return for both lubrication and governor oil) are provided to connect to the equipment being served. Valve stations allow connection to the oil sump at the equipment. Oil is returned by portable pumping, treated and transferred to the clean oil tanks from which it is pumped through the supply header back to the sump at the equipment. When delivered to the station, new oil is either processed through the purifier or piped directly to the clean oil tanks. Delivery stations for each system are located at the entrance to the powerhouse.

The oil handling and purification equipment for the oil handling systems includes;

- A mobile oil purifier designed to remove all traces of water, gates, solids and sludge from the oil;
- Two mobile positive displacement oil pumps with filters – one for clean (treated) oil and the other for dirty (untreated) oil;
- Two sets of flexible hoses.

A mobile 500L oil storage tank to flush the clean oil supply header and to supply makeup oil as required

- Laboratory equipment for testing oil systems

Transformer oil treatment is accomplished using a truck-mounted oil purification unit which can be driven into the transformer gallery.

13.6.1.18 Fire Protection and Fire alarm system

The fire fighting system consists of a high pressure water deluge and sprinkler system, low pressure water hose stations and Portable firefighting equipment.

Fire water supply system:

A reliable plentiful supply of firewater is vital to the fire safety of the plant. Two numbers fire water storage tanks will be provided near pot head yard which will be filled from tail race through set of pumps drawing water from draft tubes in power house cavern. The pumps will be located in CW galley at EL 293 m. The tanks elevation is sufficient to provide required head for water deluge sprinkler system.

i) Hydrant System

The hydrant system shall comprise;

(a) External and internal hydrant valves with hoses in hose boxes.

(b) Hose reels at internal hydrant locations.

(c) Underground and above ground fire water piping.

(d) Panels, cables and instrumentation.

The system shall be designed to operate automatically on operation of any of the hydrant valve. The system is intended to be used for an incidence of fire assuming higher proportion, uncontrolled by portable extinguishers. The system shall be pressurised and will operate by a set of pumps and related instrumentation and controls.

ii) HVWS System

Generators and Transformers in the cavern will be provided with HVWS system for fire protection. The system comprises of pressurised water source, hydraulically operated deluge valve (DV), spray network and bulb-detector network around the transformers and piping. Pressurised water is always available upto the DV. In case of fire the detectors break, the DV opens and water is discharged from the spray nozzles.

iii) Portable Extinguishers

Portable extinguishers of Water Gas Pressure type (9 liters capacity) and 4.5 kgs Carbon Dioxide type shall be appropriately distributed. Portable extinguishers are intended to be used for fire in incipient stage.

iv) Fire detection and alarm system

Suitable fire detection system using smoke detectors and/or heat detectors will be provided for the entire power House building, Fire detectors will be located at strategic locations in various rooms and floors of the building. The operation of any of the fire detectors/manual call point will result in audio and visual alarm in the panel with zone indication.

Signal will be given to air conditioning system for its shut down.

The fire water scheme is as shown in “FIRE PROTECTION SYSTEM SCHEMATIC” **Drg No. EIT-1328X-WRE-XX-STR-A077**

13.6.1.18 Work Shop Equipment

The workshop equipment shall be located at service bay subsequent to erection of all TG units. The equipment is intended to satisfy normal maintenance functions. Any special machining requirements will be performed at other facilities.

The following equipment are proposed in the workshop;

- one horizontal engine lathe with accessories,
- one radial arm drill press with accessories,
- one floor drill press,
- one power hacksaw,
- one bench grinder,
- one pedestal grinder,
- one portable pipe threader,
- two portable oxyacetylene welding and cutting units,
- one portable dc electric welding machine,
- Two workbenches,
- Assorted tools including power tools, measuring tools, hand tools, drills, taps and dies.

The above equipment shall be sized and equipped for maintaining the specific equipment provided in the powerhouse.

Electrical Workshop shall consist of following equipment;

- Electrical Work Bench,
- Laboratory standard meters,
- Secondary injection kit,
- 3 Phase and single phase variacs,
- Signal generators,
- Relay and meter test kits,
- Soldering station,
- Storage Oscilloscope.

13.6.1.19 Electrical Auxiliaries

a) Unit and Station Auxiliary Power Supply System

The auxiliary power supply system should cater with reliability and with redundancy to various unit specific auxiliary loads like Governor oil pumps, cooling water pumps, lube oil pumps, top cover drainage pumps etc and common station auxiliary loads like Dewatering and Drainage pumps, battery chargers, illumination, fire fighting, EOT crane, ventilation and AC etc. Some auxiliaries like battery chargers for DC system, Dewatering and Drainage pumps, emergency lighting etc are essential loads which should have supply even when no unit is operating and station bus supply is also not available. To meet these requirements the following system is envisaged;

1) One dry type Unit Auxiliary Transformer (UAT) will be provided connected to bus duct tap off of unit 1 and 4 to step down generation voltage to 415 volt supply. Rating will be 2000 KVA which will meet the requirement of complete plant with one transformer. Each UAT will be connected to its 415 V unit bus. Unit 2 and 3, 415 V bus will have incomers both from unit-1 and unit-4 buses as main and standby supply. A common auxiliary 415 V bus is provided which will have supply connections from unit-1 bus, unit-4 bus and also from emergency DG set.

2) One emergency DG set of about 500 KVA located near pot head yard will be provided to meet the essential loads and to provide start up supply to one unit.

3) One station Transformer of 1 MVA ratios will be provided to give station supply when plant is under shut down.

b) Unit Auxiliary Transformers

UAT will be dry type indoor two winding transformer. The UAT will have a voltage ratio of Generation voltage (11–15.75 kV) to 433 Volts and rated approx. 2000 kVA. The impedance of UAT will be selected on consideration of LV fault level. The capacity of each transformer will be sufficient to feed all power plant auxiliaries and startup power of one unit. Transformer will have bus duct connected to HV side and LV side will be a cable going to unit Service Board. Metering will be provided for metering incoming power.

UAT will be provided with required RTD’s in winding for alarm and trip function. Transformers will have following ratings:

i)	Voltage ratio	:	11-15.75 KV / 433V, 3 phases, 50Hz.
ii)	Rating	:	2000 KVA
iii)	Primary connection	:	Delta

iv) Secondary connection : Star with neutral solidly earthed

v) Type of cooling : AF

vi) Off circuit tap changer : ± 7.5% in steps of 2.5%

c) DC Supply:

220 V DC, 800 AH Redundant VRLA battery bank will be provided for power requirements of Control and protection system, SCADA system and for emergency lighting. These batteries will also be provided with battery charger equipped with float and fast charging facility. A distribution board will be provided for feeding the various DC loads. Suitable capacity of UPS system will also be provided for catering to SCADA, fire alarm system and Governors as required.

c) Lighting, Earthing and Lightning protection

I. **Lighting**

Normal and emergency DC Lighting to provide recommended illumination levels in respective areas will be provided. The lighting system will be inclusive of indoor and outdoors lighting equipment, maintenance power supply networks, and power supply outlet circuits in switchyard and in powerhouse. The lighting system will provide normal and emergency lighting scheme for the indoor and the outdoor areas, provide individual sockets / receptacles. It is proposed to provide illumination to the power house, transformer cavern, GIS station, and all the other places of the plant by providing suitable energy efficient illumination fitting with lamps, control gears, LDBs with required size of cables, conduits, junction boxes and other specials etc. It also covers providing DC emergency lighting.

The lighting requirement will be based on the required lighting level, Luminance distribution, Glare restriction, Direction of incidence of light and shadow, colour appearance and colour rendering, etc., depending upon the nature and difficulty of the visual tasks.

ILLUMINATION LEVELS: The following minimum illumination lux levels are recommended for areas of various activities :

- Turbine floor, MIV area and Generator Halls............. 200
- Switch rooms, meter rooms, oil plant rooms………… 150
- Control room…………………………………………… 200
- Compressor and pump rooms………………………… 100
- Battery and battery charger rooms……………………. 100
- Cable tunnels and basements and storage areas …… 50
- Entrance, lobbies, corridors, passageways, lift pit & stairs...100

- GIS...200
- Out door area…………………………………………….. 50

Choice Of Lighting Fittings And Lamps**:** It is proposed to provide appropriate types of lamps and fittings, which is energy efficient and suited for the specific application satisfying the design requirement.

General indoor and outdoor lighting and receptacle are served by 3 phase, 4 wire A.C. system. LED type Fluorescent lamps are mostly used in interior spaces, High-intensity Discharge (HD) Lamps, Sodium vapour lighting fixtures are preferred for outdoor lighting such as switchyards, spillways and dams, parking areas etc. Metal-halide fixtures are used for certain indoor areas such as erection bay, generator hall, machine shop, turbine pit and other "high-bay" areas. Incandescent lamps will be used only for battery powered emergency lights. However, LED type lamps will be extensively used wherever possible.

II. Earthing

It is proposed to ground all electrical installations/ equipment to ensure dangerous potentials during normal as well as fault conditions are kept within the limits, povide least resistance path for grounded neutral circuits, facilitate relaying to clear ground faults, provide a means of discharging current carrying parts which are to be handled by personnel.

The design of the system will be based on National Electric Code, CBIP & IEEE-80 guidelines. MS Flats will be used as ground conductors. the following criteria will be adopted for grounding:

Power house, Switchyard - will be designed to provide a max. resistance to ground as <0.5ohm. Touch and Step potentials limit will be maintained to an acceptable value. special care will be provided to HV GIS.

Apart from this the Instrumentation and Control System needs earthing of control supply common pole and Cable Screens. All Instrumentation cables are with metallic screens to shield the conductor from external Electro Magnetic Interferences. The shielding and shield earthing is to be provided to effectively avoid Power system fundamental and harmonic ground currents in signal grounding. The cable screen is to be grounded at one end to prevent any ground potential raise on the screens. The control supply common pole and the screen of cables shall be grounded separately from the plant main earth mesh to avoid signal noise and induced voltages that can be caused by the Power system earth faults. to a separate Earth Pit through an Insulated conductor without coming in contact with the site structures and safety Earth conductors. The equipments to be provided with separate electronic earthing include SEE, Digital governor, All PLC panels, DCS panels, communication equipemts etc.

Normally IEEE 80 is followed for designing the grounding system.

III. Lightening Protection

Lghtning protection system will be provided to ensure equipment safety, personnel safety and to facilitate designed operation of protective devices during. Llightning protection system will as per local statutory requirements and also as per international practice.

d) Energy Metering

Each transmission line will be provided with tariff metering consisting of 0.2 class, ABT compliant trivector meters. Two sets of meters one as check and other as main will be provided in GIS room / pot head yard. The meters will have features of load survey, maximum demand, event recording etc.

Each Generator and auxiliary transformer will be provided with 0.2 class ABT compliant meter to record generated energy and auxiliary consumption. The energy meters will be inter connected and will be hooked to the station SCADA for data acquisition.

e) Communication System

For continuous hot line communication with Load dispatch center PLCC through outgoing lines will be provided.

A 50 line automatic exchange for intercom within plant, and land lines for external communications will be provided.

f) Lifts

One lift in the control annex from repair bay to control room with 3 floors and capacity of 680 kg (10 persons) and one lift in power block from repair bay to MIV floor with 3 floors and capacity of 840 kg (12 persons) will be provided.

STANDARDS: The lift proposed will conform to IS 14665-2000 with latest amendments with adequate factor of safety.

No.	Technical Specification	Parameters
1.	No. of lift and capacity	One -680kg(10 persons). +One-840kg(12 Persons)
2.	Type	Passenger lift
3.	Speed	1 m/sec
4.	Type of control/drive	AC variable voltage variable frequency micro processor based with built in stabilizer.

No.	Technical Specification	Parameters
5.	Operation	Automatic operation with or without attendant.
6.	Door operation	Automatic with infrared screen for car door and pressure limiter
7	Car enclosure	Stainless steel hairline finish
8	Car and hoist way	The car and hoist way Entrance/opening entrances shall be protected by center opening sliding steel door having stainless steel hair line finish.
9	Size/number of rope	with a minimum factor of safety of 10 as per IS 14665.
10	Firemen switch	Requirement as per the Government regulation will be provided

g) Perforated Aluminium Cable Trays with Accessories

The Aluminium cable trays are required for running control/Power/ Instrumentation cables, LT cables of different cores & sizes. The construction of the cable trays shall be suitable to withstand the associated cable load without undergoing bending or sagging. The cable trays shall be of suitable width and length. Necessary provision shall be made to connect adjacent trays and the necessary components such as splicer plates, Hexagonal head screws, nuts and washers along with 90 degree Horizontal Elbow, Horizontal Tee etc. to fix the trays. The perforations provided shall be such that adequate ventilation is allowed and also facilitate binding the cables to the trays.

The trays shall be of aluminum alloy hot rolled '31000' grade of moderate strength retaining comparable ductility, corrosion resistance and shall be of 2 mm thick of H2 hardness conforming to IS 737 – 1986 with latest amendment. The aluminum shall be of 96.4% purity. The quality of alloy should be such that there should not be any sag when cable trays of 2.5m length are fabricated. The hardware shall conform to IS 1367 – 1967 (latest) and shall be Electro Galvanized. Trefoil clamps, junction boxes, adopter boxes, cable glands, lugs, marking ferrules and hard ware as required are proposed to be provided.

h) Cable Trench/Rack system

For laying of cables in the power house and GIS, a broad based system invovling cable gallery, trenches, cable racks, shafts, etc is proposed. Main considerations for routing are proper segregation and spacing.

i) LT Power, Control, Instruementation /Communication Cables

Power cables for 11 kV systems are XLPE insulated with conductor and insulation screen.

ZH-FRLS PVC outer sheathed cables are proposed to be used for underground power station and GIS.

For auxiliary power supply / Control cable : It is proposed to provide all auxiliary power supply for AC/DC to be armored, compacted circular, multicore, multistrand, copper conductor, 1.1kV grade, ZH-FRLS, PVC inner & outer sheathed.

Instrumentation Cables: Cables connected to RTDs / Analog inputs like (4-20mA) etc. will be instrumentation type, screened, armoured with twisted pair type of 0.5 sq.mm copper with high degree of insulation sustaining high temperature.

Communication Cables: Armored Glass Optical fiber cable used for communication with various devices & DCS which shall be multiple single-mode or multimode fibers graded index type, shall have Immunity to EMI/RFI, Lightning protection. It shall have higher bandwidth that supports higher data rates over longer distances. It shall be ZH-LS, galvanized corrugated steel taped armored, fully water blocked with dielectric central member for outdoor/indoor application. Armored Glass Optic Fiber cable outer sheath shall have Flame Retardant, UV resistant properties.

Sizing of cables: The sizing of all power cables is being done on the basis of current rating taking into account proper derating factors for temperature, group deration, laying conditions, fault current and fault clearing time.

13.6.2 Power Evacuation

3 Nos. 220 kV lines would be required to evacuate 400 MW power. KPTCL have been intimated about the evacuation requirement who will decide on the substation to be connected and plan transmission lines accordingly.

13.6.3 Video Surveillance System

GENERAL: It is proposed to provide closed circuit video camera surveillance system for entire station for monitoring the various equipments at strategic locations and is a ubiquitous feature of plant security system. Video Cameras shall be Digital industrial grade IP cameras of reputed make. The cameras shall have swiveling (PTZ) arrangement. The envisaged surveillance system is for viewing in the control room of the power house. cameras (as per specification) will be installed at various locations of power house:

a. One No. of Surveillance Camera shall be located at entrance of power plant/ gate near Security. (PTZ Type Camera)
b. One No. of Surveillance Camera will be located in front of Power Access Tunnel (PTZ Type Camera) and every 100m thereafter.
c. One No. of Surveillance Camera shall be located for repair bay of Power House.(PTZ Type Camera)

d. Two Nos. of Surveillance Cameras shall be located at regular intervals in Machine hall for monitoring all 4 Units.(PTZ Type Camera)

e. Four Nos. of Surveillance Cameras shall be located at suitable locations of Generator Barrels for monitoring all 4 Units.(Bullet Type Camera)

f. Four Nos. of Surveillance Cameras shall be located at suitable locations of Turbine Floor for monitoring all 4 Units.(Bullet Camera)

g. 8 Nos. of Surveillance Cameras shall be located at suitable locations of Cable Vaults/ ducts.(Thermal Camera)

h. One Nos. of Surveillance Cameras shall be located at Control Room.(PTZ Type Camera)

i. Four Nos. of Surveillance Cameras shall be located at suitable locations of GIS yard.(PTZ Type Camera).

j. Four Nos. of Surveillance Cameras shall be located at suitable locations of Transformer cavern for monitoring all GTs Units.(Bullet Type Camera)

Providing One number server & three numbers client user licenses of network video surveillance video analytics software with live and remote monitoring, recording, tamper and motion detection alarm triggers and log reports is envisaged.

Necessary STP cable interfacing to connect all the cameras with storage device and server will be provided. Storage device should be large enough to store 60 days video data (approximately 4 TB storage) any other materials required for the complete surveillance system at the Power House.

Providing of One number rack server with one number windows server at Control room of the Power House is envisaged. 2Nos. of 24’’ industrial grade Monitors having HDMI port will be provided.One of this shall be located in the Control Room with the extension of DCS console along with necessary furniture. Another unit shall be placed at the Security Room near the Power House Gate. Provision shall be made for monitoring at head of project office. Necessary interfacing software with licenses shall be provided by alongwith associated cables.

The type and number of surveillance camera and its locations indicated above are general in nature and tentative. Latest type cameras available during implementation will have to be adopted.

General Requirements For Surveillance Cameras: Dome type PTZ camera, with Daylight and Nightlight vision operation, Pixel density of min 1080p, min 25 frame per second, direct streaming for recording, dome bubble clear with UV blocking antiscratch coating, IP 68, operating temperature maximum 55 deg Celsius, pan of 360 deg Continuous, tilt of minimum 20 deg., Recording and Management Software for IP video, Images & videos are displayed with date/time, location, camera name and the status of connected devices such as detectors and sensors. Surveillance cameras of Thermal type will be provided for monitoring at Cable vaults / ducts. The camera shall be equipped with an IR-sensitive progressive scan sensor and shall provide a removable IR-cut filter, providing day/night functionality.

Necessary original interfacing software with licenses will b eprovided. The software will have following features:

- Live display of cameras,
- Play Live audio,
- Broadcast audio to remote locations,
- Live display of camera sequences,
- Live display of stitched and/or panoramic camera views,
- Control of PTZ cameras through software,
- Playback of archived video and audio,
- Retrieval of archived video and audio,
- Instant Replay of stitched and/or panoramic camera clips,
- Audio Recording range as per manufacturer standard.

Installation Of Surveillance System: It will be installed to achieve NEC (National Electrical Code – US only) guidelines of that year's revision. After installation equipment will meet Low Voltage, Class 2 classification of the NEC or equivalent standards.

13.6.4 Number of units and transportation limits

1 unit of 40 MW and 3 units of 120 MW will be installed.

The heaviest package to be transported will be 150 MVA 3 phase Generator Transformers. The weight of gas filled main tank assembly which is the largest size will be about 100 tons and dimensions will be 5 m (L) X 3 M (W) X 5.5 m (H). The road and access tunnel will be constructed to transport this package

13.6.5 Layout of Power Generating Units

The layouts of power generating units including auxiliary equipment are shown in the following drawings, Vol III.

13.6.6 Selection of Switching Scheme and Switch gear

220 kV switch gear will be GIS above ground. A double bus switching scheme with 4 unit modules, 1 bus coupler module, 2 PT modules and 4 line modules are provided

13.6.7 Auxiliary systems- Description and Justification for selection

The systems are described in section 13.6.1.19 above. The schematics are enclosed as drawing Vol III

13.6.8 Arrangement of Black start of the Power Plant

During total plant shut down if utility local supply is available unit can be started on utility supply. If total grid has failed 40 MW unit can be started on 500 kVA DG set provided. After Unit voltage is built up supply can be changed over to its auxiliary transformer.

13.6.9 Description of Plant control system

The system is described in section 13.6.1.12 above. The schematic is enclosed as drawing Volume- III

13.6.10 Selection of EHV Cables / GI Bus duct

For connection of Generator Transformers to GIS switch gear 220 kV XLPE cables are selected. The GI bus duct will be uneconomical for the length and complex for routing.

13.7 Power Benefits

Annual Energy Generation in 90% dependable year is detailed explain in Para 13.2.7.A and Firm power is explained in para 13.2.7 B..

13.8 Financial package

Debt: Equity			
	Debt	%	70%
	Equity	%	30%
	Total Debt Amount	Rs. Crs	6225.10
	Total Equity Amount	Rs. Crs	2697.90
Debt Component			
	Loan Amount	Rs. Crs	6225.10
	Moratorium Period from COD	months	Nil
	Repayment Period (including Moratorium) in years	Qrtly	12
	Interest Rate per annum	%	10%
Equity Component			
	Equity amount	Rs. Crs	2697.90
	Normative ROE (Post-tax)		15.5%

	Return on Equity for first 12 years	%p.a	15.5%
	Return on Equity for first 11 years onwards	%p.a	15.5%
	Weighted average of ROE		15.5%
	Discount Rate per annum		10.95%

13.9 Capital cost

- Civil Engineering Works = 2535.20 Crores
- Electro- Mechniacl Works = 1096.56 Crores
- Hydro Mechnical Works = 125.00 Crores
- Other Costs = 5243.24 Crores
- **Total Project Cost = 9000.00 Crores**

13.10 Implementation schedule

The total construction completion period proposed for the project is 48 months from zero date (starting of construction work).

13.11 Allocated cost of head works

Not Considered

13.12 Comparison of total cost of the present project with any other visible category

The tariff is calculated for 90% dependability energy and it works out to Rs.4.00/kWhr for Mekedatu Hydro electric project. This tariff is almost similar to the average tariff worked out for similar solar and wind farms.

13.13 Construction power requirement and proposed supply arrangement

The total Power requirement would be 10 MVA. The details are as follows:

Air Compressors	1 MVA
Aggregate Processing Plant	2 MVA
Batching Plant	1 MVA
Dewater Pumps	1 MVA
Grout Pumps	0.5 MVA
Facilities	2 MVA
Welding Machine	2.5 MVA
Bending Machine	
Total	**10 MVA**

The activities in the Head Race Tunnel, Surge Shaft & Penstocks will be supplemented with the help of temporary power supply from DG sets.. Refer Chapter -15 for detail Explanation

13.14 Economic evaluation

Unit cost of generation at Bus Bar / Average cost of Energy is considered at Rs. **4.00 per kWhr.**

Chapter 14
Navigation

This project is conceived as a power project and a balancing reservoir in order to generate power and as well as regulating / allowing the required quantum of water as per CWDT award. There is no proposal to use for Navigation purposes.

Chapter 15
Construction Methodology, Schedule, manpower and plant planning

15.1 Construction Program

The construction schedule for the Mekedatu Hydro Electric Project is considered as 48 months from the zero date (i.e Award of all the procurement contracts) taking view of the fact that it is a high level dam of length 660.00 m with a height of 99.00 m and comprising of various power components to generate 400 MW of power. The overall construction schedules for the dam and power house works are placed at **Appendix 20.1 & 20.2, Vol II** and the details of construction methodology are presented in the following sections.

The attached construction schedule details the main activities of each individual component and considers its interrelationship and dependency on the activities of other component. The planning for the time of construction is considered as days on the basis of 3shift/24 hours working per day. Every Sunday is deemed to be weekend and has been considered as a workday off.

Due to the nature of hydrology, the full phase construction is affected during the monsoon season i.e. Second half of June, July, August and September when the river discharge is high, making it difficult to work at the areas below the flood level. This effect has been considered in preparing the schedule.

The project is proposed to be executed through experienced contractors/equipment suppliers / service provided under the supervision of the staff of CNNL as per the detailed designs developed. Therefore as such the departmentally mobilized special T & P will be minimum.

15.2 Key materials planning

15.2.1 Construction Materials

The sources of the major construction materials required for the project have been anticipated as follows:

- Explosives for blasting will be obtained from suppliers from the nearest dealers.
- Cement in bulk will be obtained from cement factories/ nearest cement dealers.
- Coarse aggregate which will be produced on site from the excavated materials, Rock quarries and River Course
- Fine aggregate which will be processed from the excavated material and from local sources if necessary

- Reinforcement steel will be obtained from nearby local dealers.
- Structure steel will be obtained from nearby local dealers.

15.2.2 Abstract of major quantities of construction materials

Abstract of major quantities of construction materials required for different components of the work are assessed based on Preliminary Designs & Drawings

Table 15.1: Requirement of Construction Materials

No	Components	Explosive in MT	Sand in cum	Coarse aggregate in cum	Cement in MT	Reinforced steel in MT	Structural Steel in MT
1	Dam and allied works	562.00	929735	2258218	634344	12327	3087
2	Pressure Shaft/Penstock	70	7260	12975	6235		3055
3	Tunnel related works	990	97245	178755	83485		
4	Power House Cavern	245	9920	17740	8555	1900	30
5	Transform Cavern	45	980	1755	1045	115	0
6	Surge Chamber Cavern	125	5035	8995	5335	515	
	Total	**2037.00**	**1050175.00**	**2478438.00**	**738999.00**	**14857.00**	**6172.00**

15.2.3 Transportation Method

All the Hydro- Mechanical, Electro- Mechanical equipment, materials required for civil works such as cement, reinforcement steel, pipes, shuttering materials etc., including penstock steel plates, explosives are to be transported from the nearest dealers by road on state highway. Other materials required in small quantity also could be procured from nearby towns.

15.3 Construction Power requirement and proposed supply arrangement

The total Power requirement would be 10 MVA. The details are as follows:

<table>
<tr><td>Air Compressors</td><td>1 MVA</td></tr>
<tr><td>Aggregate Processing Plant</td><td>2 MVA</td></tr>
<tr><td>Batching Plant</td><td>1 MVA</td></tr>
<tr><td>Dewater Pumps</td><td>1 MVA</td></tr>
<tr><td>Grout Pumps</td><td>0.5 MVA</td></tr>
<tr><td>Other Facilities</td><td>2 MVA</td></tr>
<tr><td>Welding Machine</td><td rowspan="2">2.5 MVA</td></tr>
<tr><td>Bending Machine</td></tr>
<tr><td>Total</td><td>10 MVA</td></tr>
</table>

The activities in the Head Race Tunnel, Surge Shaft & Penstocks will be supplimented with the help of temporary power supply from DG sets..

15.3.1 Telecom Facility

In order to establish 24/7 communication, required infrastructure will be established with the help of DOT which will also be continued during the period of O & M

15.3.2 Wireless System

The project will be tendered and work will be entrusted to a single or multiple agencies, Respective implementing agency will be directed to maintain required communication system in terms of wireless system after taking necessary approval from the concerned department / s

15.3.3 Land requirement for infrastructure development for power components of the project

All the above facilities require land. The tentative requirement of land for the power components the project area is as below:

No.	Description	Area in sqm
1	Project Roads including New Bridges	59900 Sqm
2	Dump Yard	80000 Sqm
4	Stack Yard	48000 Sqm
6	Magazine Building	600 Sqm
8	Power Intake	15000 Sqm
10	Adit Portals	2700 Sqm
11	Adits	75137 Sqm
12	Main access tunnel and TRT	383619 Sqm
15	Power House cavern(UG)	2937 Sqm
16	Transformer cavern(UG)	1250 Sqm
17	Tailrace gallery cavern(UG)	1452 Sqm
18	Draft tube tunnel(UG)	4007 Sqm
	Total land in Sqm	**674602 sqm**
	Total land in Ha	**67.46 Ha**

15.4 Plant / equipment planning

Requirement of plant/ machinery for the deployment for the works has been proposed based on the works involved in the power complex component and similar works carried out in other projects. List of various plant/machinery to be deployed is given below. The list is indicative since same equipment can also be planned for the use for nearby works depending on the planning of the construction agency.

Table 15.2: Overall List of plant/machinery

No	Equipment	Gravity Dam	Vertical horizontal pressure shafts	Power house & transformers cavern & allied works	Surge shaft cavern	Tail race tunnel	Construction adits	Road works	Total
1	Tower crane (30 MT)	6							6
2	Batching Plant a) 1000cum/hr b) 800cum/hr	 1 1							 1 1
3	25 tonne dumper	1							1
4	Pumpcrete (Concrete pumps)	15							15
5	Creter Cranes (80 cum/hr)	3							3
6	Hydraulic Excavator (6 cum)	6							6
7	Crawler Dozer a) 200 HP b) 300 HP	 1 1							 1 1
8	Rare Dumper (85 T)	4							4
9	Air Tracks	As required							As required
10	Rocks Breakers and spilters	As required							As required
11	Dumpers (8T/ 35T)	20							20
12	Diamond Core Drills	As required							As required
13	Aggregate and sand handling Units a) 1000 TPH cap b) 2000 TPH cap	 1 1							 1 1

No	Equipment	Gravity Dam	Vertical horizontal pressure shafts	Power house & transformers cavern & allied works	Surge shaft cavern	Tail race tunnel	Construction adits	Road works	Total
14	Chilling Units (500 refrigeration tonne cap)	4							4
15	Bunker Capacity (30-40 cum)	4							4
16	Ammonia compressors	8							8
17	Raise climber (Double motor)		1	-	-	-			1
18	Hydraulic drill jumbo a) 3-Boom b) 2-Boom		 1 1	 1 1	 1 1	 1 1	 1 1		10
19	Tippers (20/25t)		10	15	10	20			55
20	Tippers (5.0m3)		5	5	5	10			25
21	Excavators (0.6m3)		6	6	6	6			24
22	JCB		3	2	2	3			10
23	Compressors (500cfm/600cfm)		2	3	1	2			8
24	DG set(500 KVA)	2	4	4	2	2			14
25	Ventilation blower (80 HP)		2	3	2	3			10
26	Dewatering pumps			As	Per	Required			
27	Wet Shotcrete machine (30m3/hr)		1	2	1	2			6
28	Concrete placer		1	2	1	2			6
29	Concrete pump (38m3/hr)		1	2	1	2			6
30	Grouting pump		1	2	2	2			7
31	Transit mixer (6.0m3)		5	8	3	5			21
32	Batching plant (30m3/hr)		-	1	-	1			2
33	D-8 Dozer (200 HP)		3	3	2	3			11
34	Vibrators			As	Per	Requirement			
35	Jack hammers				As	Required			
36	Mobile crane (10t)		1	2	1	2			6

No	Equipment	Gravity Dam	Vertical horizontal pressure shafts	Power house & transformers cavern & allied works	Surge shaft cavern	Tail race tunnel	Construction adits	Road works	Total
37	Water tanker (11000ltrs)		2	2	2	2			8
38	Concrete mixers (14/10)		2	2	2	2			8
39	Rock bolter		1	1	1	1			4
40	Vibratory compactor		5	5	5	5			20
41	Road roller				As	Requir ed		3	3
42	Electric winch (5t)		-	2	-	-			2
43	Excavator BC -30		-	1	1	2			4
44	Explosive van		1	1	1	1			4
45	Ambulance		-	-	1	-			1
46	Bus/mini bus		1	1	1	1			4
47	Workshop equipment		Comm on	To	All	Comp onents			
48	Ventilation ducting		As	Per	Site	Requir ement			
49	Diesel tanker 7000ltrs		1	1	-	2			4
50	Water sprinkler 10000ltrs		-	1	-	2		4	7

15.5 Manpower planning

15.5.1 Peak deployment of Man Power

The approximate number of man power required is given below and is indicative only and depends on construction agency's methodology of execution of works, machinery deployed etc,.

Works	Managers and Supervisors	Highly Skilled	Skilled	Unskilled	Total
Dam and appurtenant works	20	20	50	250	340
Power Intake	20	20	40	80	160
Adits	25	30	50	100	205
Power house cavern	35	50	80	100	265
Transformer cavern	10	20	40	80	150
Tailrace Gallery	10	20	40	80	150
Tailrace Tunnel	25	20	40	100	205
Main access tunnel	10	20	50	100	180

Works	Managers and Supervisors	Highly Skilled	Skilled	Unskilled	Total
Horizontal and vertical shafts	10	30	40	80	160
Draft tube tunnel	10	20	30	70	130
Total	**175**	**250**	**460**	**1040**	**1925**

15.6 Construction methodology

15.6.1 Introduction

The Mekedatu Project is located at about 40 kms downstream of Shivasamudram falls on the river Cauvery. The starting point of the 64 km stretch of the river Cauvery which forms the common boundary with Tamilnadu is 5 km below Mekedatu dam site.

The Concrete gravity Dam of the Balancing Reservoir and its appurtenant works are located at this point. The power components like Intake structure, underground power house complex, Tail race tunnel etc., are located on the right bank of river Cauvery. The Tailrace tunnel terminates below the confluence of Mulehalla with the Cauvery river.

The project is located at about 60 km from the District place Ramanagar. The project sites are approachable from Bengaluru by the state Highway No 92 passing through Kanakapura – Malavalli – Kollegal.

15.6.2 Construction Methodology

The present proposal envisages construction of a Dam and its appurtenant works, Intake, feeder channel, vertical pressure shaft, main access tunnel, power house complex works,tailrace tunnel and all the related auxillary/infrastructure works

The activities are planned in such a way that the project shall be completed as per schedule with no or minimum spillover from the zero date. It is assumed that all the pre-construction activites having a bearing on the proposed schedule such as land acquisition, infrastructure works and relevant statutory approvals from the Government are in place before commencement of the construction works.

It is proposed to execute the project as under:

- Civil works:
    - ✓ Construction of Civil works of dam and appurtenant works including energy dissipation arrangements, Intake structure etc
    - ✓ Construction of Civil works vertical pressure shaft and lower horizontal pressure shaft.

- ✓ Construction of Civil works of Underground Power house complex, Switch yard/pothead yard and tail race tunnel
- ✓ Construction of Jackwell cum pumphouse including raising main and Delivery Chamber.

- Hydro Mechanical Works
  - ✓ Design, fabrication, eretion, testing and commissioning of all Hydro Mechanical Works comprising of gates, hoists, erection, fabrication of pressure shaft pipes and pumps of required capacity.
- Design, fabrication, erection, testing and commissioning of all Electro MechanicalWorks
  - ✓ Generating Units (Turbine & Generator), Cooling Water System,
  - ✓ Drainage/Dewatering System, Unit Control & Automation, Bus duct.,
  - ✓ Valves-MIV& BFV,EOT Crane, Air Conditioning, Ventilation etc.
  - ✓ Fire Fighting, Transformers (Generator Transformer), 6.6 kV Switchgear Switchyard & Protection metering,
  - ✓ Transformer (Dry Type UAT SST),
  - ✓ DC System (Battery & Battery Charger), UPS
- Design, fabrication, erection, testing and commissioning of all Transmission Line Works

15.6.3 Methodology of Assessment of Construction

The proposed methodology of construction is presented hereunder. The works involve taking them up simulataneously which includes hydro mechanical and electro mechanical components. There is a need to see that the work shall continue uninterrupted till the completion of the project by identifying critical item which will have a bearing on the execution of the project.

15.6.4 Pre Construction Activity

For a project to be implemented in a systematic manner and to complete it within the time schedule, it is imperative to see that certain pre construction activities are completed in a proper manner. Some of the activities which are proposed to be undertaken during this period will be:

- Detailed Topographical Survey and marking the Layout at site, all preparatory construction works.
- Clearance from Government agencies like Pollution control board, Public health, Irrigation and Forest Clearance

- Acquisition of Land including muck disposal areas
- Financial closure
- Detailed design and preparation of tender documents for Civil, Electro-mechanical, Hydro mechanical works including pre construction investigation.
- Award of Contracts
- Setting up of Site office and store
- Arranging of construction power
- Construction of approach roads and bridges
- Formation of project team

15.6.5 Equipment Planning

"Guidelines for preparation of Detailed Project Reports of River Valley and multipurpose Projects" issued by Central water Commission have been used for the planning of equipment. Assumptions made for planning of equipment for various construction activities are indicated hereunder:

15.6.5.1 Working hours

It is necessary that the work will progress systematically with an intention to complete the activities as per schedule. Accordingly, it is assumed that works is proposed to be done in three shifts with effective working hours at 20 Hrs per day of 25 days in a month.

15.6.5.2 Densities of Materials

All the calculations are based on capacity of hauling units. The densities of different types of materials are considered for excavation and fill material.

15.6.5.3 Conversion factor for earth volume

Standard norms have been adopted for conversion of volumes in natural, loose and compacted state.

15.6.5.4 Efficiency of operation

The efficiency of operation for various equipments are considered as per standards

15.6.5.5 Gravity Dam including River Diversion Schemes

As described in the **section 15.6.6.1** construction methodology chapter,the construction equipment planning is worked out based on the 3rd season block concreting requirement which is around 14.5 lakhs cum.

Following are the tentative equipment envisaged catering to this requirement along with other equipment for excavation, drilling, consolidation / curtain grouting and river diversion activities.

a. 6 nos. Tower cranes, 3 nos. near upstream cofferdam and 3nos. near downstream cofferdam, with the tip of the job and hook of the tower cranes having 360 degree swing is adopted for block concreting.
b. The tower crane is to be fed by concrete agitator cars from 2 nos. batching plants of capacity 1000 cum / hr and 800 cum / hr will be established on left and right bank of gravity dam respectively through 15 nos. 9 cum capacity agitator with discharge chute fitted to 4 nos. 25 ton dumpers.
c. These 25 ton dumpers will carry concrete from batching plants to ROTEC tower belt feed conveyors to hopper to be commissioned on left bank at two places, into concrete buckets for extended tower cranes.
d. 15 nos. Pump Crete in used for reinforced concreting along with 3nos. Creter cranes for concreting, which is of capacity 80 cum / hr. will ensure optimum delivery of concreting requirement of 14.5 lakhs cum of mass concreting during 3 seasons.
e. The capacity of tower cranes and its accessories mentioned above can be augmented gradually from 1st to 3rd season to optimize on the rentals of these heavy duty cranes and its accessories.

Other equipment for diversion channel and dam excavation purpose considered is as follows

a. 6 nos. 6 cum capacity hydraulic excavators
b. 200 HP and 300 HP crawler dozers
c. 4nos. 85t rear dumpers
d. Air tracks
e. Rock breakers and spitters
f. 25 nos. of 35t / 8t dumpers

For drilling and consolidation / curtain grouting activity, following equipment are envisaged

a. Diamond core drills

For aggregate batching plant

a. 2000 TPH and 1000 TPH for aggregate and sand handling respectively.

For control of Concrete temperature

The ambient temperature would be as high as 36°C-38°C during day time in summer and the night temperature is around 22°C-24°C. The temperature of concrete has to be maintained 12°C-13°C at the batching plant so that placement temperature restriction can be adhered to. This requirement is met by

a) By cooling the aggregates to 5°C-6°C

1. Chilling Machines each of 500 refrigiration tonne capacity for pre cooling of aggregates – 4 Nos.
2. Compresser evaporator combination for chilling machine driven by 3.3 kVA 450V AC Motor is from-11 which will be compressed into liquid, to evaporate suddenly into chamber containing copper tubes. This absorbs heat from the surroundings.
3. Bunker capacity varies from 30-40 cubic.meters- 4Nos.

Aggregates from the stock pile through the vibratory feeders shall be conveyed to individual bunkers in the cooling tunnel through horizontal conveyor, transfer conveyor and shuttle conveyor which would move to and fro.

b) By adding chilled water and ice flakes for concrete.

For ice flakes required for cooling of concrete following equipments are envisaged:

1. Ammonia Compressors- 8Nos.

The above equipment shall be optimized as per mass concreting and excavation quantities requirements according to1st to 4th season construction methodology adopted in Mekedatu Gravity Dam.

15.6.5.6 Major Power House Complex Caverns and related civil works

For all the Power House and related Civil works 100% requirement of power will be met through DG sets only.

Following construction plant and machinery will be used for the power house excavation and concreting works

1. 500kVa, 4nos. DG sets
2. 2 Boom hydraulic drill jumbo along with 2 no. Tamrock
3. 30m^3/hr capacity new wet shotcrete machine (CFA)
4. 3m^3 capacity transit mixers – 4nos.
5. 30m^3/hr batching plant
6. 0.6m^3 capacity excavators – 4 nos.
7. Honey grout pumps

8. Air Tracks (ROC-203) – 4 Nos. and Jack hammers
9. Hydraulic Rock Breaker – 2 Nos.

15.6.5.7 Other Underground works excluding Major power house Complex

Following construction plant and machinery will be used for the other underground excavation and concreting works such as tunnels and galleries

1. 500kVa, 10nos. DG sets
2. 2 Boom hydraulic drill jumbo along with 8 no. Tamrock
3. 30m^3/hr capacity new wet shotcrete machine (CFA)-4Nos.
4. 3m^3 capacity transit mixers – 16nos.
5. 30m^3/hr batching plant- 4Nos.
6. 0.6m^3 capacity excavators – 20 nos.
7. Honey grout pumps
8. Air Tracks (ROC-203) – 20 Nos. and Jack hammers
9. Hydraulic Rock Breaker – 6 Nos.

15.6.6 Construction Methodology for different activities of Civil Works

15.6.6.1 Gravity Dam including River Diversion Schemes

The concrete dam is proposed to be constructed blockwise in 1.5 m lifts in general and 0.75 m lift adjacent to foundations.

The gravity dam is proposed to be constructed in 4 working seasons involving around 22 lakhs cum of concrete. The working season is scheduled by September 2020 after a mobilization period of 3-4 months prior to construction and completed by Aug 2024.

The dam construction is proposed to be completed in all aspects including erection and commissioning of service radial gates, stop log gates,sluice gates, hoisting arrangements which includes rope drum hoists, hydraulic hoists in river sluices etc.

In the 4 working seasons of dam construction, about

a. 1.6 lakhs cum of concrete in 1st season is to be concreted.
b. 3.8 lakhs cum of concrete in 2nd season is to be concreted
c. 14.5 lakhs cum of concrete in 3rd season is to be concreted
d. 2.1 lakhs cum of concrete in 4th season is to be concreted

The construction methodology and its schedule is enclosed as dwg. No. **EIT-1328X-WRE-XX-IND-A024**

Description of Mekedatu Gravity Dam construction methodology:

In the 1st season, the construction activities include the following activities.

a. 1st stage diversion arrangements by the way of diversion channel on the left bank of 40m width to channelize the river flow at 1 in 25 flood of 5517cumec.
b. A temporary earth / rock fill cofferdam is first constructed for excavation of diversion channel in the dam portion. (5.75 lakhs cum)
c. In this season, concreting of lock wall in the portion of dam is to be carried out. This lock wall will also be the part of diversion channel in dam reach portion. (1.6 lakhs cum)
d. Excavation of few blocks on either side of lock wall will have to be excavated to prevent future damage due to blasting for excavation of adjacent blocks

In the 2nd season, the construction activities include the following activities.

a. Excavation of left, right and spillway blocks up-to EL 372.00 is carried out.
b. Base concreting for carrying out drilling and consolidation grouting is carried out as next activity in this season.
c. Subsequently, upstream and downstream col-grout type cofferdam is to be constructed to cater to 2 working seasons.
d. Block concreting from EL 346.00 to EL 372.00 is to be undertaken. (3.8 lakhs cum)

In the 3rd season, the construction activities include the following activities.

a. Excavation of left and right abutments from EL 372 00 up-to EL 445.00 is completed.
b. Drilling and consolidation grouting is then completed.
c. River sluice gates with hydraulic type hoist erection and commissioning is an important event during this season.
d. Block concreting from EL 372.00 to EL 420.00 is completed. During this season, maximum quantity of 14.5 lakhs cum of concreting has to be undertaken. Hence the equipment planning and methodology and mobilization is worked out based on this requirement.

In the 4th season, the construction activities include the following activities

a. Block concreting from EL 420.00 to EL 445.00 is targeted in this season. (2.1 lakhs cum)
b. Necessary curtain grouting based on grout intake is carried out.
c. Most crucial activities for service spillway radial gates are erected and commissioned during this season to complete the Mekedatu Gravity Dam construction.

15.6.7 Proposed Roads

A new bridge across Arkavathi river upstream of its confluence with Cauvery river is being constructed and nearing completion. Since all the Mekedatu scheme power components lie on the right bank, road formation, improvements to existing cart road etc were being considered. However, it is seen that reaching the work spots from right bank main road is circuitous. Hence it would be advantageous to use the newly constructed Arkavathi bridge and reach the area on the left bank opposite to the power house complex proposed on the right bank. It is planned to construct a new bridge across river Cauvery at about 1400m downstream of the proposed dam location. After crossing the bridge, all necessary new roads will have to be constructed.

There are two adits to be provided, one connecting to Power house cavern, and Transformer cavern by branching out from the adit proposed for Tailrace Gallery, and the second adit is proposed for Tailrace Tunnel. After completion of the construction adit No 1 will be treated as ventilation tunnel later. Access roads are proposed for Tailrace exit, adit portal of Tailrace tunnel, and another road leading to adit portal of power house cavern which further connects to both switch yard and top of penstock shaft. One more access road is proposed for access tunnel entry point. All these roads will be constructed with approach from the proposed bridge which connects the left bank and the right bank. Various Infra structure works are to be taken up prior to taking up the major works of the project. Important Infra structures to be constructed are briefed as below.

No	Particulars	Length (Km)
1	Construction of Approach road from Sangama to Dam site - 2 lane, with paved shoulder with barricading/protection on reservoir side.	6.30
2	Approach road from Dam site to Power house on left flank d/s of Reservoir to reach power house on right flank 2 lane, with paved shoulder	2.50
3	Construction of WBM Road during construction period	20.00
4	Intermediate lane road between Muguru and Mekedatu Dam colony	18.00

The width of all the new access roads is 7.50 m.

15.6.8 New Bridges

Two new bridges are proposed in the present proposal.

- Construction of a High level bridge for crossing Arkavathy River to approach dam site.

- Construction of a High level bridge for Dam site to Power house on left flank d/s of the Dam to reach power house on right flank.

The location of the bridges is shown in the project layout drawing.

Bridge No.	Span	Remarks	Location
BR 1	1500 m	New	Sangama
BR 2	200 m	New	D/s of proposed Dam

15.6.9 Construction Methodology for different activities of Power components

15.6.9.1 Power House and related civil works

The Power House and related civil works components comprise of the following:

- Intake dam & Intake Structure.
- Trash rack
- Horizontal embedded penstocks
- Vertical pressure shaft
- Lower Horizontal pressure shaft connecting the bottom of the vertical shaft and the power house structure.
- Underground power house cavern.
- Transformer Cavern
- Surge chamber cavern with draft tube gate arrangement.
- Penstock
- Tail race tunnel with gates near the exit leading the tail race water back to river cauvery.
- Hydro- Mechanical works
- Gas insulated switch gear station and pothead yard

15.6.9.2 Adits and main access tunnel

Following adits and main access tunnel and all the access roads to these adits need to be ready before start of main construction activity of the power complex components.

- Ventilation tunnel to Power House cavern

- Ventilation tunnel to Transformer bay cavern
- Ventilation tunnel to Tailrace gallery
- Ventilation tunnel to Tail Race Tunnel
- Main access tunnel to power house service bay.

Excavation of these three caverns is commenced once the ventilation tunnel to the respective cavern is completed. The caverns will be excavated in stages and suitable ramps wherever are provided to enable the excavation of the cavern. The stages of excavation of individual caverns is shown in the further paragraphs.

15.6.9.3 Details of the tunnel

The total length and the shape of the tunnels proposed as part of the powercomplex components are furnished here below.

No	Description	Size	Length in m
i)	Ventillation tunnel toTailrace gallery	D- shape, 6m size	520.00
ii)	Ventillation tunnel toTop of power house cavern	D- shape, 6m size	490.00
iii)	Ventillation tunnel to Top of Transformer cavern	D- shape, 6m size	190.00
iv)	Adit toPressure shaft bottom	D- shape, 6m size	475.00
v)	Adit toTailrace tunnel	D- shape, 6m size	780.00
vi)	Main access tunnel to power house	D- shape, 7m size	833.00
vii)	Tailrace tunnel	Horse shoe, 9.50m size	2150.00
viii)	Escape tunnel	D- shape, 4m size	72.50
ix)	Draft tube – 3 nos.	D- shape, 8m size	96.00
x)	Draft tube – 1 no.	D- shape, 6m size	96.00
xi)	Bus duct tunnel-3 nos	D- shape, 8m size	40.65
xii)	Bus duct tunnel-3 nos	D- shape, 6m size	40.65

15.6.9.4 Sequence of operation of adit/ tunneling

In general, the Sequence of operation of adit/ tunneling is briefed below.

15.6.9.4.1 Drilling and Blasting

Charge factor is one of the tunneling parameters which measures the quality of tunneling. Optimum quantity of explosive to break one cubic meter of rock is obtained by theoretical design of drilling and firing pattern which is to be established in the site to achieve the maximum pull. The drilling pattern uses rounded wedge cuts, burn cuts and modified burn cuts to achieve the maximum pull.

The pattern of drill holes is to be essentially marked on the tunnel face at the outset of every cycle before drilling is resorted to. Drilling is to be ensured on the marked location and in the required direction. The quantity of explosive is to be uniformly distributed by charging in the drill holes and minimum in the periphery. Smooth blasting techniques are to be contemplated for achieving regular and smooth contours of the tunnel.

15.6.9.4.2 Tunneling through adverse Geological Reaches

Rock is not a homogeneous mass. It is characterized by different types of defects such as joint patterns, shear, fracturization, water ingress etc. Even in the same tunnel face, different locations could have different rock characteristics. This requires additional attention to design drilling pattern and charging in such weak zones of tunneling media as well as to treat different part of the same tunnel face. Besides this, in the geologically vulnerable reaches, special blasting techniques like cushion blasting, two stage blasting etc., have to be resorted to. Continuous monitoring of the face after blasting will help to avoid any cavity or chimney formation. In such events, immediate rock support by way of shotcrete, rock anchors etc., are to be ensured. This will help to reduce over break. The rock quality being generally good, geologically, expected vulnerable reaches are minimum. Hence, rock mass classes IV and V has not been considered.

15.6.9.4.3 Cycle wise operation of Tunnel Activities

The tailrace tunnel is planned to be advance by heading and benching using drill and blast methodology. All activities of the tunneling cycle have to be performed with commitment with no slack time As soon as the face drilling is completed, the charging crew is to be kept ready at the location. Similarly, immediately after blast, loaders and tippers are to be deployed to the face after allowing for defuming time.

15.6.9.4.4 Rock Support

The provisions have been made for grouted rock bolts wherever required by means of 25mm dia. Rock bolts, wire mesh and shotcreting. Provisions have also been made for installing of steel ribs.

15.6.9.4.5 Tunnel Alignment

Tunnel alignment will be checked with the help of total station in the beginning and later laser beam will be installed for checking the tunnel alignment at periodic intervals.

15.6.9.4.6 Tunnel Cycle Time

The sequence of cycle time comprises of the following activities:

- Profile marking and marking of drilling pattern
- Drilling
- Charging and blasting
- Defuming
- Mucking
- Rock anchors
- Rock support by steel ribs, wire mesh/shotcrete wherever required

12 hrs. to 15 hrs. cycle time is normally required in general on the average. This has been considered while working out time schedule for excavation of adits, tunnels.

15.6.9.4.7 Over Break

Besides, being the economy factor, over break in tunneling are also measures of quality of tunneling. means as it Is proposed to be controlled through systematic drilling and blasting Lesser the over break, more regular will be the tunnel face providing the required stability to the crown. The over break in the over all tunneling is proposed to be restricted to 6 to 8%.

15.6.9.4.8 Ventilation

During execution, noxious fumes and high temperature gets developed inside the tunnel that makes the tunneling condition unsuitable for working. As such, a forced ventilation system by blowing air through the flexible ducts installed inside the tunnel or a suction type ventilation system with rigid duct system would be adopted during construction to force out the fumes developed during blasting expeditiously and provide a congenial working environment to the working crew involved with the construction of the tunnel..

15.6.9.4.9 Tunnel excavation with Smooth Blasting Technique

All major large size tunnels would be excavated by heading and benching using drill and blast methodology to achieve required shape of face and smaller size tunnels and galleries would be excavated in full face approach using drill and blast methodology to achieve required shape of face

Perimeter holes shall be closely spaced such that ratio of spacing to burden can be maintained at about 0.8 for periphery holes and perimeter blasting with same number of detonators. This system will help to get the tunnel face of smooth perimeter. Invert, however, will be back filled with excavated muck for smooth plying of hauling equipment during the excavation and mucking of tunnel..

15.6.10 Construction of Civil Engineering components of power complex

15.6.10.1 Construction of intake structure including providing penstock pipes

The intakes are housed in power blocks of the dam. Its construction is part of the works of dam construction and will be planned as such. The intake trash rack structure will also be constructed using similar equipment and machinery as the main dam works.

15.6.10.2 Laying of penstock pipes (embedded in power blocks)

This work consists of laying of 2 pipes of 5.6m and one of 6.5 m, including bell mouth portion, gate works and transition from square shape to circular shape of penstock pipe up to the vertical pressure shaft.

The fabrication, transportation and erection of these pipes will be as per the procedures described in the para pertaining to hydro mechanical works.

15.6.10.3 Laying of the penstock pipes

Concreting around the penstock pipes, bell mouth and intake gate groove are to be carried out in a co-ordinated manner as per the procedures for the construction of the power blocks.

The time required for construction of intake structure as planned is about 20 months. Laying of penstock pipes including field welding etc is proposed to be done in 2 months.

15.6.10.4 Construction of vertical pressure shaft

The horizontal penstock pipes are connected to the vertical pressure shaft at the exit of power blocks and are of 2 of 5.6 m dia and one of 6.5 m dia. There is an R.C.C anchor block at the bend location.

The central line of penstock pipe is at RL.383.0m. The level where these shafts meet the horizontal pressure shaft is at RL. 296.50m. The depth of vertical pressure shaft is 86.50m

Excavation of deep shafts itself is a challenging task. Construction of a shaft by a conventional method of drill and blast and lifting the excavated material is time consuming. Because of availability of good rock conditions, use of Raise boring machine (RBM) and combined with conventional drill and blast method is proposed.

The methodology proposed for excavation of the vertical shafts of 86.50m will be as below:

- A pilot hole of 250 to 300 mm dia (10” to 12”) is drilled from top upto the required roof level of the adit at the bottom.

- The pilot hole is reamed subsequently to desired dia by raising from bottom of the hole to the top through the pilot hole by the reamer head attached to the drill rod of RBM.
- It is proposed to ream the pilot hole to convenient larger diameter say about 1.8m to 2.4 m depending on the prior planning.
- The reamed pilot hole is further widened to 7.1m (5.6+1.5m) and 8m for 5.6m dia and 6.5m dia. finished pressure shafts respectively, by conventional method of drilling and blasting from top downwards and mucking from the bottom adit.
- The verticality of the shaft is of prime importance while drilling pilot hole and deviations shall be limited to the permissible extent. The photographic method of use of RBM shown in fig enclosed.

Preliminary Works for Construction of Pressure Shafts:

Before the work on drilling of pilot hole or widening of the hole by RBM and further works of conventional drilling and blasting for vertical pressure shaft is taken, it is essential to carry out approaches to the location of the pressure shafts. The works involved are as below.

i) Excavation adit to pressure shaft bottom connecting to vertical pressure shafts bottom at RL 296.50m from the main access tunnel.

ii) Thus approach to the bottom of the pressure shaft is established.

iii) Similarly approach to the top of pressure shaft is also established from the left side by forming a road and then by tunneling connecting all the three pressure shaft.

Once the excavation of the shaft is completed, placing the portion of the ferrules bottom bend portion concreting around the same will be carried out from the bottom adit.

15.6.10.5 U.G. Power House Works

<u>Construction Methodology and Sequence of Excavation of Cavern</u>

Construction Methodology comprises of excavation of 508 m long, 6m dia., D-Shape ventilation tunnel and 833 m D-Shape main access tunnel for approach to power house. Ventilation tunnel approaches crown of power house with invert at around EL 322.5m while main access tunnel (MAT) joins power house in service bay at EL 309.0m. Thus majority of excavation of powerhouse has to be done through these two tunnels. For further lowering of the powerhouse approach through penstocks, bottom horizon portion and adit to pressure shaft bottom and draft tubes will be used.

Construction sequence is as under

i. Excavation of ventilation tunnel till junction with power house

ii. Excavation of 7.0m x 7.0m central gullet (pilot) of power house along its longer wall through ventilation tunnel

iii. Widening on both sides of the central gullet to EL 322.5m

iv. Benching of cavern up to EL320.5m leaving central ramp for hauling

v. Line drilling for rock ledge protection

vi. Casting of RCC crane beam at EL320.5m

vii. Constructing ramp of 1 in 10 and benching down to EL316.0m

viii. Constructing ramp of 1 in 10 and benching down to EL309.0m

ix. Further benching up to EL309.0m through main access tunnel

x. Removal of ramp to main access tunnel and benching through penstock

xi. Bottom excavation of power house units through draft tubes.

Ventilation Tunnel

Excavation of Power house will be started through ventilation tunnel. This requires the excavation of ventilation tunnel in first instance. The excavation profile of ventilation tunnel and MAT is stabilized using rock bolts, shotcrete and wire mesh only and ribs to be provided wherever necessary.

Central gullet of power house

Central gullet of size of 7.0mx 7.0m with crown of designed curvature of the power house cavern will be excavated from the end of the ventilation tunnel. Line drilling may be adopted to at some location to obtain the desired profile in the crown.

Side slashing of central gullet

Proper drilling pattern and drilling technology will be used to obtain the desired profile of powerhouse roof as designed. Simultaneous installation of rock bolts will be ensured in cycle followed by wire mesh and shotcrete.

Benching below EL322.5m up to EL 320.5m

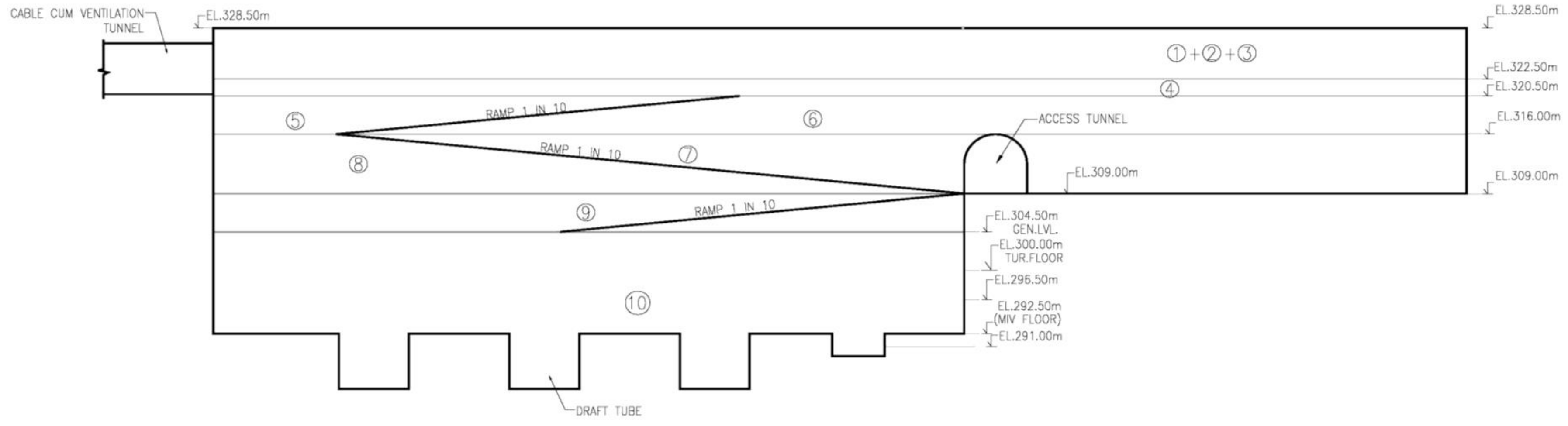
RCC crane beam will be cast at EL 320.5m which subsequently would rest on the rock legde after further lowering up to EL320.5

Concreting of crane beam at EL 320.5m

After crane beam is casted, a rock ledge of 1500mm is left after benching below EL 320.50m. Thus benching below EL m required cutting the rock in the vertical plane below the crane beam base and leaving a regular rock ledge for crane beam to rest on. To achieve this, the blasting technique of "line drilling" will be used. Needless to mention that accuracy in drilling vertical holes and at regular spacing in the same line is key to successful completion of excavation of rock ledge. A straight line along the excavation line at EL 320.5m and vertical drill hole of 51mm size drill bit is to drilled with the help of ROC and verticality of each hole is ensured by setting the machine vertical and checking its alignment throughout the drilling by a set of two plum bobs and has to be executed in close supervision. The drilled holes are plugged with jute and crane beam is casted as per the layout and planned sequence. The crane beam after concreting is then strengthened by 9m long 36mm dia. rock bolts. The tensioning will be done with the help of calibrated wrench / tensioning machine.

Benching below EL 320.5m

Benching below EL 320.5m of 1st bench of 3m depth is to be done by line drilling. First a central trench is created along the length of the power house to provide open face for the benching on its either side. Thereafter by bench blasting technique, excavation of power house up to EL 320.5m is to be completed. On achieving the level of EL 309.0m, ramp to ventilation tunnel is removed and main access tunnel is used for excavation below this level. Again, a ramp from service bay is left till level of EL 296.5m is achieved where penstocks opening are present. The ramp below EL 309.0m will be removed and further benching below EL299.5m to EL291.0m is completed through the penstocks at EL293.5m and draft tube openings at EL 291.0 The rock support measures by rock anchors and wire mesh, shotcreting will be taken as simultaneous activities including testing of rock supports. All rock supports and pressure relief holes will be completed before going ahead for the next level of benching.



POWER HOUSE LONGITUDINAL SECTION

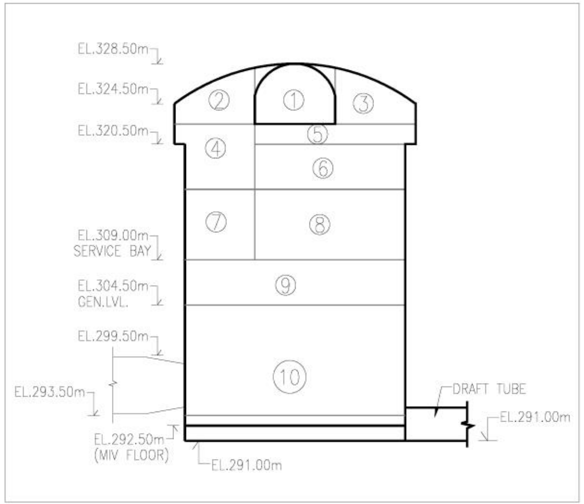


Fig. 15.1: Advancing Sequence for Excavation of Power House Cross Section

15.6.10.6 Transformer cavern

Excavation of Transformer cavern of size 78mx16mx19.5m will be taken up as parallel activity along with the excavation of power house by deploying same type of equipment. The Transformer cavern will be excavated in the same manner as power house is pilot tunnel, side slashing by creating ramps. The ventilation tunnel will be extended to full length and enlarging the side up to full width of Transformer cavern. Method of excavation would be by drilling and blasting by taking benching height of 3m at a time. Mucking will be done from ventilation tunnel until main access tunnel upto Transformer cavern is completed. Further, excavation can be carried out through main access tunnel. The required concreting of other structures will be carried out using transit mixers,pumping arrangement of concrete etc.

15.6.10.7 Surge chamber cavern

Excavation of Surge chamber cavern will be taken up as parallel activity with the excavation of power house by deploying similar equipment. The Surge chamber cavern will be excavated in the same manner as power house. The construction adit will be extended to full length and enlarging the side up to full width of Surge chamber cavern. Further, excavation would be done by drilling and blasting by taking benching height of 3m at a time. Mucking will be taken up from RL 328.50m. The required concreting of the arch portion and other structures will be carried out using transit mixers, pumping arrangement of concrete etc.

15.6.10.8 Tail Race Tunnel (TRT)

Two nos of 9.5 m dia. Horse shoe type, 2150 m long TRT has been proposed from the tail race gallery to discharge the water back to the Cauvery river. The excavation shall be carried out in heading and benching using drill and blast methodology . The tail race tunnel will be concrete lined.

The construction of tail race tunnel will be carried out from the exit face of the tailrace tunnel near the out fall and also from two faces from adit no 2. The tunneling will be done by drill and blast method using mechanised equipment. 3-boom drill Jumbo will be used for drilling holes for blasting and rock bolting of excavated sections. Robotic shotcrete machine will be used for shotcreting.

A progress of 75 m/ month from each face is planned for the excavation of the TRT. The concrete lining of the tunnel will commence immediately after completion of excavation work at respective faces. The lining of the tunnel will be done in two stages i.e overt concrete will be done first followed by invert concrete lining.

Two gantry shutters of 6 m length are proposed to be used in TRT so as to achieve a progress of 6 m/day and 150 m/month. Before concrete lining is done, support system in the form of anchor bars with grouting, contact grouting etc will be done wherever required depending geological conditions met with during tunneling of the TRT.

15.6.10.9 Gas insulated switch gear station and pothead yard

This activity involves excavation upto EL 380.00 m to create a level platform, construction of sub station and foundation for equipements including cable duct.

15.6.11 Construction of Power Equipment

Once the excavation is completed within the limits of a unit and crane beam is ready, installation of EOT Crane will start. Lowering of draft tube liner, etc will start thereafter. After first stage concreting, lowering of spiral case segments, fixing, alignment, welding, etc., will be taken up. After pressure testing of spiral casing, it will be concreted. Then generator pit/barrel with all the embedment will be concreted. Once the concreting is completed, erection of turbine-generating sets will be taken up starting with the turbine, then the stator and finally rotor. Mechanical and Electrical auxiliary and associated equipments will be installed in parallel with turbine generator installation. Testing and commissioning of each unit will take about two months thereafter. Various activities involved in installation of various equipment/systems in brief is as follows;

- Installation of ground mat, Laying, pipes, connecting, providing bentonite clay, etc, testing.
- Erection of EOT Crane, testing. Crane beam level is EL320.5m.
- Erection of first stage embedment of turbine and hydraulic equipments, erection of draft tube and clearance for first stage concreting. Bottom level of draft tube is EL 286.5 m
- Erection of second stage embedment and spiral casing, pressure test and clearance for second stage concreting. Centre line of spiral casing is EL 296.5 m.
- Erection of stay ring, guide vane assembly, shaft assembly, etc.
- Assembly of stator segments and testing in service bay and lowering in to pit.
- Assembly of rotor in service bay, testing and lowering in to pit.
- Coupling of turbine and generator shaft.
- Erection of Governor panels, testing.
- Erection of excitation transformer, SEE panels, etc., Testing.
- Installation of embedments, BFV, servo motors, etc., testing. Floor level of BF Valve is EL 292.5m. 2200mm dia and 4300mm dia BFV for 40MW and 120MW units respectively are provided.

- Erection of bus duct. Floor Level is EL 309.0 m connecting generator floor/machine floor to transformer cavern. Length of bus duct is about 40 m.
- Assembly of generator transformers at service bay, placing in transformer cavern, filling of transformer oil, testing, connecting to bus duct and cables.
- Erection of UAP, CAP, DG Set, etc of Electrical auxiliary system.
- Laying of 220 kV XLPE cables, testing, and connecting it to GTs and Pot head yard. From EL 319 m in Transformer cavern to GIS/Pot Head yard at EL 380.0m. Approximate distance is about 100m. 13 numbers of 220kV, XLPE cables are to be laid.
- Erection of Ground mat for GIS, erection of SF6 modules, erection of equipments including Breakers, CTs, PTs, LAs, disconnecting switches, etc., for 4 unit bays, 2 PT bays, 3 Line bays, Testing. XLPE cable termination and installation of LAs, etc in the pot head yard at EL 380.0m.
- Fixing of cable trays, laying of cables, cable termination, testing.
- Erection of control, protection and metering panels, cable connections, testing.
- Erection of communication cables, SCADA equipment, testing. Control room Level is at EL320.5m.
- Laying of pipes, erection of air compressors, testing.
- Laying of oil pipes, erection of pumps, etc of oil pressure system, testing.
- Laying of water pipes, erection of pump sets, etc., of cooling water system, testing.
- Laying of pipes, detectors, for Fire protection system including HVWS, MVWS, system, fire suppression system, testing.
- Laying of pipes, erection of pump sets, etc., for drainage and dewatering system.
- Erection of pipes, ducts, etc of HVAC system, etc., testing.
- Erection of UATs, SST, testing.
- Erection of NGT, LVAT, etc., Testing.
- Installation of Battery Banks, erection of battery charger panels, etc., and testing.
- Cable laying, Installation of Camera, etc., of CCTV surveillance system and testing.
- Laying of pipe lines, etc for oil handling system.
- Installation of workshop equipment.
- Installation of Lightning protection equipment.
- Laying of PVC conduits, wiring, installation of DBs, cabling, fixing of energy efficient fitting and lamps.
- Installation of communication equipment for PLCC, testing.

- Erection of embedments, rails, installation of lift in machine hall to MIV floor and service bay to control room.
- Laying of 220 kV XLPE cables/Overhead Lines for (3 Lines of 220kV), providing pot head yard at an intermediate station, erection of line bay equipment at receiving end station, testing.

Overall Program: Planning, detailed engineering, manufacture, testing at factory, quality assurance, transportation, delivery at site, intra site transportation, erection, testing and commissioning, etc., of all of the Generating Units and its associated equipments and auxiliaries is programmed to be completed in 48 months.

15.7 Project Organization

15.7.1 General

The project area is spread over a length of about 8 km on the left and right flanks of River Cauvery. Any planning of construction of a major dam including its power components shall be supported by a proper infrastructures all located within the project area. They are but not limited to:

- Permanent and temporary colonies
- Ofices
- Roads
- Workshops etc

The present project envisages completing all the activities within 48 months including the required infrastructure facilities.

The construction proposal considers carrying out the construction through contracting agencies by dividing the project into probable suitable packages as under:

- Bridges, Access roads, slope stabilization and cross drainage works. Permanent and temporary buildings, water supply, electrification of colonies, communication systems, workshops and stores, etc.
- Constructions of dam and other appurtenant works including energy dissipation arrangements, Intake structure etc
- Construction of Main access Tunnel, Pressure Shaft, draft tube tunnel etc

- Construction of Powerhouse complex and associated works including tail race channel & switchyard.
- Hydromechanical works including fabrication and erection of pressure shaft steel liner, gates and trashrack etc.
- Electro Mechanical works

The works relating to preparation of detailed designs, technical specifications and construction drawings for various components of the project would be executed through a separate contract package by a competent consultant.

The terrain in which the project is proposed is a hilly terrain and the quantum of design and construction work involved is quite expansive in nature. This requires a very close coordination to avoid time and cost over-runs. The organization of the project has, therefore, been planned keeping the above in view. Broad features of this organization structure are described in the following paragraphs.

15.7.2 Project Organization

The implementation of the project to meet the schedule of completion will be tunder the purview of various officers of the department. In this connection, an organization chart has been prepared as under:

The overall supervision will be under a Chief Engineer specially designated for the Mekedatu Hydro Electric Project. The Chief Engineer would be assisted by separate wings to look after the planning, construction management, quality control, administration, financial and accounts aspects of the project. There will be two circles, each headed by a Superintending Engineer one for civil waorks and other for Electrical and Mechanical works. Under these two circles, there will be 7 divisions headed by Executive Engineers, 4 for civil and 3 for electrical.

Under the Executive Engineers, there will be 14 Assistant Executive Engineers heading sub divisions with 20 Assistant Engineers and 20 Junior Engineers. Suitable number of Accounts staff and others including assistants will be in place.

Refer **Fig. 15.2**- Organization chart below for details

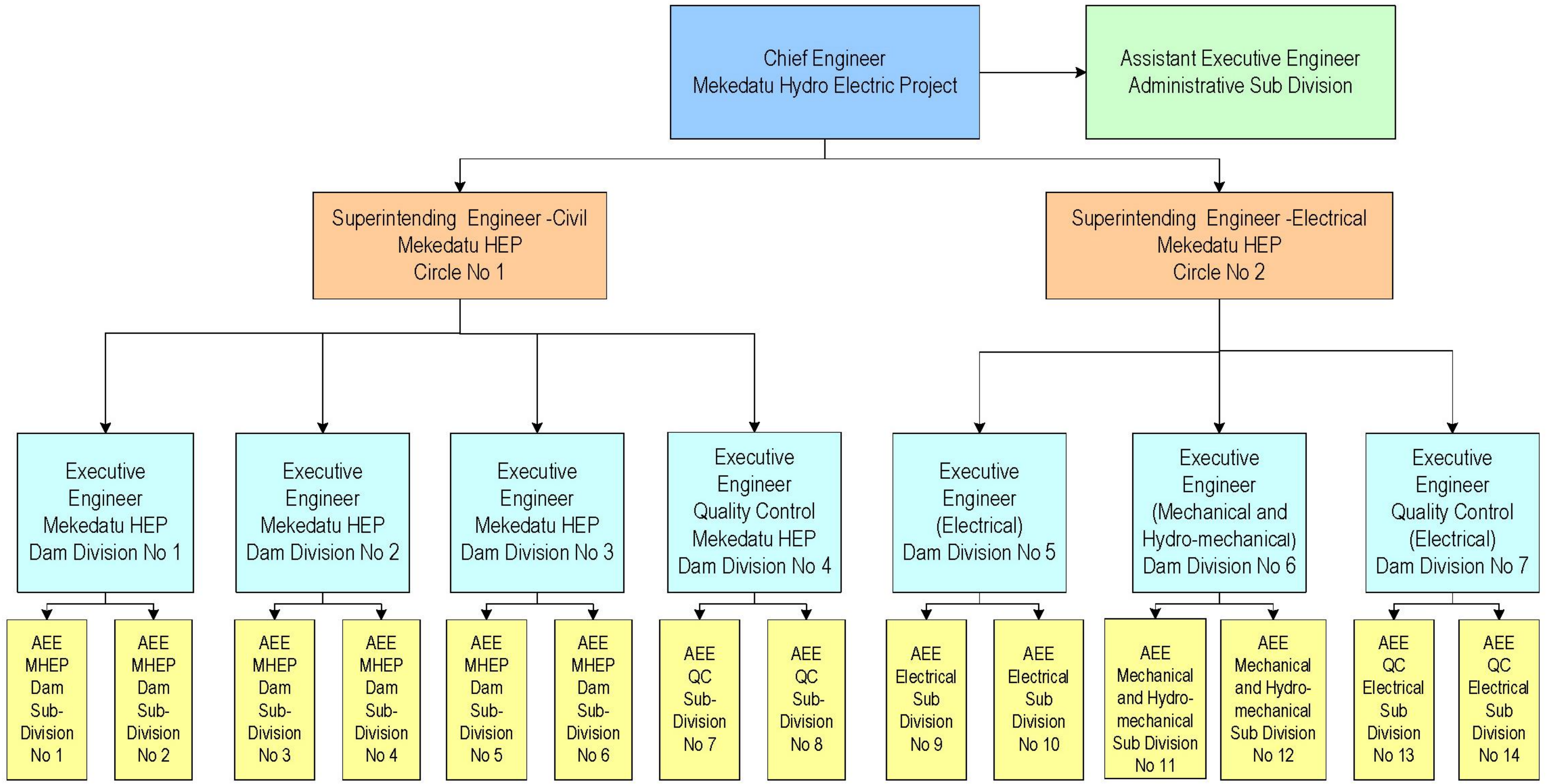


Fig. 15.2: Organisation Chart

15.7.3 Functions and responsibilities

15.7.3.1 Superintending Engineer (Civil)

He will be assisted by four executive Engineers (Civil) for supervising the execution of these works. The distribution of duties among Executive Engineers will be as under:

Executive Engineer (Dam Division 1): He will be responsible for the construction of dam and other appurtenant works on the upstream of the dam including Intake structure

Executive Engineer (Dam Division 2): He will be responsible for the construction of energy dissipating arrangements on the downstream side including all other additional works, construction of Pressure Shaft and other associated works along with main access tunnel leading to underground power house

Executive Engineer (Dam Division 3): He will be responsible for construction of proposed bridges, access roads and other infrastructure works.

Executive Engineer (Quality Control Division 4 - Civil): He will be responsible for organizing all testing of materials and quality control for the entire civil works and would also be in charge of upkeep and maintenance of all laboratories. In addition, he will be responsible for control survey of the whole project. For this purpose, he will be assisted by the supporting staff

15.7.3.2 Superintending Engineer (Electrical & Mechanical works)

The Superintending Engineer (Electrical & Mechanical works) will be responsible for the following works:

- ✓ Switchyard and Transmission Line,
- ✓ Procurement of Stores and equipment
- ✓ Material management
- ✓ Construction and running of workshops
- ✓ Communication and Transport
- ✓ Inspection and maintenance of field machinery and
- ✓ Construction power.
- ✓ Stores

There will be four Assistant Executive Engineers attached as under:

Executive Engineer (Electrical Division 5): He will be responsible for construction of power house switchyard complex and its associated works including tail race channel includingall Electro Mechanical works.

Executive Engineer (Mechanical & Hydro Mechanical Division 6): He will be responsible for afbrication & erection of power pipe, procurement of material equipment, material management maintenance of stores, construction and running of workshops including maintaenance of field machinery etc

Executive Engineer (Quality Control Division 7 - Electrical): He will be responsible for organizing all testing and quality control for the entire electrical works and would also be in charge of upkeep and maintenance of all relevant laboratories. For this purpose, he will be assisted by the supporting staff.

15.7.4 Basis of different wings

Different wings headed by the Chief Engineer and Superintending Engineers, as proposed above, considers the functional and physical requirements of works. The works have been so distributed that appropriate progress is achieved for critical items of works without affecting progress on other works.

15.7.5 Project Adiministration

The Project Administration which also includes maintenance of colonies, dispensaries, public relations, welfare etc are looked after by an Assistant executive Engineer (Administration) posted in the office of the Chief Engineer.

It is also proposed to have a Security officer along with supporting staff to carry out aspects concerned with vigilance and security of the project areas.

The organization structure will be reviewed and firmed up as part of the detailed planning in the pre-construction stage.

The project management shall function as a fully integrated team dedicated to the implementation of the project. Every member of the team shall report regularly to his officer-incharge and shall be subject to review of his performance.

The Chief engineer assumes responsibility for all aspects of the project. His deputies have to ensure that their reports reflect the up to date status of the project at any point of time. It is their duty to periodically review the progress of works, identify the problem areas, suggest remedial measures including their implementation and have a realistic forecast of the status of the project in the intermediate time frame.

To achieve the above objective, the Divisional Engineers shall ensure that they and their personnel are interacting regularly on a day-to-day basis with all the concerned personnel of the project whose work has a direct impact on the progress of their own work, and take corrective actions, wherever called for, to adhere to work schedule.

15.7.6 Technical Advisory Committee

A Technical Advisory Committee comprising of renowned experts in respective fields shall be constitutedby CNNL. This committee will advise the project team through the Chief Engineer on all critical aspects of project planning, design and construction activities

15.7.7 Reporting / Reviews

The project will be subject to monthly reviews so that all concerned are aware of progress to date. The monthly report will give details of manpower, productivity, schedule and costs. The purpose of these reviews will be to highlight the problem areas and provide the required additional supervision and action to resolve the problem. The reports will be prepared using inputs from consultants, contractors, construction supervisors, procurement officers etc., so that a realistic picture of the project is available for review and report.

Chapter 16
Foreign exchange element

No Foreign Exchange Element is envisaged in this project.

Chapter 17
Environment, Ecology and Forest aspects of the project

17.1 Introduction & Background

Environmental Impact Assessment (EIA), a systematic process to identify, predict and evaluate the significant environmental effects of proposed actions and projects which is applied prior to major decisions and commitments being made. Under this study the social, cultural and health effects form an integral part in order to prevent, mitigate and offset the significant adverse effects of proposed undertakings.

The EIS study provides information for decision-making on the environmental consequences of proposed actions; and promotes environmentally sound and sustainable development through the identification of appropriate enhancement and mitigation measures.

With the infringement of the site, the impacts become more complex and larger in scale. Thus, in order to reduce the burden of environmental impacts it becomes necessary to undertake EIA study for maintaining the sustainability of the project even after the developmental processes.

Applicability of EIA Notification 2006 and its subsequent amendments on 14th August 2018: The proposed project involves harnessing of 400 MW of hydro power annually and the project components falls within Cauvery Wildlife Sanctuary and the upstream of interstate boundary of Tamil Nadu at a distance of 5.00 km. Hence, the proposed project is considered as Category 'A' as per EIA notification, 2006 and its subsequent amendments on 14th August 2018. Therefore, the project requires Environmental Clearance from Ministry of Environment, Forests and Climate Change, Govt. of India, New Delhi.

17.2 Project Description

The proposed location of project area is at Mekedatu at Latitude 12° 16´ 20° N and Longitude 77° 26´ 25˝ E in Kanakapura and Kollegal taluks of Ramanagaram and Chamarajanagara districts. The Catchment area of the river Cauvery up to the proposed Mekedatu balancing reservoir project is 34,273 Sq. km. A fall of 310 m is available in the River Cauvery in the reach between Shivanasamudram Anicut within the State and the border between Karnataka and Tamilnadu states below Mekedatu. Hence it is also possible to generate cheap hydro-electric power utilizing this natural fall in the river bed.

The advantage of constructing a balancing reservoir also facilitates utilizing the present prevailing condition for generating hydropower. The technology employed for power generation at the Mekedatu balancing reservoir is converting the potential energy available in the water flow into mechanical energy using hydro turbines and then electrical energy using alternators. The generated power will be transformed to match the nearest grid substation for proper interconnection and smooth evacuation of power. The project activity envisages employment of highly efficient advanced hydro power generation technology indigenously available in India. Figures below provides the location of the project site on a google earth.

Fig. 17.1: Google Map of the Current location

Fig. 17.2: Google earth Image showing aerial view

The Mekedatu project consists of the following main components:

- The dam and created reservior on the upstream
- Intake Structure
- Water Conductor System

- Underground power house
- Approach tunnel and
- Tail race tunnel

17.3 Project Scope of Work

The Ministry of Environment and Forests (MoEF) Gazette Notification dated 14 September 2006 and its subsequent amendments on 14th August 2018 specifies screening criteria for new projects and for expansion/modernization of existing projects. According to the MoEF specification, a hydropower project (Capacity>25MW) does require environmental clearance from the Ministry of Environment, Forests and Climate Change, Govt. of India, New Delhi.. This project is planning to generate about 400 MW of hydropower, which clearly indicates the requirement of the environmental clearance from the regulatory authorities. The feasibility study is a notification specifying conditions under which EIA and environmental clearance may become necessary. These conditions are:

(i) If the project is located inside or within 10 kms distance from boundary of

  a. Protected areas notifiedunder wild life (protection) Act, 1972;
  b. Critically polluted areas notified by Central Pollution Control Board;
  c. Notified eco-sensitive areas;
  d. Inter-state and International boundaries.

(ii) If expansion or modernization of existing unit results in increase in plant capacity beyond 25 MW threshold limit

(iii) If the cumulative impacts of proposed project in conjunction with existing or proposed hydropower projects in vicinity is expected to be significant;

(iv) If the funding agency specifies EIA as a precondition for funding of the project.

The objective of the Environmental Impact Assessment study is to identify, predict and evaluate the likely environmental impacts due to the proposed hydel project during its construction and operational phases. As such, the EIA study has been limited to carrying out a Environmental Impact Assessment (EIA) study that relies on the secondary data available from various sources. The EIA study also aims at developing an appropriate Environmental Management Plan (EMP) to mitigate environmental impacts, if any, affecting the environs of the proposed project.

EIA report consists of thirteen chapters and also an executive summary of the study will be provided, which contains the brief findings of the EIA study. Further the study describes details of the envisaged hydel project, documents the baseline scenario and predicts impacts of the project on various relevant environmental attributes of the study area during the construction and operational phases. The study also presents the Environmental Management Plan (EMP) to be implemented during the construction and operation phases of the project.

17.4 Description of Environment

17.4.1 Baseline Environment Description

At the start of the Environmental Impact Assessment (EIA) study, the Consultant identified the baseline levels of relevant environmental parameters which are likely to be affected as a result of the construction and operation of the proposed project. Baseline data describes the environmental and socio-economic status of project site and project impact area for pre-project condition/s. The study area comprises the project area to be utilized for various project components and area within 10 km radius from main project components (Balancing Reservoir, power house etc.). Ecological information is collected from field studies as well as secondary sources.

A summary of environmental attributes, related parameters and source of information is given in **Table 17.1**

Table 17.1: Environmental attributes, parameters and Source of Information

No.	Attribute	Parameter	Source
LAND ENVIRONMENT			
1	Land Use	Land use pattern	Topo-sheet Map, Field Studies
2	Soil	Soil Characteristics Soil erosivity in catchment area	Field studies, Literature review
3	Geology	Geological Status	Detailed Project Report
4	Seismology	Seismic Hazard	Literature review
WATER ENVIRONMENT			
5	Water Resources	Catchment Area, Flow, Design	Detailed Project Report
6	Water Quality	Physical, Chemical and Biological parameters	Field studies, Literature review
7	Hydrology	Drainage area and pattern	Detailed Project Report and field studies
8	Meteorology	Temperature and Relative humidity	Literature review

No.	Attribute	Parameter	Source
		Temperature, Relative humidity, Rainfall, Wind Speed and Wind Direction	India Meteorological Department, Literature review
BIOLOGICAL ENVIRONMENT			
11	Ecology	Flora & Fauna Diversity	Field Studies, Information from Forest Department, and Literature Study
12	Aquatic Ecology	Density & diversity of aquatic species	Fisheries department, field studies and Literature review
SOCIO-ECONOMIC			
13	Socio-economic aspects	Socio-economic characteristic of the affected area	Field Studies, Literature review.

Fig. 17.3: Pictorial view of the project site

As shown in above, the project site is surrounded partly by rocky boulders with pockets of water flow. At Shivanasamudram, the Cauvery River branches off into two parts and falls through a height of 91 m. in a series of falls and rapids. The falls at this point is utilized for power generation in the upstream of the project site. The power station at Shivanasamudram was built as early as 1902. The two branches of the river join after the falls and flows through a wide gorge which is the present project site known as "Mekedatu" and continues its journey and forms the boundary between Karnataka and Tamil Nadu States for a distance of 64 km.

17.4.2 Land Environment

Geographically, Kanakapura Taluk is about 412.78 in sq.km in area Ramnagar is about 3576 sq.km in area, which includes forest area (69946 ha) and cultivated area (175539 ha). The district with major part sloping towards south and south east forming Pediplain interspersed with hills in the granitic terrain, all along the western part with the elevation in the range of 996 m and 1467 m mostly.

The Pediplain form major part of the district underlain by gneisses and granites with the highest pediplain in the range of 850 m to 950 m above msl. Rocky upland pediplain and plateau constitute erosional topography. Major part of pediplain constitutes low relief area having matured dissected rolling topography with erosional landscape covered by layers of red soil of varied thickness. Major parts of the pediplain are dissected by streamlets flowing in southerly direction. An alluvial valley with low relief of 600 – 650 m is located in Kanva plain. The Taluks geomorphology majorly consist of Rocky uplands, Plateaus, and Flat topped hills. The Cauvery basin is one of the main water source flowing within the district.

17.4.3 Physiography

The elevation falls from 833 m to 620 m from the north of the LPA to south up to Arkavathy valley and increases in elevation generally towards the south-west. Terrain shows undulating topography with varying elevation between 833 m to 620 m above msl. The lowest elevation being 620 m is found around kanakapura town in the valley portion. The region has a slope varying from 20-150 meters/kilometer.

Kanakapura taluk lies in the Cauvery basin, the main tributary of the Cauvery, river Arkavathy. The drainage density and stream frequency are moderate to high (hilly zone, in the northern, eastern and western part) and medium to low in the central part of the taluk.

Physiography	Soil Types
Rolling Lands	Deep, red gravelly clay soils
undulating lands	Moderately deep, red clay soils, moderately deep, red gravelly clay soils
gently sloping lands	Deep, red clay soils
Valleys	Very deep, clayey alluvial soils with saline-sodic in patches

17.4.4 Ground water

Groundwater studies suggests, occurance in weathered and jointed zones of gneisses, granites, Charnokite, Closepet granite and alluvium along river courses in unconfined or water table conditions where as it occurs in semi confined to confined conditions in fractured formations at deeper depths. The thickness of weathering in major part of the district ranges from 5-10m and more than 10m in rest of the district. Unconfined aquifer system is tapped by dug wells and shallow bore wells. This zone extends down to 25 mbgl. The yield tests in dug wells show that the specific capacity is in the range of 0.64 to 4.18 lpm/mdd .The dug wells generally sustain discharge in the range of 10 to 20 m3 /day. The yield range in bore wells is mostly less than 1 lps and occasionally up to 5 lps.

17.4.5 Soils

A major part of the district is occupied by red sandy soil (60%), and the remaining by red loamy soil. Red sandy soil mainly occurs in Channapatna, Kanakapura and Ramanagara taluks in undulating land slopes. These soils are derived from acidic rocks, granites and granitic gneiss. These soils occur on gently sloping pediplain. They are dark brown colour with loam to sandy loam composition on the surface and sandy clay loam to clayey soils in the sub-surface horizons. They are neutral to alkaline in nature. Red loamy soils generally occur on hilly to undulating land slope on granite and granite gneisses. It is mainly covered in Magadi taluk and parts of Channapatna and Kanakapura taluks.

17.4.6 Catchment Profile (Directly Draining)

The entire area of Ramanagaram and Chamarajanagar districts are part of the Cauvery basin. The major tributaries of the Cauvery River draining the district are Arkavathi and Shimsha rivers. The Arkavathi basin primarily comprises four watersheds 4B3B5, 6, 7 and 8 and Shimsha River comprises three watersheds 4B3C1, 2 and 5. The rivers and streams originate from small watersheds and empty into number of tanks scattered in the district. The drainage pattern in the area can be described as semi dendritic to dendritic.

17.4.7 Geomorphology/Geology

The districts comprise of rocks that belong to Charnokite group, Sargur group, peninsular gneissic complex (PGC), Closepet granite, and basic and younger intrusives. Charnokite group is represented by Charnokite. Sargur group comprises of ultra-mafic rocks, amphibolite, banded magnetite quartzite, occurring as small bands, and lenses within the migmatite and gneisses. PGC includes granites, gneisses and migmatite and occur to the east and west of Closepet granite. Transformation of PGC into Charnokite is reported locally in the districts. Closepet granite occurs as intrusive bodies trending nearly N-S within the gneisses over a distance of 50 km and with a width of 15-20 km. The Closepet granite contains enclaves of migmatite, gneisses, quartzite and amphibolites and is reported to be of variable composition. The basic intrusives are represented by dolerite, gabbro, occasionally Norite and pyroxenite. The dolerite is dominant among the basic dykes.

A detailed assessment including Meteorological studies, Ambient Air Quality Monitoring, Ambient Noise level monitoring, Surface and Ground Water quality analysis, Hydrology and Geology studies, Soil quality analysis, Land Use and Land cover aspects, Terrestrial Ecology and Biodiversity studies, Aquatic environmental studies including fisheries aspects, Socio-economic studies, Waste Management studies and Risk Assessment studies will be carried out during EIA studies.

17.4.8 Water Environment

17.4.8.1 Water Quality Parameters

Water quality parameters were collected from the Bangalore Water Supply and Sewerage Board (BWSSB). These water samples were collected at the Cauvery inlet point of the Thorekadanahalli by M/s Environmental Health and Safety Research & Development Center, Bangalore.

Understanding from the site visit, the difference in temperature between the surface and bottom layers of water is not very significant. The level of dissolved oxygen at the surface is fairly high as different varieties of small fishes in large numbers were found moving swiftly in the running water at Sangama crossing point on the way to the Mekedatu balancing reservoir site point.

The visual depth of the water was clear and without any kind of suspended particles. Throughout the region, floating solid wastes were not visible which shows certain good efforts by the concerned authorities towards maintaining the river which is considered as a tourist point.

Table 17.2: Water quality parameters. Source: BWSSB test report

		Parameters	**Test Methods**	**Results**	**Standards IS 10500:2012(2nd revision) DL-PL**
Cauvery Raw Water	**Chemical Analysis**	pH Value	4500H+B	7.84	6.5-8.5
		Turbidity (NTU)	2130 B	0.15	1-5
		Total Dissolved solids (mg/l)	2540 C	94.0	500-2000
		Total Hardness (mg/l)	2340C	47.0	200-600
		Fluoride (mg/l)	4500F D	0.54	1.0-1.5
		Calcium as Ca (mg/l)	3500-Ca	10	75-200
		Magnesium as mg (mg/l)	3500 Mg B	5.34	30-100
		Chloride as Cl (mg/l)	4500Cl B	14.78	250-1000
		Residual free Chlorine (mg/l)	4500 Cl B	BDL	0.2-1.0
	Bacteriological Examination	E-Coli (CFU/100ml)	IS:15185	Absent	Absent
		Total Coliform(CFU/100ml)	9222 B	1	10
		Fecal Coliform (CFU/100ml)	9222 B	<1	Nil

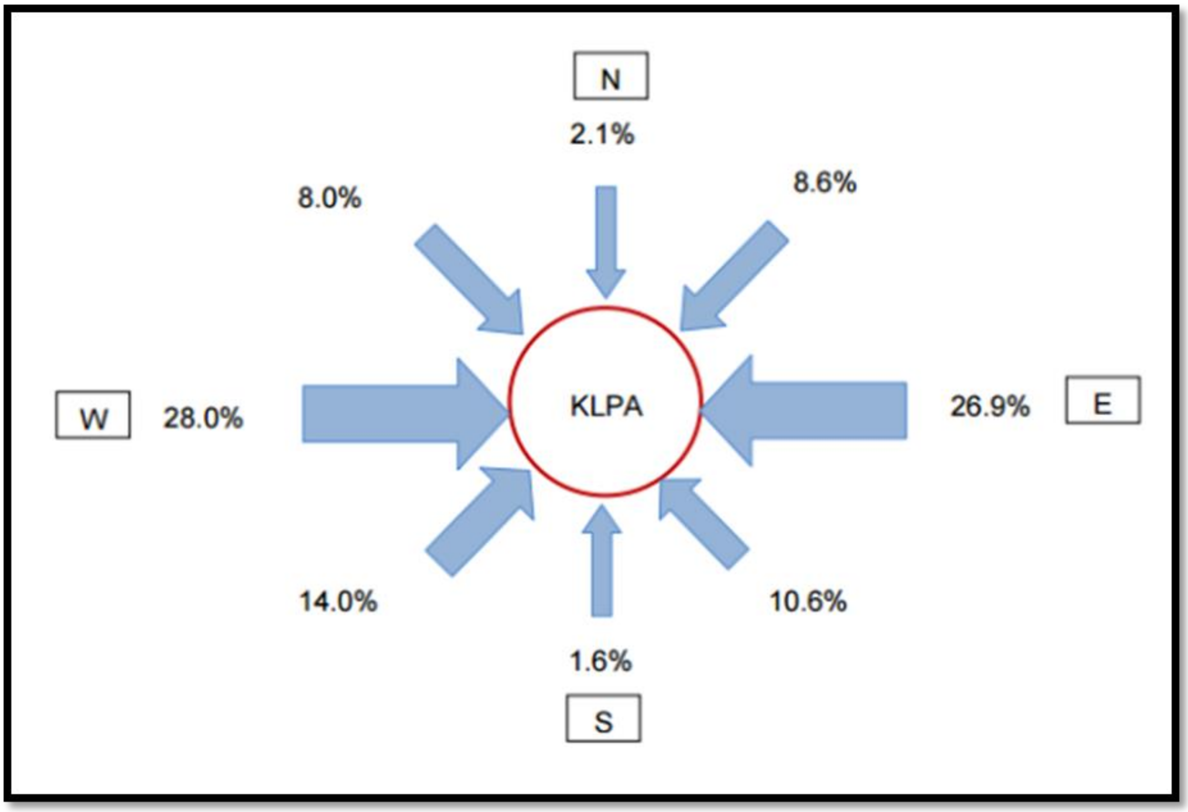
From the results of BWSSB, it suggests that the chemical analysis and biological examination conducted on the raw water sample of the Cauvery River were all within the Desirable Limits and Permissible limits. Hence it is understood that the water quality of the Cauvery River is considered as a good source of water for all activities.

By constructing a Balancing reservoir it directly results in providing solutions in many ways such as;

- Solves local water issues for all the surrounding communities throughout the year,
- Helps the fishing community as there will be an increase in the quantity of fishes,
- Attracts more tourists to this point,
- Becomes a permanent sources of drinking water to the animals living in the vicinity of this region..

17.4.8.2 Wind Directions

It is seen from the wind rose data collection from the Indian Meteorological Department (IMD) at Bangalore that the wind direction is mostly moving from east to west. In the morning i.e., 0830hrs, the wind is towards west during May to September and east during November to February. Whereas, in the evening i.e, 17:30 hrs, the wind blows towards west during June to September and in November to march. Hence, it can be taken that the wind generally blows towards west. The strongest winds (>19 kmph) are observed in the months from June to August.



17.4.8.3 Climate

The division enjoys a mild equable climate throughout the year. Deforestation and degradation of forest have contributed towards gradual warming. Polar basin experiences a very hot climate and the maximum temperature during summer goes beyond 40°C.

The year may broadly be classified into four seasons. The dry season is from January to February, followed by hot weather from March to May. The SW monsoon season is from June to September and the NE monsoon period from October to December.

17.4.8.4 Rainfall pattern and distribution

The amount of rainfall is being measured from rain gauge stations located in the district. A study of the rainfall data from 2001 t0 2010 from various rain gauge stations has shown that the amount of rainfall is relatively uniform throughout the district. The normal rainfall of the district is 854mm and varies from 822 mm at Kanakapura to 868 mm at Magadi. December to March represents very low rainfall months. The pre monsoon period has a normal of 345mm (35%), SW monsoon period has 363 mm (37%) and the NE monsoon period receive 263 mm (27%) rainfall. It is observed that there is not much variation in the distribution of rainfall during pre-monsoon, SW monsoon and NE monsoon periods. During the year 2011, the district received an average rainfall of 970mm. However it varies from a lowest 800 mm at Kanakpura to a highest 1130 mm at Magadi station.

17.4.8.5 Vegetation

Agricultural activity is mainly confined to the traditional kharif season depending on the monsoon rainfall and rabi cultivation is restricted to localized patches where irrigation facilities are available. During the year the major crops grown are Ragi, Mulbery, Paddy, Horsegram, Groundnut, Maize, Sugarcane and Fruits.

17.4.9 Biological Environment

Literature survey on the ecological characteristics of the study area was conducted, particularly with reference to listing of species & assessment of the existing baseline ecological conditions of the flora and fauna. Data has been collected through secondary sources viz., Government Departments, such as Social Forestry and Forest Office of Ramanagaram and Chamarajanagar districts, Government of Karnataka. On this basis, the checklist of flora and fauna was prepared.

17.4.9.1 Biotic Communities

Plankton: The density and composition of the plankton do not reflect any eutrophic tendencies. The modest plankton community (68 to 112 organism’s I-1) comprises phytoplankton to the extent of 48.85%. Characteristic feature of the phytoplankton is the domination of Chlorophyceae, followed by Cyanophyceae and diatoms (Table 2.9). Enrichment of the plankton community is influenced by the nutrients brought in by the rain washings (Devaraj et. al., 1987). Maximum plankton is during the post-monsoon period, extending from late August to February and a significant increase in phytoplankton are noticeable during April to August.

Littoral and Bottom Biota: Nutrient status of the soil is high, compared to the water and this is amply reflected in a rich community of littoral organisms comprising crustaceans, insects, mollusks, small fishes, tadpoles and oligochaetes, at a density ranging from 64 to 966 organisms m-2. Insects, the major component of this community, are represented by chironomid larvae, water bugs and the nymphs of dragonfly and damselfly. Viviparous and Gyraulus are the common genera of gastropods found among the littoral community, while the bivalves encountered are Corbicula and Unio. Insects, molluscs and worms constitute the benthic invertebrate community in that order of abundance, their density varying between 2 042 and 4 174 organisms m-2. The riverine zone has a high population density of benthic organisms than the rest of the reservoir.

Macro Vegetation: The aquatic macrophytes of the reservoir comprise mainly submerged and rooted vegetation belonging to seven species viz., Ceratophyllum demersum, Charaspp, Cyperus corymbosus, Hydrilla verticillata, Nymphaea odorata, Potamogeton nodosus and Utricularia vulgaris.

Table 17.3: Composition of various groups of phytoplankton in Cauvery Catchment

ORGANISMS/GROUPS	PERCENTAGE COMPOSITION			
	Deep Zone	Admixture zone	Intermediate zone	Riverine zone
Microcystis	23.20	18.44	10.16	19.16
Anabaena	0.51	1.43	-	0.83
Oscillatoria	7.52	9.72	8.31	7.50
Nostoc	4.41	8.20	7.31	7.40
Cyanophyceae	35.64	37.79	25.78	34.89
Diatoma	13.20	17.68	21.00	21.20
Asterionella	4.54	4.90	2.60	5.00
Bacillariophyceae	17.74	22.58	23.60	26.20
Spirogyra	12.44	7.61	7.64	11.48
Pediastrum	11.23	12.52	11.93	10.18
Zygnema	18.34	14.46	26.30	12.96
Ulothrix	3.95	4.99	4.70	4.25
Chlorophyceae	45.96	39.58	50.57	38.87

Source: Forest Office of Ramanagar district, Government of Karnataka

17.4.9.2 Fisheries

Fish fauna of Cauvery comprising of species shown in the list below includes a number of native fishes deserving attention from conservation point of view.

Table 17.4: List of Fishes available in Cauvery basin

Fish Species in Cauvery Karnataka, India					
[No. of Species listed in Fishbase.org=88]					
Species	Family	Habitat	Length (cm)	Trophic level	Status
Amblypharyngodon mola	Cyprinidae	benthopelagic	20 TL	3.0	native
Anguilla bengalensis bengalensis	Anguillidae	demersal	120 TL	3.2	native
Anguilla bicolor bicolor	Anguillidae	demersal	100 TL	3.6	native
Aristichthys nobilis	Cyprinidae	benthopelagic	112 TL	2.3	native
Balitora mysorensis	Balitoridae	demersal	7 TL	2.8	native
Barbodes bovanicus	Cyprinidae	benthopelagic	12 TL	3.0	native
Barbodes carnaticus	Cyprinidae	benthopelagic	12 TL	3.0	native
Barbodes sarana	Cyprinidae	benthopelagic	42 TL	3.4	native

Fish Species in Cauvery Karnataka, India					
[No. of Species listed in Fishbase.org=88]					
Species	Family	Habitat	Length (cm)	Trophic level	Status
Barbodes wynaadensis	Cyprinidae	benthopelagic	25 TL	3.0	native
Barilius gatensis	Cyprinidae	benthopelagic	15 TL	3.0	native
Catla catla	Cyprinidae	benthopelagic	180 TL	2.8	native
Chanos chanos	Chanidae	benthopelagic	220 TL	2.0	native
Cirrhinus cirrhosus	Cyprinidae	benthopelagic	122 TL	2.4	native
Cirrhinus fulungee	Cyprinidae	benthopelagic	37 TL	2.8	native
tenopharyngodon idellus	Cyprinidae	demersal	150 TL	2.0	introduced
Cyprinus carpio carpio	Cyprinidae	benthopelagic	147 TL	3.0	introduced
Danio aequipinnatus	Cyprinidae	pelagic	15 TL	3.2	native
Danio rerio	Cyprinidae	benthopelagic	6 TL	3.2	native
Esomus danricus	Cyprinidae	benthopelagic	13 TL	3.0	native
Etroplus suratensis	Cichlidae	benthopelagic	40 TL	2.0	native
Gagata itchkeea	Sisoridae	benthopelagic	8 TL	3.0	questionable
Garra gotyla stenorhynchus	Cyprinidae	benthopelagic	15 TL	2.7	native
Garra mcclellandi	Cyprinidae	benthopelagic	18 TL	2.6	native
Garra mullya	Cyprinidae	benthopelagic	17 TL	2.6	endemic
Glyptothorax annandalei	Sisoridae	benthopelagic	15 TL	3.1	native
Glyptothorax madraspatanum	Sisoridae	benthopelagic	15 TL	3.1	native
Hemibagrus punctatus	Bagridae	demersal	45 TL	3.1	native
Hypophthalmichthys molitrix	Cyprinidae	benthopelagic	105 TL	2.0	introduced
Hypselobarbus curmuca	Cyprinidae	benthopelagic	120 TL	2.6	native
Hypselobarbus dobsoni	Cyprinidae	benthopelagic	0 TL		native
Hypselobarbus dubius	Cyprinidae	benthopelagic	25 TL	2.9	native
Hypselobarbus kolus	Cyprinidae	benthopelagic	30 TL	3.0	native
Hypselobarbus micropogon	Cyprinidae	benthopelagic	90 TL	3.1	endemic
Labeo ariza	Cyprinidae	benthopelagic	37 TL	2.5	native
Labeo bata	Cyprinidae	benthopelagic	61 TL	2.7	native
Labeo boggut	Cyprinidae	benthopelagic	20 TL	3.0	native
Labeo calbasu	Cyprinidae	demersal	90 TL	2.0	native
Labeo fimbriatus	Cyprinidae	benthopelagic	91 TL	2.5	native
Labeo kontius	Cyprinidae	benthopelagic	61 TL	2.7	native
Labeo pangusia	Cyprinidae	benthopelagic	60 TL	2.7	native
Labeo porcellus	Cyprinidae	benthopelagic	35 TL	2.8	native
Labeo potail	Cyprinidae	benthopelagic	30 TL	2.7	native
Labeo rohita	Cyprinidae	benthopelagic	200 TL	2.0	native
Lepidocephalus thermalis	Cobitidae	demersal	8 TL	2.0	native
Longischistura bhimachari	Balitoridae	demersal	7 TL	2.9	endemic
Megalops cyprinoides	Megalopidae	pelagic	150 TL	3.3	native
Mesonoemacheilus guentheri	Balitoridae	demersal	7 TL	2.9	native
Mesonoemacheilus pulchellus	Balitoridae	demersal	6 TL	2.9	endemic
Mystus cavasius	Bagridae	demersal	49 TL	3.7	native
Mystus malabaricus	Bagridae	demersal	15 TL	3.3	native
Mystus vittatus	Bagridae	demersal	26 TL	4.0	native

Fish Species in Cauvery Karnataka, India					
[No. of Species listed in Fishbase.org=88]					
Species	Family	Habitat	Length (cm)	Trophic level	Status
Nemacheilus kodaguensis	Balitoridae	benthopelagic	5 TL	2.7	native
Notopterus notopterus	Notopteridae	demersal	74 TL	3.5	native
Ompok bimaculatus	Siluridae	demersal	55 TL	3.9	native
Osteochilichthys brevidorsalis	Cyprinidae	benthopelagic	15 TL	2.0	native
Osteochilus thomassi	Cyprinidae	benthopelagic	32 TL	2.5	native
Pterocryptis wynaadensis	Siluridae	demersal	30 TL	3.2	native
Puntius arulius	Cyprinidae	benthopelagic	12 TL	3.0	native
Puntius cauveriensis	Cyprinidae	benthopelagic	8 TL	2.9	native
Puntius chola	Cyprinidae	benthopelagic	15 TL	3.0	native
Puntius conchonius	Cyprinidae	benthopelagic	14 TL	2.9	native
Puntius dorsalis	Cyprinidae	benthopelagic	25 TL	2.0	native
Puntius fasciatus	Cyprinidae	benthopelagic	15 TL	3.0	native
Puntius filamentosus	Cyprinidae	benthopelagic	12 TL	2.6	native
Puntius melanostigma	Cyprinidae	benthopelagic	10 TL	2.9	native
Puntius narayani	Cyprinidae	benthopelagic	6 TL	2.9	native
Puntius parrah	Cyprinidae	benthopelagic	15 TL	3.0	endemic
Puntius sophore	Cyprinidae	benthopelagic	13 TL	3.0	native
Puntius ticto	Cyprinidae	benthopelagic	10 TL	2.5	native
Puntius vittatus	Cyprinidae	benthopelagic	5 TL	2.0	native
Rasbora caverii	Cyprinidae	benthopelagic	10 TL	3.1	native
Rasbora daniconius	Cyprinidae	benthopelagic	15 TL	3.4	native
Salmostoma acinaces	Cyprinidae	benthopelagic	15 TL	3.0	native
Salmostoma balookee	Cyprinidae	benthopelagic	15 TL	3.0	native
Salmostoma belachi	Cyprinidae	benthopelagic	0 TL		endemic
Salmostoma horai	Cyprinidae	benthopelagic	10 TL	3.0	native
Salmostoma novacula	Cyprinidae	benthopelagic	13 TL	3.0	native
Salmostoma phulo	Cyprinidae	benthopelagic	12 TL	3.0	native
Salmostoma untrahi	Cyprinidae	benthopelagic	20 TL	2.9	native
Schistura semiarmata	Balitoridae	benthopelagic	7 TL	2.6	native
Silonia childreni	Schilbeidae	demersal	48 TL	4.5	native
Sinilabeo dero	Cyprinidae	benthopelagic	75 TL	3.0	native
Sperata aor	Bagridae	demersal	180 TL	3.8	native
Sperata seenghala	Bagridae	demersal	150 TL	3.4	native
Tenualosa ilisha	Clupeidae	pelagic	74 TL	2.0	native
Tor khudree	Cyprinidae	benthopelagic	50 TL	3.1	native
Tor mussullah	Cyprinidae	benthopelagic	150 TL	3.0	native
Wallago attu	Siluridae	demersal	240 TL	4.5	native

Most of the fishermen are the local farmers and farm laborers who take up fishing as a vocation and / or additional income. This can be related to the fact that fishing does not yield good income to the fishermen. In fact, the average catch per individual fishermen on a normal day is 2 to 6 kg, which fetches them Rs. 150

to Rs. 250 per day, though during the peak fishing season the daily earnings can go up to Rs. 500 subjected to the number of visitors (Field Studies).

From the Field visit and the collected data, it is clearly understood that the fishing activity is generally concentrated in the fishing camps located upstream (Sangama) of the project site. Moreover, the income realized from the fishing activity is also not attractive to the fishing communities. By implementing this project the fishing camps are going to be benefited a lot by increasing their fishing practices, which will impact their living standard in a positive manner.

17.4.9.3 Flora

During the field visit, the commonly observed trees were hongay Tree, Mathi Tree, Nerale Tree etc. shrubs like Kavali, Torni etc. are found in the study area. Due to various factors like rainfall, edaphic, biotic and management practices, the forests of Bangalore Rural and Ramanagar districts (Data provided by the Forest Department, Government of Karnataka) can be classified under various categories. It is however, sufficient to broadly classify these forests into the following main categories;

- Dry deciduous type
- Sandal bearing scrub sub-type
- Thorny scrub type
- Riverine sub-type

1. **Dry deciduous type:** The average height of these forest is 10 m. Most of the trees shed foliage in dry season for several months. This type of forest is represented in parts of Sathanur and Kanakapura Ranges and in some pockets of Bangalore Urban District as at Kaggalipura, Basavanthara and Sulekere. The main species in this group are Tectona grandis, Dalbergia latifolia, Terminalia paniculata and Dalbergia paniculata.

2. **Bambusa bambos sub-type**: Apart from sporadic occurrence of this bamboo in some protected niches and along streams, this sub-type occurs in Sathanur Range at Basavanabetta Reserve Forest in association with Terminalias, Anogeissus species and other deciduous forests.

3. **Sandal bearing scrub sub-type**: Sandal occurs in profusion in relatively drier areas associated with species like Tamarind, Neem, Memecylon, Canthium, Albizzia, Wrightia, Diospyros montana, Acacia, Feronia, Pongamia, Strychnos potatorum, Cassia, Phyllanthus, Lantana, Dendrocalamus, etc.

4. **Dendrocalamus strictus sub-type:** This type of forest occurs in varying intensity in elevations between

17.4.9.4 Fauna

The list of species found in the study area is given in the Table below

Wild animals – As per the data collected, lot of elephants and few other wild animals come to the river for drinking water purpose. By constructing a balancing reservoir, we can ensure that sufficient water is available throughout the year.

Reptiles –Harmless and harmful snakes are found in the study area. Both species and individuals are numerous, and barren and rocky hills, little frequented by man, give innumerable hiding places which favour their existence. Some best known species found here are, Cobra, Rat snake, Russell's viper, etc.

Birds – In the study area, species of birds are observed. Many loving birds are found in this region shown in the list below.

Butterflies and insects – Varieties of butterflies and insects found here are commonly observed species in agricultural lands and forest areas. No endangered and rare butterfly or insect is present in the region.

Amphibians – Amphibians are found in fresh water and marshy places. Frogs, toads are common.Details of the cattle's and live stocks of Channarayapatna Taluk is depicted in the table below:

Acrocephalus aedon (Thickbilled Warbler)	*Esacus magnirostris* (Great Stone Plover)	*Nycticorax nycticorax* (Night Heron)
Acrocephalus agricola (Paddyfield Warbler)	*Egretta intermedia* (Smaller Egret)	*Pandion haliatus* (Osprey)
Acrocephalus dumetorum	*Flaco tinnunculus* (Kestrel)	*Pelargopsis carpensis*
Alcedo atthis (Small Blue Kingfisher)	*Fulica atra* (Coot)	*Pelecanus philippensis* (Grey Pelican)
Amaurornis akool (Brown Crake)	*Galicrex cinerea* (Kora Watercock)	*Phalacrocorax carbo* (Large Comorant)
Amaurornis phoenicurus)	*Gallinago gallinago* (Fantail Snipe)	*Phalacrocorax fuscicollis* (Indian Shag)
Anas acuta (Pintail)	*Gallinago media* (Great Snipe)	*Phalacrocorax niger* (Little Comorant)
Anus clypeata (Shoveller)	*Gallinago minima* (Jack Snipe)	*Phalaropus lobatus* (Rodnecked Phalarope)
Anas crecca (Common teal)	*Gallinago nemoricola* (Wood Snipe)	*Philomachua pugnax* (Ruf and Reve)
Anas Penelope (Wigeon)	*Gallinago stenura* (Pintail Snipe)	*Phoenicopterus minor* (Lesser Flamingo)
Anas poecilorhyncha (Spotbill duck)	*Gallinula Chloropus* (Moorhen)	*Phoenicopterus roseus*
Anas querquedula (Garganey)	*Glareola lacteal* (Small Indian Pranticole)	*Platalea eucorodia* (Spoonbill)
Anas strepera (Gadwall)	*Halcyon pilleata* (Blackcapped Kingfisher)	*Plegadia falcinellus* (Glossy Ibis)
Anastomus oscitans (Openbill stork)	*Halcyon smirnensis*	*Ploceus manyar* (Streaked Weaver Bird)
Anhinga rufa (Darter)	*Haliastur Indus* (Brahminy Kite)	*Ploceus philippinus* (Baya Weaver Bird)
Anser indicus (Barheaded Goose)	*Himantopus himantopus* (Black-Winged Stilt)	*Pluvialis dominica* (Easter Golden Plover)
Ardea alba (Large Egret)	*Hirundo daurica* (Striated Swallow)	*Pluvialis squataola* (Grey Plover)
Ardea cinerea (Grey Heron)	*Hirundo Rustica* (Barn/Common Swallow)	*Podiceps ruficollis* (Little Grebe)
Ardea purpurea (Purple Heron)	*Hirundo Smithii* (Wiretailed Swallow)	*Porphyrio porphyrio* (Purple Moorhen)
Ardeola grayii (Pond Heron)	*Larus ridibundus* (Blackheaded gull)	*Porzana fusca* (Ruddy Crake)
Ardeola striatus (Little Green Heron)	*Limosa limosa* (Blacktailed Godwit)	*Porzana pusila* (Baillon's crake)
Aythya ferina (Common Pochard)	*Lonchura malabarica* (White-throated Munia)	*Pseudibis papillosa* (Black ibis)
Aythya fuligla (White-eyed Pochard)	*Lonchura Malacca* (Blacheaded Munia)	*Rallus striatus* (Blue Breasted Blended Rail)
Botaurus stellaris (Bittern)	*Lonchura striata* (White backed munia)	*Recurvirostra avocetta* (Avocet)
Bubo zeylonensis (Brown Fish Owl)	*Merops leschenaultia*	*Rostratula bhengalensis* (Painted Snipe)
Bubulcus ibis (Cattle Egret)	*Merops crientalis* (Small Green Bee Eater)	*Sarkidiornis melanotus* (Comb duck)
Calidris minuta (Little Stint)	*Merops philippinus* (Blue tailed bee eater)	*Scolopax rusticola* (Woodcock)
Calidris teminckii (Teminck's Stint)	*Metopidius indicus* (Bronze winged Jacana)	*Sterna acuticauda* (Blackbellied Tern)
Calidris testacea (Curlew Sandpiper)	*Milvus migrans govinda* (Pariah kite)	*Sterna aurantia* (Indian River Tern)
Caryle rudis (Lesser Pied Kingfisher)	*Motacilla alba* (White wagtail)	*Tadorna ferruginea* (Brahminy Duck)
Charadrius alexandrinus (Kentish Plover)	*Motaciila cinerea* (Greay Wagtail)	*Threskiornis aethiopica* (White Ibis)
Charadrius dubius (Little Ringed Plover)	*Motacilla flava bheema* (Blue Headed Yellow Wagtail)	*Tringa erythropus* (Spotted Red Shank)
Ciconia ciconia (White Stork)	*Motacilla flava melnogrisea* (Black-headed Yellow Wagtail)	*Tringa glareola* (Wood Sandpiper)
Ciconia episcopus (White necked stork)	*Motacilla flava thunbergi* (Grey Headed Yellow Wagtail)	*Tringa hypoleucos* (Common sandpiper)
Circus aeruginosus (Marsh Harrier)	*Motacilla maderaspantensis*	*Tringa nebularia* (Green shank)
Circus melanoleucos (Pied Harrier)	*Mycteria leucocephala* (Painted Stork)	*Tringa ochropus* (Green Sandpiper)
Circus pygargus (Montague's Harrier)	*Nettapus coromandelianaus*	*Tringa stegnatilis* (Marsh Sandpiper)
Cisticola juncidis (Streaked Fantail Warbler)	*Numenius arquata* (Curlew)	*Tringa terek* (Terek Sandpiper)
Dendrocygna javanica		*Tringa totonus* (Common Redshank)
Egretta garzetta (Little Egret)		*Vanellus cinereus* (Greyheaded apwing)
Egretta gularis (Indian Reef Heron)		*Vanellus indicus* (Red wattled Lapwing)
		Vanellus malabaricus (Yellow Wattled Lapwing)

17.4.10 Socio-economic Environment

The Concept of water and development has been changing in the recent decade. Water for life, energy, agricultural, industrial and domestic sectors should be wisely managed between upstream and downstream sides of the water source. These water managements will mitigate the socio-economic impacts in the local regions. The notion of economic impact refers to the effects, on the local and regional economies, of project construction and subsequent operating activities. These include: direct and secondary demands for labor and services, as well as effects on local resources and thus on the very structure of the local economy. Such economic effects also cause significant social impacts which impinge on economic parameters. Also various impacts stem directly from the project activities and these also have economic implications. Overall, socio-economic impacts endanger a complex dynamic stage which is not easy to predict accurately.

Socioeconomic factors are of greater interest in the recent years in EIA as they represent specific aspects of human environment and the changes represent the most critical alterations associated with project implementation.

Further, a detailed study will be conducted which will provide us to understand how the potential changes could increase /decrease in population, disruption of settlement patterns, change in land use, disruption in religious pattern, attitudes and life styles, changes in transportation systems, relocations of highways and rail roads. Detailed studies will be provided on the Infrastructure and cultural sites located within 10 km radius of the project site as a part of detailed study before implementation of the project.

17.4.10.1 Demographic Profile (population)

The total population in the district is 10,82,636 (as per 2011 census). The schedule caste population constitutes 3,23,636 lakhs and the schedule tribe population constitutes 54,333. The sex ratio in the district is 955 females for every 1000 males. And the density of population is 323 per sq.km. The main occupation of the people in the district is cultivation and most of them are agricultural laborers. The literacy rate is 61.9% in rural parts of which male literacy rate is 72.4% and female literacy rate is 51.1%. And in urban parts of the district the literacy rate is 76.2 % of which male literacy rate is 81.9% and female literacy rate is 70.10%.

The drainage area of the river Cauvery in the three States including the Union Territory of Puducherry are as under: in km^2; Karnataka 34,273, Kerala 2,866 , Tamil Nadu (including Puducherry) 4,4016 and the Total area is 81,155. The Cauvery Water Disputes Tribunal has divided the Cauvery basin upto the Lower Coleroon Anicut into 16 sub-basins.

17.4.10.2 Details of Taluk

Kannada is the Local Language in Ramanagara District which is divided into 4 Taluks and 1847 Villages.

17.4.10.3 Cultural Sites

(a) Places of worship: Major cultural locations such as Temples, Ashrams and guest houses are located at a range of 2 kilometer radius of the project. Some of the main locations are

- Sri Ganapathi Sachidananda Ashrama
- Madiwala Shivanakareshwara Anandadhama Retreat
- Om Shantidhama
- KTDC Guest house

(b) Archeological sites/monuments: Sangama is the confluence of two rivers – Arkavathi and Cauvery

(c) Anthropological sites: Nil

Before the project gets implemented, physical survey of the area under submergence will be carried out in order to identify such sites and also to plan effective relocation and rehabilitation

17.5 Environmental Impact and Mitigation Measures

17.5.1.1 Details of Investigated Environmental Impacts and Mitigation Measures

Based on the project details and the baseline environmental status, potential impacts due to the construction and operation of the proposed Balancing reservoir at Mekedatu have been identified. This chapter presents the potential impacts (both positive and negative impacts), likely to occur as a result of the implementation of the project. Wherever possible, impacts have been quantified and otherwise, qualitative assessment has been considered.

The impacts have been covered as per categories below;

- Water Environment
- Climate and Weather Environment
- Land Environment
- Ecological Environment

17.5.1.2 Water Environment

The various aspects covered under water environment are:

- Water resources
- Water quality

17.5.1.3 Water Resources

The selected site for the constructing a balancing reservoir along with a hydroelectric power project is located at Mekedatu, downstream of the confluence (Sangama) of the Cauvery River and Arkavathy. The project envisaged is a balancing reservoir project to regulate the flow downstream as per the Award. As such, there is no adverse impact on the quantity of water available for the surface water supply schemes for surrounding community and Towns.

17.5.1.4 Water Quality

a) Construction phase

The major sources of surface water pollution during project construction phase are as follows;

- Sewage from labour camps/colonies.
- Effluent from construction areas
- Dumping and disposal of excavation materials

17.5.1.5 Sewage from labour camps

The project construction is likely to last for at least a period of 48 months from the day of commencement. The peak labour strength likely to be employed during project construction phase is approximately 250 workers and 50 technical staff (including the families accompanying about 400 people). The total Bio-chemical oxygen load from the labour population is calculated to about 15 - 18 kg/day. In general, for a small labour population like this, there is no adverse effect on the environment.

Mitigation measures: Adequate toilet facilities should be provided at the construction site and septic tank should be constructed to provide on-site wastewater treatment. Additionally, periodic water quality monitoring is to be conducted during the construction phase to have a constant vigilance of water quality.

- **Effluent from construction areas**

The water consumption from the construction activities as well as the washing effluents of trucks and other machinery is very minimal. The Effluent quantity is negligible to cause any adverse impact on the environment.

Mitigation Measure: Adequate care should be taken so that excess suspended solids in the wastewater are removed before discharge into water body.

- **Dumping and disposal of excavation materials**

During construction of the project activity, construction waste will be generated in the form of excavated materials. Environment-friendly disposal practices should be adopted to avoid adverse impact of the land and water near the disposal sites.

Mitigation Measure: It is proposed to dispose of the remaining excavated material in an environmental friendly manner at identified locations with proper stabilization of the dumped materials. Additionally, a green-belt should be developed around the disposal site to prevent any erosion of soil and silting of river.

b) Operation phase

The major sources of water pollution during project operation phase are the effluent from project offices.

- **Effluent from project offices**

In the operational phase, about 8-10 O&M staff will reside in the area with well-designed septic tanks and other infrastructure facilities, the problems of water pollution due to disposal of sewage are not anticipated throughout the project

Mitigation Measure: Adequate toilet facilities should be provided at the site and septic tank should be constructed to provide on-site wastewater treatment.

Table 17.5: Summary of water quality during both construction and operation phase.

Sl.No	Parameters	Effects of the project	Mitigation Measure
Construction Phase	Sewage from labour camps/colonies.	For a small labour group of 350-400 people, there is no adverse effect on the environment.	Timely water quality monitoring plans.
	Effluent from construction areas.	Negligible Water quantity is consumed, which can not cause any adverse impact on the environment.	Excess suspended solids in the wastewater are removed before discharge into water body.
	Dumping and disposal	Excavated hard rock would	Proposed to dispose of the

Sl.No	Parameters	Effects of the project	Mitigation Measure
	of excavation materials.	be utilized in constructing random rubble machinery structure	remaining excavated material in an environmental friendly manner.
Operational Phase	Effluent from project offices.	Water pollution from disposal of sewage are not anticipated throughout the project due to well-designed septic tanks	Adequate Care in operation and maintenance of septic tank.

17.6 Air and noise environment

The various impacts covered under the above category are:

- Ambient air quality
- Noise

17.6.1.1 Ambient air quality

In this project activity, air pollution occurs mainly during project construction phase. The major sources of air pollution during construction phase are:

Dust due to loading and unloading of construction materials

- Pollution due to fuel combustion in various construction equipment's.
- Impacts due to vehicular movement.

17.6.1.2 Pollution due to fuel combustion in various equipment

Normally, diesel is used in operation of various construction equipment's. The major pollutant which gets emitted as a result of diesel combustion is SO_2. The SPM emissions are minimal due to low ash content. Based on past experience in similar projects, the increase in SPM and SO_2 is not expected to increase significantly due to fuel combustion in various construction plant and machinery. As such, no significant impact on ambient air quality is expected as a result of operation of various construction equipment's.

Mitigation Measures: Optimal usage of diesel and other combustible fuels are advised, such practices are needed to be enforced.

17.6.1.3 Impacts due to vehicular movement

During construction phase, there will be increased vehicular movement for transportation of various construction materials to the project site. Large quantity of dust is likely to be entrained due to the movement of trucks and other heavy vehicles. However, such ground level emissions do not travel for long distances. Thus, no major adverse impacts are anticipated on this account.

Mitigation Measure: Spraying of water daily on the path way to reduce any kind of dust during the vehicular moment.

Table 17.6: Effects of Air Pollutants on Plants and Animals

No.	Pollutants	Principal Anthropogenic Sources	Contribution from the proposed project	Mitigation Measures
1	Carbon Dioxide	Fuel combustion for heating, transport, energy production	Vehicular moment and operating machineries during the construction	Proper maintenance of vehicles and operating machineries, helps in
2	Carbon Monoxide	Incomplete fuel combustion (as in motorvehicles)	From the vehicles and DG utilized in the construction phase.	Operating vehicles and machineries show have emission test certificate.
3	Sulphur Dioxide	Burning of sulphur containing fuels like fuel oil	Fuel consumed by the operational machineries	Good quality fuel should be utilized
4	Suspended particulate matter	Smoke from domestic, industrial and vehicular sources	Vehicular moment and operating machineries during the construction phase	Proper maintenance of vehicles and operating machineries, helps in reducing excuses emission

17.6.1.4 Impacts on noise environment

In the project activity, the impacts on ambient noise levels are expected only during the project construction phase, due to earth moving machinery, etc. Likewise, noise due to quarrying, blasting, vehicular movement will have some adverse impact on the ambient noise levels in the area. The noise level varies linearly with distance.

17.6.1.5 Impacts due to operation of construction equipment

The noise level due to operation of various construction equipments are given in 17.7

Table 17.7: Noise level due to operation of various construction equipment

Equipment	Noise level (dB(A))
Compressors	75-85
DG Sets	72-82
Concrete placers	70-80
Batching plant	75-85
Crushers	68-70
Concrete Pumps	68-70
Tippers	60-65

Equipment	Noise level (dB(A))
Boomers	65-75
Excavator	70-80
Mixers	65-75
Shovel	75-85
Loader	70-80
Dozer	70-80
Tunnel Loading Machine	75-85

Based on the noise modeling results and considering of attenuation due to various factors, no significant increase in ambient noise level was anticipated, beyond a distance of 200 to 300m from the construction sites.

Mitigation Measure Blasting shall be performed using approved procedures such that the noise levels are within the permissible limits for that period and all safety precautions shall be taken by the implementing agency.

17.6.1.6 Impacts due to increased vehicular movement

During construction phase, there will be significant increase in vehicular movement for transportation of construction material. The project site is situated in the vicinity of existing state and district roads and presently the vehicular movement on these roads is of the order of 1-5 trucks/hour. During construction phase, the increase in vehicular movement is expected to increase up to a maximum of 15 to 20 trucks/hour. However, significant increase in ambient noise level is not anticipated as a result of increased vehicular movement, during project construction phase as majority of the movement are expected to take place during day-time when the ambient noise levels are generally at a higher level.

Mitigation Measure: Optimal utilization of vehicles should be insisted.

17.6.1.7 Noise Impacts on labour

The effect of high noise levels on the operating personnel has to be considered as this may be particularly harmful. It is known that continuous exposures to high noise levels above 90 dB (A) affects the hearing acuity of the workers/operators and hence, should be avoided. To prevent these effects, it has been recommended by Occupational Safety and Health Administration (OSHA) that the exposure period of affected persons be limited as in Table-17.8

Table 17.8:Maximum Exposure Periods specified by OSHA

Maximum equivalent continuous Noise level dB(A)	Unprotected exposure period per day for 8 hrs/day and 5 days/week
90	8
95	4
100	2
105	1
110	½
115	¼
120	No exposure permitted at or above this level

Mitigation Measures: During blasting at the construction sites, there is possibility of noise levels going beyond the permissible limits for a very limited period. However, ear plugs may be provided to the construction workers near the vicinity of the blasting site.

17.6.1.8 Noise Impacts on wildlife

The noise generated due to blasting, construction activities, vehicular movements, DG sets, operation of construction plant and machinery, etc will affect the wildlife activities.

Mitigation measures: Construction activities will be carried out during day time. Proper signage boards will be installed to reduce speed limits.

17.6.1.9 Impacts on land environment

The major impacts anticipated on land environment are due to following:

- Storage of construction materials and parking space for construction plant and machinery
- Acquisition of land
- Storage of construction materials and parking space for construction plant and machinery

During construction phase, various types of equipment will be brought to the site. These include crushers, batching plant, drillers, earth movers, rock bolters, etc. The siting of these construction plant and machinery would require significant amount of space. Similarly, space will be required for storing of various other construction plant and machinery. In addition, land will also be temporarily acquired, i.e. for the duration of project construction for storage of quarried material before crushing, crushed material, cement, rubble, etc.

Mitigation Measures: During the project, efforts shall be made for proper storing of construction materials and equipment such that the impact on the nearby residents is minimized. Hence, impacts on this account are not expected to be significant.

17.6.1.10 Terrestrial Ecology

17.6.1.11 Increased human interferences

The direct impact of construction of the project activity is generally limited in the vicinity of the construction site only. As mentioned earlier, labour population including technical staff, workers and other group of people are likely to congregate in the area during the project construction phase. It can be assumed that the technical staff will be of higher economic status and will live in a more urbanized habitat, and will not use wood as fuel, if adequate alternate sources of fuel are provided. However, workers and other population groups residing in the area may use fuel wood (if no alternate fuel is provided) which may lead to felling of nearby trees.

Mitigation Measures: To minimize impacts, community kitchens have been recommended. These community kitchens shall use LPG or diesel as fuel.

- **Disturbance to wild life**

Since the project components falls within the protected area, construction activities, human activities, disposal of wastes, hunting,etc will cause disturbance to wildlife. The project area is also a considered as a major elephant corridor. Therefore, construction and human activities will affect the movement of elephants and other wildlife.

Mitigation measures: Construction activities will be carried out under the supervision of Forest officers. Awareness to the labourers with respect to importance of scheduled species and RET species will be provided to avoid hunting of animals. Construction activities will be restricted only to day time to avoid disturbances to wildlife activities. Proper mitigation measures such as segregation of wastes and disposal of wastes to municipal authorities, storage of muck properly in designated areas, hanging solar fences etc will be implemented.

17.7 Aquatic Ecology

a) Construction Phase

The construction of the proposed balancing reservoir along with hydropower plant would involve extraction of different types of construction material from the river bed including boulders, stones, gravel, sand, etc. Extraction of gravel and sand causes considerable damage to fish stocks and other aquatic life by destabilizing the sub- stratum, increasing the turbidity of water, silting of the channel bottom and modifying the flow which in turn may result in erosion of the river channel. These alterations upset the composition and eco-balance of aquatic organisms.

During construction of a hydropower project, huge quantity of debris is generated at various construction sites. For debris, a separate area for dumping of the material is not marked, invariably would flow down the river during heavy precipitation. Such a condition adversely affects the development of aquatic life.

The Project Owner is expected to procure the construction material from authorized suppliers. Hence, the impacts from the extraction of construction material are outside the scope of the Project Owner. However, the impacts from disposal of construction debris can be controlled by the Project Owner.

Mitigation Measures: Hence, the construction debris should be disposed in an environmentally-friendly manner at suitable earmarked locations.

Impacts due to increased human activities

The increase of human activities in the project area, results in enhancement in indiscriminate fishing, which can adversely affect the riverine ecology. However fishing is carried out in the fishing ponds located upstream of the project site. And, significant fish stocks are not available in the vicinity of the project site. Hence the impact from indiscriminate fishing is not significant.

b) Operation phase

The completion of the Balancing Reservoir at Mekedatu would not pose any major significant changes in the riverine ecology, due to the already existing Hydro-electric power plants in both upstream (Shivanasamudra Hydropower plant) and downstream (Mettur) of the project site.

Migitation Measure : Majority of the Fishing and aquatic related problems are well taken care of at other projects executed in the upstream of the proposed project site. However, the proposed approach channel design provided in the DPR will reduce the adverse impact on the fish species present in the river. Introducion of fingerlings into the reservoir will result in proliferation of fish species and Deccan Mahasheer which is a flagship species found in the River Cauvery within Cauvery WLS

17.8 Environmental Management Plan

The impacts on the environment from the construction and operation of the Balancing reservoir along with the proposed hydropower plant project activity has been explained in the previous chapters.

Environmental Management Plan

This chapter documents the mitigation measures for the identified adverse impacts for both construction and operation phases of the proposed project activity in the form of an Environmental Management Plan

(EMP). The measures to be adopted for both construction and operation phases to mitigate the adverse impact on the various environmental media are summarized in **Table 17.9** below;

Table 17.9: Summary Of Mitigation Measures For Both

CONSTRUCTION PHASE	OPERATION PHASE
WATER RESOURCES:	
Adequate toilet facilities should be provided at the construction site and septic tank should be constructed to provide on-site wastewater treatment. During the Construction period, it can be recommended to monitor the river-water quality downstream of the project site every month as per the monitoring programme described in Section "WATER QUALITY MONITORING PROGRAMME" in this chapter.	Adequate toilet facilities should be provided at the Project Office and Pump House along with a septic tank to account for on-site wastewater treatment. Adequate care in operation and maintenance of septic tank is required. During operation phase, river-water samples can be collected (as per Section "WATER QUALITY MONITORING PROGRAMME" in this chapter) downstream of the project site once a year and monitored for three years. Based on the water quality results of three years, further sampling programme can be decided upon.
SURFACE WATER QUALITY	
Since industries are not located on the upstream of the Cauvery river, there is no change in the water quality. During the construction period, surface water may get polluted for a few days due to generation of suspended particulate matter at the time of excavation of muck. Hence, surface water quality monitoring, near Mekedatu Water Supply Intake, should be carried out on a periodic basis, preferably once-a-month during the construction period. Water quality monitoring is carried out as per "WATER QUALITY MONITORING PROGRAMME" in this chapter.	During the operational period, the power generator will not discharge any effluents. Hence, there shall not be any impact on the surface water quality. However, considering that the communities in and around the project location and the intake wells if any which are located within 3kms downstream of the project site, the water quality need to monitored on a periodic basis. Water quality monitoring is carried out as per Section "WATER QUALITY MONITORING PROGRAMME" in this chapter.

CONSTRUCTION PHASE	OPERATION PHASE
GROUND WATER QUALITY	
Groundwater is not extracted for construction purposes. Further, the solid waste that is generated from the construction site is disposed in an environmentally-friendly manner in an off-site disposal site. Hence, ground-water quality is not affected by the construction of the project. However, groundwater quality near the construction debris site can be monitored every quarter during the construction period and every year thereafter for three years. The groundwater quality monitoring can be carried out as per **"**WATER QUALITY MONITORING PROGRAMME" in this chapter.	During the operation phase, no raw waste water will be discharged into any groundwater bodies. Solid waste is not generated (other than small quantity from the project office) and the generated solid waste will not be discharged to any ground water bodies. Hence, the groundwater quality will not be affected by project operations.
AIR QUALITY	
Water will be sprayed by high pressure water hoses during dust generating construction activities like excavation, crushing, demolishing, concrete mixing and material handling etc., to suppress dust. Any vehicle, not meeting the vehicular pollution standards will not be allowed within the construction site and for the construction activity. All vehicles and construction equipment will be maintained for effective fuel combustion to reduce carbon particles, CO and HC emissions. Controlled blasting will be done under expert guidance.	No measures are required as there is no impact.

CONSTRUCTION PHASE	OPERATION PHASE
NOISE:	
Construction equipment generating minimum noise and vibration will be diploid. Ear plugs and ear muffs will be provided to the construction workers working near the noise generating activities and machines. Blasting will be avoided to the extent possible. If needed, control blasting will be adopted. DG set will be kept in a sound proof chamber.	The equipment will be maintained regularly to ensure reduced noise levels. The source of continuous noise generating equipment such as turbines, compressors, pumps, etc., will be designed to have a noise level less than 40.0 dB(A). The best way to mitigate the noise, is to plan 4-line greenery in the form of native local trees with a good crown cover as a buffer to the surrounding areas.
IMPACT ON LAND ENVIRONMENT **Quarrying operation**	
The proposed scheme involves a powerhouse, tail-race channel. Required aggregates is available at the nearby area. It will not have any impact on soil erosion or the project.	This problem does not arise.
(b) Operation of construction equipments	
The proposed hydel scheme is very small. Generally, dozers, excavators, dumpers, tippers etc are required during the construction of land for sitting of construction equipment and materials, waste material etc.; Efforts are to be made to ensure minimum land to be acquired for such purposes.	
(c)Disposal of debris	
For the construction of a balancing reservoir along with hydroelectric project and related structures, lots of stones, excavated earth etc gets accumulated. These should be stacked away from the river course to prevent their	

CONSTRUCTION PHASE	OPERATION PHASE
entry to avoid obstructions, siltation etc. However, groundwater quality near the construction debris site can be monitored every quarter during the construction period and every year thereafter for three years.	This problem does not arise during the operational phase. This problem does not arise during the operational phase.
SOCIO-ECONOMIC-ENVIRONMENTAL IMPACT:	
(a.) Rehabilitation and Resettlement:	
In the course of project development, only minimum land will be utilized. As such, under this scheme, small scale rehabilitation of population or loss of property structures will arise.	These will be small impact during the operation phase, since the project area affect the communities around the Sangama tourist point along with some ashrams being located within proposed the area. First priority will be given to reanalyze the present design, as to how best it is possible to accommodate the existing setup and examine the feasibility of the project. Next best solution is to call for a Stake-holders meeting proposed between all the related Governing bodies and the public, along with the consultants and amicable agreement for further course of action needs to be held. Best options are to allot or grant alternate lands for the loss of property for a community developmental activity.

CONSTRUCTION PHASE	OPERATION PHASE
(b.)Socio-economic-cultural-aesthetic aspects of 10 kms radius:	
Local population within 10 kms radius of project site area will be employed for construction work to a certain extent.	After completion of the proposed scheme, local people may be employed if required to an extent possible. Employment and income generation and eco-development would be on an average level. It is considered that the proposed scheme will not have any adverse effect on the existing socio-economic status in the nearby areas. On the other hand the development of the proposed project would improve the standard of living of the local population.
HEALTH RISKS AND WATER BORNE DISEASES OF THE PROJECT SITE.	
During construction phase, skilled persons from the local community are expected to be hired for work on the project. Hence, possibility of workers relocating to a workers' colony is minimized to a great extent. And, the local community workers are expected to live in the existing residential areas in and around the project site with adequate sanitation facilities and provisions to reduce occupational hazards. Hence, the project is not to pose health risks to the area.	During the operation phase also, the focus is on employing locally available skilled persons for the positions. Hence, the project is not likely to pose any health risks in the area.

CONSTRUCTION PHASE	OPERATION PHASE
ECOLOGY:FLORA	
During the construction phase, a little impact may occur and it is unavoidable. The present survey does not reveal the presence of any rare, endangered or threatened, endemic plant species. During the construction period, surface water may get polluted for a few days and the nominal river bed plants may be impacted. To counter the impact, Green Belt Programme (as described in Section 4.4 of this Chapter) may be implemented in the form of green belt around the area.	The proposed scheme is to utilize water during the monsoon period. It will utilize this available water for power generation by establishing a powerhouse across the Cauvery river. Hence there is no impact in the operation phase. Greenery belt programme as described in Section 4.4 of this chapter may be implemented near the banks.
AQUATIC IMPACT:FISHES	
During the construction of the powerhouse and tail-race channel, the excavated material accumulates. Hence to prevent their entry into the river, these are to be stacked at a distance to avoid siltation and obstruction.	Approach channel /Surface bypass collector/diversion channel are required to be provided at intake points to prevent entry of fish along with water into the turbines. There would be no adverse impact on the fish life on account of the construction and operation of the Hydro Power structure with the implementation of the suggestions. During this phase monitoring and studies are required to be carried out for a specific period, at least once in 2 years to assess the changes and to remedy any impacts on the fish life.
TERRESTRIAL FAUNA:	
The proposed water spread area is free from wildlife.	There will be a positive impact on animals and birds from the proposed project due to the fact that abundant water will be available for animals and birds as a result of storage.

CONSTRUCTION PHASE	OPERATION PHASE
CATCHMENT AREA:	
Catchments area is on the village outskirts with nominal vegetation in and around the project site. There will be no adverse effect to the surrounding but suitable measure have to be take in managing the construction waste solid waste from the site.	There is no adverse impact on the catchment area during this period. Subsequently, it is suggested to have tree planting around the periphery of the power house and other project areas.
DOWNSTREAM ENVIRONS	
The proposed hydel scheme is a run of the river scheme which utilizes flow of the Cauvery river. After power generation, the water will be released back to the same river, without consumption. Hence it will not affect the water flow in the downstream environs.	After generation of Hydro Power, water will be released back to the river. Hence, no impact on downstream environs. However, considering the possibility of small tribal communities 3kms downstream of the project site, the water quality need to monitored on a periodic basis. Water quality monitoring is carried out as per "WATER QUALITY MONITORING PROGRAMME" in this chapter.

17.9 Water Quality Monitoring Programme

Three basic monitoring programs will be designed and implemented corresponding to the baseline description period (EIA), construction period, and operation period.

17.9.1 Baseline period

The primary purpose of the baseline monitoring program are two fold: First, the baseline monitoring program should provide sufficient information to enable accurate (justifiable) predictions of potential effects of the hydropower project on water quality parameters; second, the baseline data set will provide the "standard" against which project effects and/or mitigation effectiveness can be determined. The water samples can be collected as a part of the monitoring program at three different locations, each from upstream side of the project site, project site, downstream of the project.

17.9.2 Construction period

The purpose of the water quality monitoring program for the construction period, likewise, can serve two purposes: First, the program should be designed to enable evaluation of the effect of various construction activities and construction related facilities on water quality; second, certain components of the program can provide further baseline information for determining the effect of project operation on water quality.

17.9.3 Operation period

The purpose of the final water quality monitoring program to be implemented during operation also has two purposes: First, data collected during the operational period are compared with the baseline data to determine if projections made in the EIA are accurate and mitigation or avoidance measures are effective; second, the monitoring program can be used to determine if changes occur during the operation period and might require attention and can be used as a basis to determine the sources of any pollutants.

17.10 Description of Greenbelt Development

During the operational phase, the restoration of abused areas including dumping site of the excavated materials at the site or excavated dump site should be ensured by transportation and filled up to the burrow pits, occurring in the catchment area. Such area will be treated for greenery with suitable native plants.

17.10.1 Green Belt Development

The Ministry of Environment and Forest (MoEF) has recommended that project proponents should mandatory develop green belt around the project site.

The objectives of developing green belt are given below;

- Noise abatement
- Ecological restoration
- Soil erosion prevention
- Improvement of aesthetic environment.

17.10.2 Selection of different plant species for green belt and plantation

The following different species would be selected for Green belt and Plantation;

- Tall growing ever green trees, native to the area with closer spacing and their adapt ability to different temperature and flood flows.
- Uniform spreading crown habit and medium canopy, and not disturbing the traffic by wide horizontal branches.
- Ability to stand conditioned like undulation, salinity and drought and soil improving plants (Nitrogen fixers) rapidly decomposable leaf litter.

- Attractive appearance with good flowering and fruit bearing and birds, insects attracting tree species.
- Sustainable green cover with minimal maintenance.
- For effective implementation, the Forest Departments help should be taken.

17.10.3 Plantation

Trees with umbrella canopy with attractive flowering and 10 feet long branches; trees of conical growth forms should be planted along the channels.

Trees with medium spreading branches to avoid obstruction to the traffic and general movement of public and also to attractive bird population. Open space is available for parks, to introduce ornamental trees with spreading branches, with colorful flowers and for recreation.

A List of Plants for air and noise pollution attenuation and economically viable plants:

The following plants could be planted to control dust and improve air quality of the environs:

1. Alstonia scholaris R.Br.
2. Calophyllum elatum Bedd
3. Garcenia Morella Desr
4. Holigarna grahamii Hk.f.
5. Mesua ferrea L
6. Syzygium gardneri Thw.
7. Vateria indica L
8. Hopea parviflora Bedd.

Finally, we strongly conclude that the Balancing reservoir along with the hydropower plant located at mekedatu near Sangama, will cause least disturbance to the environment and the impacts appear to be very minimal while executing the project activities.

17.10.4 Compensatory Afforestation and Net Present Value

The project requires 4879.02 Ha of Wildlife area and 198.31 Ha of forest land which is involved under submergence area. Therefore, the land of Compensatory afforestation activities will be identified and the Management Plan with respect to Forest and Wildlife activities will be implemented.

SUMMARY OF ENVIRONMENTAL IMPACTS ARISING FROM THE PROJECT ACTIVITY

Activity	Adverse Impact
Construction of weir, surface power house and switch yard, diversion channel	1. Reservoir sedimentation and deterioration of water quality 2. Air and noise pollution and disturbance to flora and fauna by work force 3. Visual intrusion caused by construction activity 4. Soil erosion due to removal of vegetation and excavation of construction material
Construction of transmission line	1. Damaging flora due to right of way clearing 2. Minimal damage the lives of fauna 3. Visual intrusion
Stream diversion through channel and conduit	1. Loss of habitat of fish and other aquatic flora and fauna 2. Decrease in dilution capacity of stream 3. Depletion in ground water recharge where diversion is taken off from effluent streams
Ponding	1. Flow disruption 2. Channel degradation during generation or spilling and flushing of silt from dam 3. Trapped nutrients and sediments, eutrophication 4. Changed water temperature 5. Changes in land uses resulting from submergence of agricultural land 6. Change in aquatic plant life and fish species 7. High evaporation rate 8. Sedimentation adversely affects fish spawning areas by burying them 9. Provides increased habitat for mosquitoes and snails which are vectors of diseases like malaria, yellow fever, dengue, encephalitis and schistosomiasis.

Activity	Adverse Impact
Operation of hydropower station	1. Increase in pollution concentration in the downstream due to release of pollutants from residential areas, hydropower plant 2. Released water containing low dissolved oxygen 3. Fish mortality from turbine passage 4. Sonic impact: noise level may increase
Peaking operation of power station	1. Damage to fish spawning ground and nesting ground for water fowls and other aquatic birds 2. Erosion of banks 3. Transport of nutrients from the shallow water to deeper water in pond 4. Exposure of drawdown zone creates visual intrusion

SUMMARY OF POSITIVE IMPACTS ON THE ENVIRONMENT DUE TO THE PROJECT ACTIVITY

Positive environmental impacts of hydropower projects are somehow ignored as a routine probably due to the fact that these projects are conveniently considered as demanding an environmental price. It is equally important to highlight and quantify (to the extent possible) positive environmental impacts of SHPs.

Positive Socio-Economic Impacts

1. Multiplier effect of electricity on economy of the area especially in remote areas such as agro-industrial units
2. Project related infrastructure (roads, health facilities, education facilities will help the local people as well as project affected people. There will be net improvement in community health
3. Improves the standard of living of local people
4. Creation of Pond age will increase potential for fish and fisheries.
5. Generation of employment opportunities locally. Direct employment during construction and indirect employment in allied activities.
6. Motivation of higher literacy.
7. Check on migration from villages to towns, thereby checking urban concentration of population
8. Hydro power plant does not require much expertise to build and operate. Components of hydro projects are simple and fairly visible at site. They can become centre of education.

9. In specific cases, SHPs are eligible for carbon credits through reduction in CO_2 emission and adding sink for CO_2 via plantation schemes.
10. Increase in the groundwater levels in and around the weir, due to the pond age.

Positive Ecological/Environmental Impacts

1. There will be a significant increase in the wildlife population
2. There will be creation of habitats in the backwaters of the proposed reservoir
3. There will be proliferation of fish species, Tor Khudree (Deccan Mahasheer)
4. There will be increase in the diversity of floral and faunal species
5. Reservoir acts as water hole for wild animals and it also improve prey-predator relationship
6. Clean and renewable source of energy. SHPs result in saving of non-renewable fuel resources such as coal, liquid fuels and gases.
7. It is benign source of power generation, harnessing only gravitational potential of water to make it yield energy in a continuum
8. Decrease of pollution in the area (hydro replacing diesel generation, electricity replacing polluting energy sources).
9. Increased water surface creates habitat for aquatic life in or near the reservoir. Receiving waters create dry mudflats which provide feeding sites for migratory birds and breeding habitat for resident species.
10. Improved ground water table enhancing greenery all around
11. Improvement towards vegetation and plantation associated with the project (compensatory afforestation) and thus providing sink for CO_2 emission
12. Improved habitat
13. Lake shore environment in otherwise dry areas
14. Modification of micro climate due to storage and regulation of water to a more or less uniform pattern. This also leads to a somewhat stabilizing impact on local environment influencing flora and fauna – aquatic as well as terrestrial.
15. SHPs are environmentally friendlier than conventional large hydro plants:
    a) Non-involvement of setting up of large dams and thus not associated with problems of deforestation, submergence or rehabilitation
    b) Non-polluting and environmentally benign. It is one of the least CO_2 emission responsible power sources, even by considering full energy chain right from the impact of production of plant equipment etc.
    c) Least impact on flora & fauna (aquatic and terrestrial) & biodiversity due to localized nature ofactivities

CHECK LIST OF IMPACTS DUE TO PROJECT ACTIVITY

NO	PROJECT PHASE / ENVIRONMENTAL IMPACT	IMPACT		NO CHANGE	SHORT TERM	LONG TERM
		POSITIVE	NEGATIVE			
A.	**Impacts due to Project Location**					
1	Displacement of People		*		*	
2	Loss of Land / Change in Land Use		*			*
3	Encroachment into Forest Land / Loss of Forest Produce			*		
4	Encroachment into Nature Reserves & Wildlife			*		
5	Loss of Historical/Cultural Monuments		*		*	
6	Loss of Infrastructure		*		*	
7	Erosion and Silt Risks		*		*	
8	Disruption of Hydrological Balance			*		
B.	**Impacts due to Project Construction**					
9	Soil Erosion at Construction Sites		*		*	
	Muck Generation		*		*	
	Transportation of muck and construction material		*		*	
10	Deforestation			*		
11	Human Health		*		*	
12	Water Quality		*		*	
13	Cultural Hazards		*		*	
14	Air and Noise Pollution		*		*	
C.	**Impacts due to Project Operation**					
15	Reservoir Evaporation Losses			*		
16	Deforestation		*			*
17	Effect on Wildlife			*		
18	Change in Water Quality & Risk of Eutrophication			*		
19	Increased Incidences of Water Borne Diseases			*		
20	Impact on Fish and Aquatic Life			*		
21	Public Health	*				*
22	Drainage			*		
D.	**Positive Impacts**					

NO	PROJECT PHASE / ENVIRONMENTAL IMPACT	IMPACT		NO CHANGE	SHORT TERM	LONG TERM
		POSITIVE	NEGATIVE			
23	Clean and renewable source of energy	*				*
24	Employment Opportunities	*			*	*
25	Catchment Area Treatment	*				*
26	Recreation and Tourism Potential	*				*
27	Additional Habitat for Aquatic Wildlife / Wetland Species	*				*
28	Fisheries & Aquaculture potential	*				*
29	Benefits to Economy	*				*
30	Reduction in Air Pollution	*				*
31	Reduction in Greenhouse gas Emissions	*				*
32	Increased Infrastructure	*				*

The approximate cost for implementation of mitigation measures is works out to be 1568.90 Crores. The details provided in **Appendix 1 Vol II.**

The detailed Enviornmnet, Forest and Wildlife studies will be carried out as per MoEF&CC guidelines and ToRs of the Ministry.

Chapter 18
Estimate

18.1 Broad Guidelines for Preparation of Project Estimates for Major irrigation and Multipurpose Projects.

The Project estimates prepared are based on the "Broad guidelines for preparation of Project Estimates for Major & Multipurpose Projects" issued by Central Water Commission, New Delhi and its further revisions.

18.2 Classification of units

The project works have been grouped into the following units:

i. **Unit-I:** Head-Works including main dam , spillway, outlet works,energy dissipation devices, regulators including intake structures and diversion works.

ii. **Unit-II** -Main canals, branches, and distribution system inclusive of all pucca works – Not a part of the present project.

iii. **Unit III - Hydro-electric installation**

a) Power Plant and appurtenant works: Civil works, and Power equipment.

b) Transmission lines.

c) Sub-stations.

iv. **Unit-IV-** Navigation works - Not a part of the present project

v. **Unit-V -**Water supply works-Not a part of the present project

vi. **Unit-VI**- Command Area Development Works-Not a part of the present project

18.3 Account heads

18.3.1 Minor heads

(i) Direct Charges

These shall include the followings:

I. Works
II. Establishment
III. Tools and Plant
IV. Suspense.

V. Receipts and recoveries on capital account

(ii) Indirect Charges:

These shall include the following:

a) Capitalized value of abatement of land revenue, and

b) Auditand account charges.

18.3.2 Detailed sub – Heads under I – Works

The details of the Sub-heads under I – Works are indicated below.

A - Preliminary
B- Land
C- Works
D- Regulators
E- Falls(for canals only)
F- Cross Drainage works(for canals only)
G- Bridges (for canals only
H- Escapes
I- Navigation works
J- Power plants civil works
K- Buildings
L-for canals only
a) Earth work
b) Lining
c) Service roads
M-Plantation
N- Tank and Reservoir
O- Miscellaneous
P- Maintanance
1% of cost of I - works less(A+B+M+O+Q+X+Y)
Q- Special T and P
R- Communication
S- Power plant and Electrical system
T- Water supply works(LS)
U- Distributaries,Minors & sub minors
V- Water courses and Field channels
W- Drainage
X- Environment and ecology
Y- Loss on stock & Unforeseen

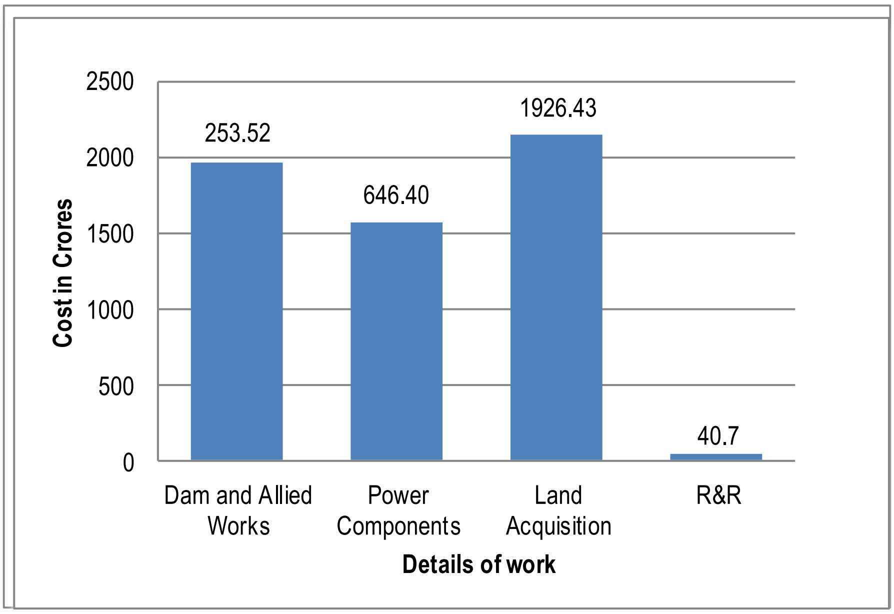
18.4 Abstract of cost

Details of the Abstract of the Cost estimates are presented in **Appendix 1- Vol II.**

No.	Particulars	Rupees in Lakhs	Remarks
1	A- Preliminary	5025.00	Details Enclosed
2	B- Land	192643.00	Details Enclosed
3	C- Works	253520.00	Details Enclosed
4	D- Regulators	12500.00	
5	E- Falls(for canals only)	NIL	
6	F- Cross Drainage works(for canals only)		
7	G- Bridges (for canals only)		
8	H- Escapes		
9	I- Navigation works	NIL	
10	J- Power plants civil works	64640.00	
11	K- Buildings	4540.00	Details Enclosed
12	L-for canals only	NIL	
	a) Earth work		
	b) Lining		
	c) Service roads		
13	M-Plantation	125.00	Details Enclosed
14	N- Tank and Reservoir	NIL	
15	O- Miscellaneous	72.00	Details Enclosed
16	P- Maintanance		
	1% of cost of I - works less(A+B+M+O+Q+X+Y)	4881.60	
17	Q- Special T and P	35.00	Details Enclosed
18	R- Communication	43304.00	Details Enclosed
19	S- Power plant and Electrical system	109656.00	Details Enclosed
20	T- Water supply works(LS)	NIL	
21	U- Distributaries,Minors & sub minors	NIL	
22	V- Water courses and Field channels	NIL	
23	W- Drainage	NIL	
24	X- Environment and ecology	156890.00	Details Enclosed
25	Y- Loss on stock & Unforeseen		
	0.25% of I works less (A+B+M+O+Q+X+P)	1220.40	
	Total cost of I works	**849052.00**	
II	Establishment (5% of cost of I works less B - Land)	32820.45	
III	Tools & Plants (1% of I works including B)	NIL	

No.	Particulars	Rupees in Lakhs	Remarks
IV	**Suspense**	NIL	
V	**Receipts and recoveries on capital account**		
	a) Recoveries on account of K-building 15 % salvage value of building cost.	NIL	
	b) Recoveries towards resale transfer of special T & P @ 75 % of machinery & 20% of cost of vehicle	NIL	
	Total Direct charges	**881872.45**	
	INDIRECT CHARGES		
	a) Capitalised value of abatement of land revenue(5% of B-Lands)	9632.15	
	b)Audit and Account charges (1% of cost of I works)	8490.52	
	Total Indirect charges	**18122.67**	
	TOTAL DIRECT AND INDIRECT CHARGES	**899995.12**	**Lakhs**
	Rounding off	**4.88**	**Lakhs**
	Total cost of the project	**900000.00 Lakhs**	
		9000.00 Crores	

The graphical representation of the major cost components are given hereunder:



18.5 Preparation of estimates

The estimate for various components of the project work comprises of two parts. Firstly, the estimate of quantities for the identified items for each work and secondly the cost estimate which is based on rates for each item of work.

Further the estimates comprise of three major categories namely estimate for civil works, estimate for electro mechanical works and estimate of hydro mechanical works. There will be other components like project roads, buildings etc.

The estimate for quantities for civil works is based on the drawings prepared based on designs and assumptions.

In respect of E & M works the estimates are based on budgetary offers obtained for some major equipment's and machinery.

In case of hydro mechanical works, except trash rack, the weight of gates & embedded parts and hoist capacities are worked out based on the empherical formulae provided in the schedule of Rates of W.R.D.O of Govt. of Karnataka.

The cost estimates for civil works are based on basic rates as per KP.L. SoR. Since the project completion period being 4 years' additional provision of 20% of the estimated cost is made for each components of work, to provide for additional men and machinery to be deployed by the construction agency for speedy completion of works.

The rates for hydro mechanical works is also based on SoR of WRDO Government of Karnataka.

For each item of work, provision is made for contingency @ 3% and 2% towards work charged establishment.

The cost arrived at for each item is rounded off to the near rupee in Crores.

18.6 Detailed estimates of costs I - Works

I. WORKS

A. PRELIMINARY

A provision of **Rs. 5025.00 lakhs** is made for charges for detailed survey, investigation, preparation of Designs, Drawings, Estimates and DPR, Third Party Quality Auditing etc and other preliminary works as required for the project.

B. LAND

A provision of **Rs.192643.00 lakhs** is made in the estimate towards Land acquisition for construction of Dam and allied works including the Power components

C. WORKS

A provision of **Rs 253520.00 lakhs** is made in the estimate towards, construction of Dam and allied works

D. REGULATOR AND MEASURING DEVICE

A provision of **Rs 12500.00 lakhs** is made towards Hydro Mecjanical works of Dam, construction of spillway gates, river sluice gates, and Hydro Mechanical works of Power house.

E. FALLS

No provision is required to be made in the estimate.

F. CD WORKS

No provision is required to be made in the estimate.

G. BRIDGES

No provision is required to be made in the estimate.

H. ESCAPES

No provision is required to be made in the estimate.

I. NAVIGATION WORKS

No provision is required to be made in the estimate.

J. POWER PLANT CIVIL WORKS

A provision of **Rs 64640.00 lakhs** is made in the estimate.

K. BUILDINGS

A provision of **Rs 4540.00 lakhs** is made in the estimate towards construction of office buildings and staff quarters in the project area.

L. EARTHWORK

No provision is required to be made in the estimate as construction of canals is not envisaged in the present project

M. PLANTATION

A provision of **Rs. 125.00 lakhs** is made for planting trees along the periphery of the submergence area, approach roads and at colonies.

N. TANKS AND RESERVOIRS

No provision is required to be made in the estimate.

O. MISCELLANEOUS

A provision of **Rs. 72.00 lakhs** is made in the estimate

P. MAINTENANCE

At 1% of cost of I - works less (A+B+M+O+Q+X+Y), a provision of **Rs. 4881.60 lakhs** is made in the estimate.

Q. SPECIAL TOOLS AND PLANTS

A provision of **Rs. 35.00 lakhs** is made in the estimate

R. COMMUNICATIONS

A provision of **Rs. 43304.00 lakhs** is made towards construction of Ayacut roads.

S. POWER PLANT AND ELECTRICAL MECHANICAL SYSTEM

A provision of **Rs 109656.00 lakhs** is made in the estimate.

T. WATER SUPPLY WORKS

No provision is required to be made in the estimate.

U. DISTRIBUTARIES MINORS AND SUB-MINORS

No provision is required to be made in the estimate.

V. WATER COURSES

W. DRAINAGE AND PROTECTIVE WORKS

No provision is made in the estimate.

X. ENVIRONMENT AND ECOLOGY

A provision of **Rs. 156890.00 lakhs** is made towards Catchment area treatment, restoration of land, public health measures,control of acquatic weeds and supply of here fuel wood for workers

Y. LOSSES OF STOCK

A provision of **Rs.1220.40 lakhs** is made in the estimate at 0.25% of the cost of I – works less A, B,O,M,P,Q and X as per CWC guidance.

TOTAL OF I WORKS – Rs. 849052.00 lakhs

18.7 Detailed estimates of costs II - Establishment

The project will be executed by existing set up of CNNL offices. A provision of **Rs 32820.45 lakhs** is made towards Establishment charges i.e. 10% of total I works

18.8 Detailed estimates of costs III – Tools & Plants

SMALL T&P 1% OF I - WORKS

No provision is made in the estimate

18.9 Detailed estimates of costs IV - Suspense

No provision is made in the estimate.

18.10 Detailed estimates of costs V – Receipts and recoveries on capital account

a)	Recoveries on account of K – Building at 15% salvage value of building cost	-Nil-
b)	Recoveries towards resale, transfer of special T & P @ 75% of machinery and 20% of cost of vehicle	-Nil-

18.11 Direct and Indirect charges

TOTAL DIRECT CHARGES

A provision of **Rs. 881872.45 lakhs** is made in the estimate**.**

INDIRECT CHARGES

a)	Audit and accounts charges (1% of I – works)	Rs 8490.52 lakhs
b)	Capitalized value of abatement of land revenue (5% of the cost of cultivable lands)	Rs 9632.15 lakhs

TOTAL INDIRECT CHARGES

A provision of **Rs. 18122.67 lakhs** is made in the estimate

GRAND TOTAL = 899999.92 LAKHS

Say 9000.00 CRORES

Chapter 19
Financial resources

19.1 Present Position of the scheme regarding its inclusion in the plan – concurrence of the State Planning Finance Department

As a measure to conserve water and also to address energy shortage, Government of Karnataka is planning to build a balancing reservoir across river Cauvery near Mekedatu. The total outlay of the project as per the estimate prepared based on the current Schedule of Rates 2018-19 is estimated to be **Rs.9000.00 Crores**. Government of Karnataka has already allocated a sum of Rs.25 Crores towards the preliminary studies in its budget for the year 2015-16.

Consequent to the approval of the scheme, Government of Karnataka would like to make provision for a special outlay in their budget in order to meet the project expenses over the planned construction period of four years. To that extent, the State Planning Finance Department of Government of Karnataka will be approached to get the necessary financial outlay.

19.2 Provision for the Sector / for the scheme in the plan

Consequent to the approval of the scheme by the CWC/CEA and also environmental clearance from the Ministry of Environment & Forests, the project implementation agency / authority will revise the estimate and update the same to the current year of Schedule of Rates before start of implementation.

The revised estimate will be presented to the State Planning Finance Department of Government of Karnataka for giving its concurrence and obtain necessary project funds. Besides, the extent of project funding approved by the Finance Department will be allocated in the budget of the respective year.

19.3 Central / Foreign Aid contemplated, if any

The present project envisaged by the Government of Karnataka meets the basic requirement of common man such as, drinking water and energy. As such, it is the responsibility of the Government of Karnataka to ensure when such projects are implemented, necessary funds are allocated.

To that extent, Government of Karnataka is committed and hence necessary allocation will be made in the budget for the speedy implementation of the project. However, looking into the substantial project expenses and also the amount required towards land acquisition, Government of Karnataka may look for assistance in the form of grant or soft loan from Government of India or any other funding agencies. The decision in this regard will be taken at appropriate time.

19.4 Information on similar / related pending projects in the state, their status. Stage / percentage of completion, percentage of expenditure incurred and average annual expenditure by the state on these projects put together year-wise during the last 5 years

Not applicable.

19.5 Commitment on the work in Progress in the plan and allocation available for starting new scheme

As narrated in the earlier paragraph, looking into the need for meeting the basic requirement such as drinking water and energy needs, Government of Karnataka has already earmarked necessary budget to meet the initial project expenses to an extent of Rs.25 Crores. Government of Karnataka will definitely initiate action in making further allocation for the speedy implementation of the project.

19.6 Effect of inclusion of the scheme in the plan on the schedule of other works in progress budget staff, etc

Government of Karnataka has excellent track record in terms of managing the revenue and also allocating the budgets for projects of national importance and projects which will meet the basic needs of the people.

Hence, while allocating the necessary budget, it will be ensured that other on-going similar projects will not be disturbed due to the inclusion of this and to that extent necessary provision will be made.

19.7 Requirement of funds for the scheme and its yearly phasing as in project report

The project is proposed to be completed in a span of four years and accordingly the budget for the major items of project works will be as under:

No	Year	Amount in INR Crores
1.	First Year	1200.00
2.	Second Year	3000.00
3.	Third Year	3000.00
4.	Fourth Year	1800.00
	Total	**9000.00**

19.8 Adequate / strengthening of organizational set up for execution for all projects together as contemplated

CNNL, the nodal agency for executing the projects in the Cauvery basin will be the implementing agency. Under this, it is proposed to have a separate zone for the said project headed by the Chief Engineer and assisted by Superintending Engineers, Executive Engineers and Asst. Executive Engineers. Refer **Fig. 15.2-** Organisation Chart.

19.9 Advance action proposal for starting the preliminaries of the project, if any

Government of Karnataka has allocated a sum of Rs.25 Crores in their budget for the year 2015-16 in order to carry out the preliminary activities such as preparation of detailed Project Report and other appurtenant activities.

Chapter 20
Revenues

20.1 Basis of Profitability Analysis

- The profitability of the project is calculated based on "With and without" concept..
- The analysis is based on annualized cost and benefit.
- Full "Free market" conditions are assumed. This means that all the labour and material costs of both inputs and outputs are at their opportunity cost and so no shadow pricing is done.
- Profitability index is used in BC ratio, which is defined as the ratio of annual benefit to annual cost.
- While implementing the Mekedatu Project, the following facts are to be considered in the profitability analysis.
  - ✓ Construction of Dam with Sluice and Power house along with appurtenant structures
  - ✓ Acquisition of 4996.00 Ha of land which is going to be submerged.
  - ✓ The R & R component involved with land acquisition and resettlement of villages.

20.2 Annual Benefits

Annual benefits will be worked out in terms of meeting the drinking water and power needs.

20.3 Cost component considerations

20.3.1 General

The various costs of the major components of the project development are as under:

- ➢ The land coming under submersion is 4996.00 Ha and the total land to be acquired is 5252.40 Ha.. The cost of land for Dam and allied works is **Rs 188573.00 Lakhs** and for Rehabilitation and Resettlemet works out to **Rs. 4070.00 Lakhs**. The Total cost works out to **Rs. 192643.00 Lakhs.**
- ➢ Cost of construction of Concrete dam and related appurtenant structures including river bed sluice and foreshore lift scheme for bulk water supply works out to **Rs 253520.00 Lakhs**

- Cost of power components including underground power house , tail race channel etc works out to **Rs 64640.00 Lakhs**
- The cost of works/compliances under Environmenent and Ecology works out **Rs. 156890.00 Lakhs**

20.3.2 Operation and Maintenance (O&M) charges

The present rate of operation and maintenance per TMC of potential (inclusive of establishment) considered is 0.5 to 1.50 % of the works portion

20.4 Annual cost details

- The Capital recovery of civil works is taken as 1% depreciation plus 10% interest (With the existing economic condition 8% interest should be sufficient. However 10% is used as a convention).
- The capital recovery of hydro mechanical components is again considered as depreciation as per norms mentioned above plus 10% interest on capital cost.
- Taxes being only transferred payment are deleted for the cost in calculating economic indices.
- The cost of the land is included in computing the annual cost. So the annual benefit foregone from this land is not considered to avoid double counting..

Chapter 21
B.C.Ratio, Financial Return and Internal Rate of Return

Mekedatu Hydroelectric project is envisaged to be developed in single stage to ensure releases to Tamil Nadu in a normal year as per CWDT award as modified by the Hon'ble Supreme Court of India and meet the drinking water requirement besides generating Hydro power from releases.

The revenue from the project is contemplated only in terms of cost towards drinking water supply to municipalities and through sale of the power. Accordingly, the following parameters have been considered while arriving at the value of the gross revenue generated from the project.

No	Particulars	Unit	Quantity	Rate in Rs Lakhs	Amount / Revenue in Lakhs per annum
1	Water charges	MCum	1401.30	100	140130.00
2	Energy charges	MU	650.28	40	260112.00

B C Ratio and IRR

The financial feasibility of the project is examined through the financial indicators such as NPV, FIRR and B/C ratio. For a project to be feasible, the NPV value at the defined discount rate should be '0' or greater than '0'. The Internal Rate of Return should be more than the lending rates of financial institutions which are normally in the range of 10 to 12%. The Benefit cost ratio shall be more than 1.0 at the predefined discounted rate.

Based on the above guidelines, the financial feasibility in terms of NPV, FIRR and B/C ratio has been worked out for a total duration of 50 years including 4 years construction period. The analysis has resulted in following:

1. NPV at 10% discount rate is Rs. 450334.50 lakhs which is positive.
2. Financial Internal Rate of Return (FIRR) is 15.69% which is greater than 12.0%
3. B/C ratio is **1.67** which is greater than 1.0

The detailed analysis is furnished as **Appendix 21 Vol II**

Chapter 22
Future utilization of facilities created (buildings)

Most of the facilities such as buildings, accessibility, communication network, treatment plants (STP & WTP) and other infrastructures will be located above the FRL and the same will be retained after carrying out minimum repairs and maintenance and utilized during O & M.