त.अ.क्र.डी.पी.आर.(पी)-1/2008
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कार्यालयीन उपयोग हेतु
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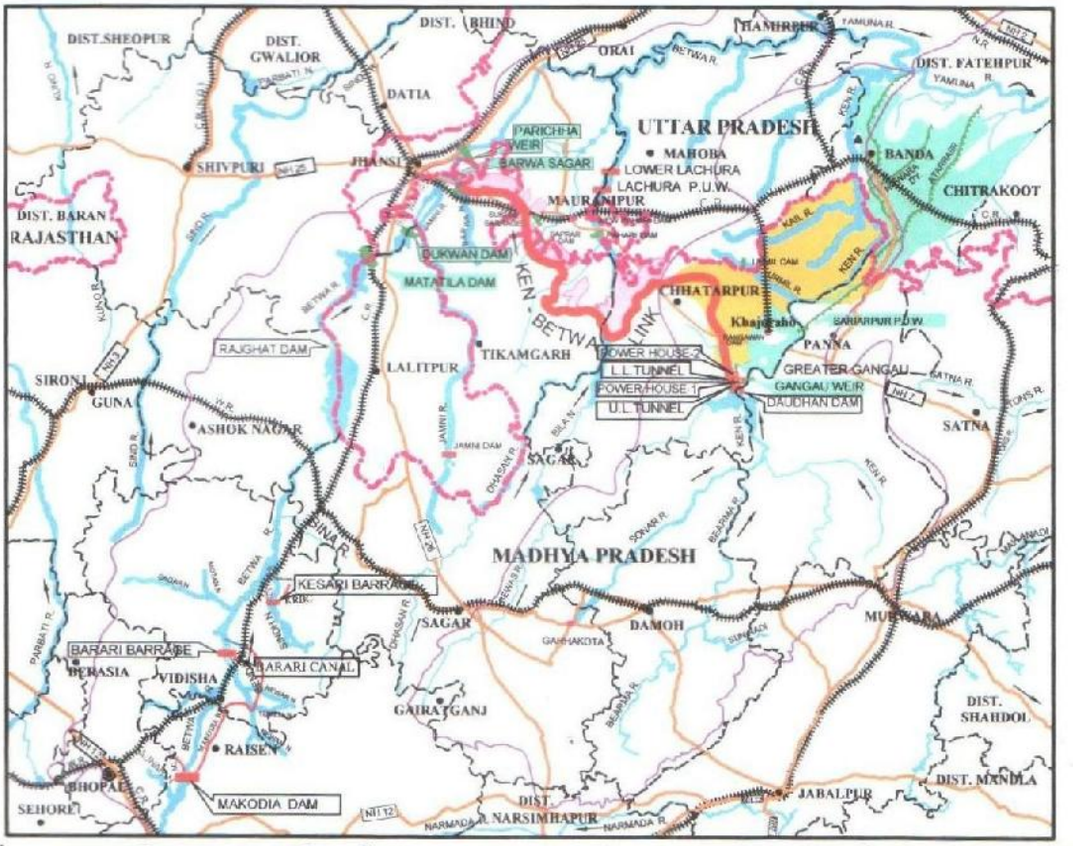
राष्ट्रीय जल विकास अभिकरण

(भारत सरकार जल संसाधन मंत्रालय के अधीनस्थ सोसाइटी)

NATIONAL WATER DEVELOPMENT AGENCY

(A Govt. of India Society Under The Ministry of Water Resources)



केन–बेतवा लिंक परियोजना की विस्तृत परियोजना प्रतिवेदन

(प्रथम चरण)

DETAILED PROJECT REPORT OF KEN-BETWA LINK PROJECT

(Phase - I)

प्रतिवेदन खण्ड

REPORT VOLUME

लखनऊ, अप्रैल, 2010

Lucknow, April, 2010

SECTION-1

CHECK LIST

Foreword

The Ministry of Water Resources (MOWR) prepared a National Perspective Plan (NPP) in the year 1980 for Water Resources Development in the country envisaging transfer of water from water surplus areas to water deficit areas. Based on numerous water balance studies, toposheet studies of reservoir sites and link alignments etc., National Water Development Agency (NWDA) identified 30 links, 16 under Peninsular Component and 14 under Himalayan Component for the preparation of feasibility reports in line with the proposals of NPP. The Inter Basin Water transfer programme has gained momentum in the recent past as efforts have been made for a comprehensive assessment of this important infrastructure development programme with a focus on the southern Rivers. NWDA has so far completed feasibility reports for fourteen links under the Peninsular Component. Government of India has been making continuous efforts with the State Governments in building consensus on these link proposals and has prioritized five link proposals to obtain the consent of basin States to take up the Detailed Project Reports (DPR) of prioritized link. Series of meetings between officers of Uttar Pradesh (UP) & Madhya Pradesh (MP) were organized by NWDA in consultation with Central Water Commission (CWC) & Ministry of Water Resources to arrive at consensus between them. These efforts culminated in a tripartite Memorandum of Understanding for preparation of Detailed Project Report of Ken-Betwa Link which was signed by the Chief Ministers of UP & MP and Union Minister of Water Resources on 25th August 2005 in the presence of the Hon'ble Prime Minister.

Subsequently, the work of preparation of DPR was entrusted to NWDA by Ministry of Water Resources in January 2006. The mandate of NWDA was enhanced in the Special General Meeting held on 28.06.2006 to include the work of preparation of DPR of Ken-Betwa Link Project & other Links. The field investigations commenced effectively in November 2006. Gwalior circle headed by Superintending Engineer with three divisions took up the work under the overall directions & guidance of Chief Engineer (N), Lucknow. Other expert agencies like Central Water Commission (CWC), Central Electricity Authority (CEA), Central Soil & Materials Research Station (CSMRS), National Institute of Hydrology (NIH), Geological Survey of India (GSI), National Remote Sensing Agency (NRSA), Indian Institute of Technology (IIT), etc. were entrusted various investigations & studies. The Environmental Impact Assessment (EIA) & Resettlement & Rehabilitation (R&R) studies have been carried out by AFC Ltd, Hyderabad, as per the terms & conditions approved by Ministry of Forest & Environment. Ministry of Water Resources had constituted a Committee headed by Chairman, CWC to monitor and supervise the overall work of preparation of DPR of Ken-Betwa Link. This Committee held seven meetings during last 3 years and gave guidance to NWDA for expeditious completion of the DPR. Engineer-in-Chiefs of both the States of UP & MP were also represented in the said Committee to give their views from time to time. A Steering Committee headed by Secretary, Ministry of Water Resources also reviewed the progress of work from time to time.

DPR was completed in December 2008 and was sent to the concerned States i.e. U.P and M.P. for their concurrence. Govt. of M.P. sent an alternative proposal in Upper Betwa basin and Govt. of UP sent its comments.

In order to sort out various issues for the finalization of DPR and future strategy for implementation of Ken – Betwa Link, Secretary Level Meeting was held on 03.02.2010 at New Delhi under the Chairmanship of Secretary, MOWR with Principal Secretaries of UP & MP. Senior Officials of MOWR/CWC/NWDA and State Govt. of UP & MP also participated in the meeting. During the meeting various issues raised by both the states on the DPR were discussed and finalized. It was decided that the DPR of the project will be prepared in two phases. In Phase-I, Daudhan dam, two power houses, link canal and their other components will be completed by April, 2010. The projects suggested by the Govt. of MP for Upper Betwa basin, will be taken up in Phase-II after completion of their Survey & Investigation work and examining their techno-economic viability.

The DPR, Phase-I is in three parts, i.e., Report, Appendices and Drawings volumes. Report part is contained in 1 volume whereas Drawings are contained in 3 volumes. The data & detailed reports of the various expert agencies associated with the work and cost estimate are contained in Appendix Volume-I to IV. A separate volume containing the executive summary has also been prepared for ready reference.

The Ken-Betwa Link Project, Phase-I envisages transfer of surplus water of Ken-Basin to Betwa basin.

The project components include a 77 m high dam at Daudhan across Ken river, 218.695 km long Link canal, two power houses having combined installed capacity of 78 MW. The Ken-Betwa Link project Phase-I will provide annual irrigation to 3.83 lakh ha in new command area, besides giving assured irrigation benefits to the 2.13 lakh ha (CCA) of existing command area. The total cost of the project is Rs. 9393 crores. The cost allocated to Power component is Rs. 593.47 crore. The Benefit cost ratio of the project works out to 1.56 & the unit cost of the power based on the allocated cost is Rs. 7.61 crore per MW.

Secretary (WR) as well as Chairman, CWC took keen interest and continuously monitored the progress of preparation of DPR & gave valuable guidance in its timely completion. Their contribution in this regard is gratefully acknowledged. The Cooperation of officers of UP & MP and of various other agencies like Central Water Commission (CWC), Central Electrical Authority (CEA), Central Soil & Material Research Station (CSMRS), National Institute of Hydrology (NIH), Geological Survey of India (GSI), Indian Institute of Technology (IIT) Roorkee & Indian Institute of Technology (IIT) Delhi who were closely associated in the various aspects of the investigation & studies is also acknowledged.

I would also like to place on record my sincere thanks to the officers of NWDA for their sincerity and devotion in completing this challenging task in the assigned time period.

30.04.2010
New Delhi

(A.D. Bhardwaj)
Director General

Detailed Project Report of Ken-Betwa Link Project(Phase-I)

Section-1
CHECK LIST

Name of the project	Ken- Betwa Link Project (Phase-I)
Location:	
(a) State(s)	Madhya Pradesh, Uttar Pradesh
(b) District(s)	Panna, Chhatarpur,
(c) Taluka	Bijawar
Category of the project:	
(a) Irrigation or Multipurpose	Multipurpose project
(b) Storage or diversion	Storage-cum-diversion

S.No.	Item	Reference
1	2	3
	Planning	
1.	Has the Master plan for overall development of the river basin been prepared and stages of basin development discussed briefly?	Yes, Prepared by Govt. of M. P.
2.	Have the alternative proposals been studied and their merits and demerits discussed?	Yes
3.	Does the scheme fit in the overall development of the river basin and its priority in the overall development of the basin discussed?	This is an inter basin water transfer project benefiting both Ken and Betwa river basins.
4.	Are there any features which are not likely to fit in the overall development of the basin?	Nil
	Have the other Departments concerned with the development been informed.	Yes
5.	Is the present scheme proposed to be executed in stages? If so, are its various stages of execution and development discussed in the report?	No. This Project i.e.,Phase-I is proposed to be executed simultaneously along with Phase-II of the project.
6.	Are the effects of the scheme on the riparian rights existing upstream and downstream projects, etc. discussed?	All the requirements of u/s and d/s projects have been accounted before proposing diversion under this project, which is being taken up as per the MOU signed between both the states viz., MP and UP.

	Interstate and International Aspects	
7.	Are there any International/Interstate issues involved? If so, have these issues been identified and present status of agreement indicated specially in respect of	Interstate issues between M.P. & U.P. involved.
	(a) Sharing of water	Yes. MoU among the concerned states and GOI have been signed. Refer Annexure:1.3 Page no: 369 of Report volume.
	(b) Sharing of cost	Specific MoU for sharing of cost & benefits including arrangements for management and control of water will be signed by the states based on the DPR of the project.
	(c) Sharing of benefits	
	(d)Acceptance of the submergence by the upstream state(s)	Submergence is within one of the beneficiary states only viz., Madhya Pradesh which has signed the MOU for preparation of this DPR.
	(e)Compensation of land coming under submergence	Provisions kept as per R & R policy of Govt. of India. Refer para 9.4.2.1 at page no. 326 of Report volume.
	(f) Settlement of oustees	Suitable R&R plan has been proposed for PAP. Refer Annexure:9.1, page no. 501 of Report volume.
	(g) Any other	Nil
	Surveys	
8.	Have the detailed topographical surveys been carried out for the following items and maps prepared as per prescribed scales?	Yes.
	(a) River surveys	Yes. Refer para 2.1.1 at page 28 of report volume.
	(b) Reservoir surveys	Yes. (para 2.1.2 at page 29)
	(c) Head-works surveys (dam, dykes, barrages, weirs, etc., and auxiliary components)	Yes. (para 2.1.3 at page 29)

	(d) Plant site and Colonies	Yes. (para 2.1.4 at page 30)
	(e) Canals, Branch canals and water conductor system	Yes. (para 2.1.5 at page 30)
	(f) Major canal structures	Yes. (para 2.1.5 at page 30)
	(g) Power house, switch-yard, surge shafts, tailrace	Yes. (para 2.1.6 at page 31)
	(h) Tunnel(s), adits, penstocks, etc.	Yes. (para 2.1.7 at page 32)
	(i) Surveys(Detailed and sample) of areas of the command for OFD and drainage works	Yes. (para 2.1.8 at page 33 of Report Volume)
	(j) soil surveys	Refer para 2.2.6 at page 37 of the report volume.
	(k) Surveys for soil conservation	Refer para 2.1.9 at page 35
	(m) Any other surveys i.e. Archaeological, Right of way, communication, etc.	Yes. Communication survey only. Other details have been collected from concerned department. Refer para 2.2 at page 35 of Report volume.
	Geology	
9.	Have the geological surveys for the following items been carried out and report on geology appended?	Yes. Refer Appendix volume-I.
	(a) Regional Geology	Yes.Refer para 2.3 and 2.4 at page nos.37 to 43 of Report Volume.
	(b) Reservoir	
	(c) Head works and energy dissipation area	
	(d) Power house and appurtenances	
	(e) Intake and regulators	
	(f) Major canal structures	
	(g) Tunnel(s), Penstock hill, etc.	
	(h) Communication routes	
	(i) Any other	
10.	(a) Has the Seismicity of the region been studied and co-efficient of vertical/horizontal acceleration for the various structures discussed?	Yes. Earthquake and Seismicity study of Daudhan dam area has been carried by IIT, Roorkee. Please refer Appendix:2.3 of Appendix volume-I.
	(b) Has the approval of the Standing Committee for recommending design of seismic co-efficient for River Valley Project been obtained?	Yes. Approval of National Standing Committee on earthquake and Seismicity has been obtained. Refer Annexure 4.3 at page 406 of Report volume

	Foundation Investigations	
11.	Have the detailed foundation investigations (including insitu tests and laboratory tests) for the following structures been carried out and detailed report(s) appended?	Yes. Refer Appendix Volume-I .
	(a)Earth and rock fill dam/barrage/weir.etc	Yes. Refer Appendices: 2.1, 2.4, 2.5
	(b) Masonry/concrete dam/weir,etc.	Yes. Refer Appendices: 2.1&2.5
	(c) Canal	Yes. Refer Appendices : 2.6
	(d) Power house, tunnel(s), canal structures,etc.	Yes. Refer Appendices: 2.6 & 2.7
	(e) Any other	Nil
12.	Are there any special features affecting the designs?	No.
	Material Surveys	
13.	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 dam.	Yes. Refer Appendix: 2.12 of Appendix volume .II
	(b) Sand	Yes. Refer Appendix:2.14 of Appendix volume : II
	(c) Rock and aggregate	- do -
	(d) Bricks and tiles	N.A.
	(e) Pozzolona	N.A.
	(f)Cement and lime stone	No
	(g) Steel	No
	(h) Other scarce materials:	No
	(i) Any other	Nil
14.	Have the sources for each of the above material been identified and need etc. indicated?	Yes. Refer para 2.5 at page nos.44,45&46 of report volume
15.	Have the proposals for procurement of scarce materials been indicated?	Not applicable
	Hydrological and Meteorological Investigations	
16.	Have the hydrological and meteorological investigations been carried out and status of data discussed in report?	Following pages of Appendix volume-III may be referred.
(a)	Rainfall	Refer Page nos.:27-58
(b)	Gauge	Yes.
(c)	Discharge	Refer Page nos:27-58

(d)	Sediment	Refer Page nos: 144-150
(e)	Water quality	No.
(f)	Evaporation and whether the above data has been appended?	Yes. Refer Page nos:160
	Hydrology	
17.	Is the hydrology dealt with in details in a separate volume?	Yes. Refer Appendix volume-III.
(a)	Have the brief details been included in this report?	Yes. Refer chapter-III of Report Volume
(b)	Is an index map and bar chart showing location of various hydrometric, climatic and rainfall stations and the data availability at those stations been attached?	Yes. Refer page.57, 60 to 62 of Report volume.
(c)	Are brief notes about quality, consistency, processing and gap filling of the data included?	Yes. Refer page 65 of Report volume.
18.	Have hydrological studies been carried out for the following:	
(a)	to establish the availability of water for the benefits envisaged.	Yes. Refer page:85 and Annexures: 5.1(page no.425)
(b)	to determine design flood for the various structures (Spillway, weir, barrage, etc.)	Yes. Refer page: 75-78 of Report volume.
19.	Have the analysis for the water flows, evaporation and command area rainfall been discussed?	Yes.
20.	Have the studies regarding reservoir sedimentation been carried out and revised Elevation-Area Capacity curves been used in the simulation studies?	Yes. Refer para no.3.6.6 in page nos.72-74 of Report volume.
21.	Have the other requirements such as low flow augmentation, water quality control, etc. been included in the project report and incorporated in the simulation studies?	Yes.
22(a)	Design of major Civil Engineering Components have been finalized taking Seismicity of the region into consideration	Yes
(b)	Have the details of the simulation studies and conclusions arrived from the various alternatives explaining the factors and assumptions been included and discussed?	Yes. Refer page no: 84& 85.
(c)	Have the number of failures for difference aspects been indicated?	Yes. Para 4.2 at page 101 of the Report volume.

23.	Have the likely desirable and undesirable changes in the hydrologic regime due to the project been brought out in the report?	Yes. Refer para 3.9 at page 86 of Report volume.
24.	Is the criteria adopted for selection of the construction in the hydrologic regime due to the project been brought out in the report?	Yes.
25.	Is the basis for fixing up the storages discussed?	Yes. Refer page.140-145 of Report volume.
26.	Have the flood routing studies been carried out?	Yes. Annexure 5.4.1 at page 429 of Report volume.
27.	Have the back water studies been carried out?	Yes. Refer page no. 195 of Appendix volume-III.
	Land acquisition and resettlement of oustees	
28.	Have the type and quantum of land proposed to be acquired in the submergence area project area, area coming under canal and distribution system, area required for rehabilitation of the oustees been detailed?	Yes. Refer para 9.4.2.1 at page 326 of Report volume.
29.	Is the basis for provision for land acquisition indicated?	Yes. Refer para 9.3 at page no:323
30.	Have the rehabilitation measures, amenities and facilities to be provided to the oustees been discussed specially for the oustees from the upstream state?	Yes. Refer Chapter:IX (page nos: 318-330) of Report volume.
31.	Are the basis of land acquisition of the submerged area upon FRL/MWL etc. discussed?	- do –
	Design	
32.	Has the final location of the head works and appurtenances, in preference to the other sites investigated, been discussed?	Yes. Chapter-IV of the Report Volume.
33.	Has the layout of the project area viz., location of head works, workshop, sheds, offices, colonies, etc. been finalized and discussed?	Yes.
34.	Has the layout of the various major components of the headworks been discussed in the light of site feature, geology, and foundation characteristics, etc.	Yes.
35.	Have the designs been prepared for the following components and appended?	Yes.

(a)	Earth or rock fill dam, masonry or concrete dam, spillway, barrage, weir, etc. and appurtenances.	Yes.
(b)	Energy dissipation arrangements, training wells, etc.	Yes.
(c)	Opening through dam-galleries, head regulators, penstocks, other outlets, sluices, etc.	Yes.
(d)	Regulators	Yes. Refer Annexure:4.7 page no :414
(e)	Canal and water conductor system	Yes. Refer page nos.409-412
(f)	Canal structures	Yes. Refer Annexure:4.10 page no.418
(g)	Power House, tunnels, surge shaft	Yes.
(h)	Instrumentation	Yes.
36.	Have the assumptions made in the design of above components of the project been indicated and basis of assumption discussed?	Yes.
37.	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?	To be conducted at construction stage.
38.	Has the final alignment of canal(s) and branch canal(s) been discussed in the light of various alignments studied?	Yes
(a)	Does the canal design provide for meeting requirements of rush irrigation?	Yes.10% extra has been provided for rush irrigation
(b)	Have any intermediate storages and tail tanks been considered to reduce the canal capacities?	No intermediate storages considered along the link canal. The canal will outfall into existing Barwasagar reservoir.
39.	Is the canal and distribution system being lined and if so what is the minimum capacity of the channel proposed to be lined?	Only main canals are to be lined.
40.	Is the location of canal structures on main and branch canals fixed after detailed surveys of the final alignments?	Yes.
41.	Are the regulation arrangements of the off-taking channel both near and away from the cross regulators discussed?	Yes.

42.	Are sufficient escapes including terminal escapes provided on the main/branch canal distributaries/minors?	Yes.
43.	Have the basis for adopting water way for the cross drainage works been discussed?	Yes.
44.	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?	No.
45.	Has any model studies for major canal structure(s) been carried out and if so, are the results discussed and incorporated in the design?	No.
	Irrigation and Command Area Development	
46.	Have the conveyance and field irrigation efficiencies for paddy and upland crops during Kharif, rabi, etc. been indicated, discussed and justified?	Yes. Refer page no:217 of Report volume.
47.	Have the weekly/fortnightly Crop water requirements at the canal head been worked out?	Yes. Fortnightly crop water requirement furnished in Annexure:6.3 (page nos.478)
48.	Are there any proposals for introducing Warabundi and if so have these proposals been discussed in the report and sample calculations for a typical distributary /minor/ sub-minor furnished?	No.
49.	Has the present position of irrigation in the command through existing canals, tanks, lift schemes, wells, etc. been brought out in the report?	Yes. Refer chapter:VI (page nos.206-207)
50.	Are the particulars for minor irrigation projects existing/proposed in command been indicated?	Yes.
51.	Are there potential areas, indicating the potential where ground water is available? If so, has the quality of the ground water been indicated?	Yes. Refer Annexures:6.3 to 6.5 (page nos.478,479,480) of Report volume.
52.	Has the quantum of available ground water been assessed indicating the basis for conjunctive use with surface water discussed?	-do-
53.	Have the semi-detailed soil surveys been carried out for the entire command and soil and land irrigability classifications brought out in the report?	Yes. Refer page nos.470-477.

54.	Is the method used for determining the crop water requirements discussed?	Yes. Refer page no:216
55.	Has the pre-project cropping pattern and justification for the proposed cropping pattern been furnished?	Yes. Refer page no:209-210
56.	Are the areas and percentages of the CCA that will be irrigated during kharif, rabi, two seasonal, summer and perennial been indicated?	Yes. Refer page no:211 & 212
57.	Is justification furnished for irrigating perennials and summer crops from the reservoir?	Yes.
58.	Have the monthly reservoir operation studies carried out at least for 20 years and summary on annual basis attached?	Yes. Refer page nos:217 - 219.
59.	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?	Sample command area surveys have been carried out in enroute command area including OFD work.
60.	Have the existing locations of the (Trial cum Demonstration Farm) inputs centres, (seeds, fertilizers and insecticides) in the command been indicated and proposal to strengthen the same discussed?	Nil.
61.	Have the arrangements for financing the OFD works and proposals for strengthening the same been discussed?	Nil.
62.	Have the agencies responsible for execution of the OFD works been identified and simultaneous planning of execution of OFD works along with engineering works discussed?	Nil.
63.	Has the yearwise phasing of irrigation development as a result of the project been discussed?	Nil.
64.	Is the existing communication system within command area sufficient to meet the requirement after full development of irrigation? If not, have the new proposals been planned and discussed?	Yes. However, suitable provisions have been kept in the estimate for future demand also.
65.	Is the adequacy of the marketing centres in the Command Area and new proposals to meet the requirements after full development of irrigation been discussed?	Yes.

	Flood Control and Drainage	
66.	Have the various flood control components of the multipurpose project been indicated?	N.A.
67.	Have the damage areas been identified and flood intensities worked out at each of the damage centre(s) which gets affected?	N.A.
68.	Have the following aspects been discussed?	
	(a)Flood cushion in the reservoir	N.A.
	(b) Maximum moderated flood out flows over the spillway etc. and its frequency	Yes
	(c) Safe carrying capacities of the channel below in the dam existing and after construction of flood embankment, channel improvement, river diversion, etc.	Yes
	(d) Synchronized moderated peak floods due to release (s) from the Dam upstream and un intercepted catchment upto the damage centres	Yes
	(e) Average annual expenditure incurred on flood relief works	N.A.
	(f) Area and population affected/likely to be affected before/after the project	N.A.
	(g) Estimated saving in annual loss of life, property, cattle, crops, etc. (evaluated in terms of money) due to flood control.	N.A.
69.	Have the following aspects drainage been discussed?	
	(a) Surface and sub-surface drainage problems of the command area with details of studies on sub soil water table.	Yes
	(b) Maximum intensity of 1,2 & 3 day rainfall	N.A.
	(c) Deficiencies in farm drains	N.A.
	(d) Deficiencies in existing natural drains	Yes
	(e) Proposal for improvement of drainage / water logging of the area with criteria	N.A.
	(f) Identification of the area in Command which will get benefited due to execution of drainage network and benefits thereof in terms of relief from crop damage, increased yields, etc.	N.A.

	Navigation	
70.	Is the present scheme for remodeling of the existing facilities and /or extension of the Navigable reach or New proposals?	N.A.
71.	Is the existing inland transport system being fully utilized? If not, have the bottlenecks in its full utilization been identified and discussed?	N.A.
72.	Have the traffic surveys been carried out and discussed in respect of present and projected:	
	(a) Goods traffic	N.A.
	(b) Passenger traffic	N.A.
	(c) Existing traffic in the area and its comparison with the other modes of transportation	N.A.
	Is the extent of modification required in the existing system discussed and justified?	N.A.
73	Have the main goods that are being carried and / or proposed to be carried been indicated?	N.A.
74.	Are the canal sections and canal structures designed from Navigation considerations or irrigation considerations?	Canal sections have been designed for irrigation considerations only.
75.	Have the proposals to develop the new scheme and phases of development in the different reaches been discussed?	N.A.
76.	If the area is being served by inland water transport, have the following been discussed:	
	(a) The existing toll rates and registration fees, for the crafts(size wise)	N.A.
	(b) Proposals for revision of tollage rates and fees, if any	N.A.
	(c) Concurrence of the competent authorities for revision of rates and fees.	N.A.
	(d) Proposal to subsidize the tariff, tollage, craft registration fee, passenger fare, etc. to attract traffic.	N.A.
77.	Has the State Inland Water Authority been consulted while finalizing the scheme and its view point discussed?	N.A.
78.	Has economic justification and viability of the Navigation component of the multipurpose project been discussed?	N.A.

	Power	
79.	Have the following points been discussed?	
	(a) Availability of the power generating capacity in the region from different sources	Yes.Refer page no.157 of Report volume.
	(b) Total energy available and peak capacity of the system	Yes. Refer page no.157 of Report volume.
	(c) Integrated operation of the system and present status of utilization	Yes
	(d) Surpluses and shortfalls in the system	Yes
	(e) Future plans of power development from different sources in the State/region.	Yes
	(f) Fitment of the scheme in planning of power development of the State/region	Yes
	(g) Energy generated from the project, firm power; seasonal power and total power	Yes
	(h) Proposal for transmission connecting to the existing system/grid	Yes
	(i) Cost of generation per kwh installed and per kwh generated as compared to the different hydro-electric projects and difference sources in the State/region to justify the power component of the project.	Yes.
	Construction Programme and Plant and Manpower Planning	
80.	Are the major components of work proposed to be done departmentally or through contractor	Through contractor
81.	Have the various alternative for construction programme been studied and proper justification furnished for the final programme adopted?	Yes.
82.	Has the proposed construction programme keen prepared and synchronized for timely completion of each of the major component of work including Command Area Development?	Yes
83.	Have the yea wise quantities of the following materials of construction been worked out for various components of the project:	
	(a) Excavation – soft and hard strata	Yes

	(b)Earthwork in filling-impervious, semi-pervious and pervious	Yes
	(c)Rockfill- dam, toe, rip rap, etc.	Yes
	(d) Stone for masonry	Yes
	(e) Coarse aggregate for concrete	Yes
	(f) Sand – filter, masonry, concrete	Yes
	(g) Gravel – filter	Yes
	(h) Steel of various sizes and type –reinforcement	Yes
	(i) Cement normal, quick/slow setting with or without pozzolana	Yes
	(j) Lime –surkhi-pozzolana	Yes
	(k) Scarce material – special steel	No
	(m) Other material – fuel, electricity, explosive, etc.	Yes
84.	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
85.	Have the labour intensive items of the various major components of the project been identified and the quantities of such items worked out?	Yes
	Foreign Exchange	
86.	Have the details of the plant and machinery, spares, instruments, scarce materials to be imported worked out and item wise justified?	Yes
87.	Has the phasing of imports and source(s) of imports been discussed item wise?	N.A.
88.	Are the imports to be affected under foreign grants/credits or internal resources of the country?	N.A.
	Financial Resources	
89.	(a) Has the concurrence of the Finance Department been obtained?	No. Yet to be obtained.
	(b) Whether the scheme has already been started? If so, is the present stage of construction indicated?	Yet to be started.

90.	Is the scheme included in the plan? If not, what is the present position regarding its inclusion in the plan?	To be included by G.O.I.
91.	Have the year wise requirement of funds been indicated?	Yes. Refer Annexure:12.1 of page no:530 of Report volume.
92.	Is the scheme covered under State sector or Central sector?	Joint sector with 90% funding by Central Govt. and the rest by M.P. & U.P. states.
93.	Is the scheme covered under any foreign assistance/aid agreement?	No.
	Estimate	
94.	Is the separate volume of estimate attached as appendix?	Yes. Refer Appendix volume-IV Cost estimate.
95.	Is the year to which the rates adopted in the estimate indicated?	Yes. Refer Page no:331 of Report volume.
96.	Have the analysis of rates for various major items of work for the major components of the project been furnished, with basis for analysis?	Yes. References to analysis of rates furnished in each annexure in Appendix volume-IV.
97.	Are the provisions for the following items made on the basis of sample survey and sub-estimates:	
	(a) Distributaries, minor and sub-minors	Yes. Refer page nos.205 & 307 of Appendix Vol-IV.
	(b) Water courses	Yes. Refer page nos.206, 315 of Appendix Vol-IV.
	(c) Drainage	Yes. Refer page nos.207, 316 of Appendix Vol-IV.
	Revenues	
98.	Are the basis for the following sources of revenues furnished?	
	(a) Betterment levy and proposal for its recovery	No revenue from Betterment levy considered.
	(b) Irrigation cess	Yes. Refer page no.348 of Report volume.
	(c) Flood protection cess	No
	(d) Cropwise water rates	No revenue from cropwise water rates considered.

	(e) Sale of water for village water supply	A rate of Rs.0.26/cum considered as prevailing in M.P. state.
	(f) Miscellaneous	Nil
99.	Have these rates been compared with the existing rates at the other projects in the State region?	Yes. Existing rates of the state government have been adopted.
100.	In case the rates are being enhanced, has the concurrence of the concerned departmentally been obtained?	As per prevailing adopted system.
101.	Have the organizational set up for the collection of revenue been indicated?	No. Existing system needs to be strengthened by M.P. & U.P. governments.
	B.C. Ratio	
102.	Are the allocated costs for the following components of the multipurpose project worked out and basis furnished?	
	(a) Irrigation	Yes. Refer Annexure:10.10 (page no:524) of Report volume.
	(b) Power	- do -
	(c) Flood Control	N.A.
	(d) Navigation	N.A.
	(e) Water supply	Yes
	(f) Any other	N.A.
103.	Have the various departments/State agreed to the sharing of the above allocated cost?	90% of the cost will be borne by Central government being declared as National Project and the rest will be decided by M.P. & U.P states after acceptance of this DPR.
104.	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?	Yes. Refer page no:517of Report Volume.
105.	Have the crop wise benefits been worked out for the proposed cropping pattern after the introduction of irrigation in consultation with the	Yes. Refer page no:517 of Report volume.

	agriculture department and statement furnished?	
106.	Is the B.C. ratio of Irrigation Projects acceptable or otherwise justified?	Yes. Refer page no:525 of Report volume.
107.	Is the B.C. ratio for Flood Control Projects acceptable or otherwise justified?	N.A.
108.	Have the following financial return statements been furnished keeping in view the phasing of development:	
	(a) Irrigation	Yes
	(b) Power	Yes
	Are the benefits other than considered in the B.C. ratio and financial return statement been identified?	Yes
	Ecological aspect	
109.	(a) Is the area likely to have any of the following environmental and ecological problems due to the altered surface water pattern and preventive measures discussed?	
	(i)Excessive sedimentation of the reservoir	Yes.
	(ii)Water logging	No
	(iii) Increase in salinity of the ground water	No
	(iv)Groundwater recharge	No. However, groundwater table will improve.
	(v) Health hazard-water borne diseases, industrial pollution, etc.	No
	(vi) Submergence of important minerals	Nil
	(vii) Submergence of monuments	Nil
	(viii)Fish culture and aquatic life	Yes. The same will be improved considerably due to the creation of the reservoir.
	(ix) Plant life – forests	Yes
	(x) Life of migratory birds	No. Same will be improved.
	(xi) National Park and sanctuaries	Some area of Panna tiger reserve will be affected due to submergence of Daudhan reservoir. However, major part of the affected area lies in the Ken river course only.

	(xii) Seismicity due to filling of reservoir	Nil
	(xiii) Any other	Nil
	(b) Has the concurrence of the Environmental Appraisal Committee been obtained?	Concurrence of the environmental appraisal committee of MOEF has been obtained for carrying out detailed surveys & investigations of this project. Final permission is yet to be obtained.
	Colonies and Buildings	
110.	Has the planning of the colony/building been done keeping in view the ultimate use for optimum utilization of the investment?	Yes.
111.	Has the estimate of the extent of higher cost involved been made and details discussed?	Yes.
112.	Are the permanent buildings being constructed required for maintenance for the project only?	Yes.
113.	Can the buildings other than required for maintenance of the project being constructed to put to some other use after the completion of the project by the department or any other agencies?	Yes. Refer page no: 362 of Report volume.
114.	Have the interested agencies been consulted in planning of the buildings to suit their requirements later on?	Not yet.
115.	Have the proposals for disposal of temporary buildings been discussed?	Yes.
	Public participation and Cooperation	
116.	Are the possibilities of these been discussed in:	
	(a) Planning	Yes.
	(b) Construction	No
	(c) Improved agricultural practices	N.A.
	(d) Any other	N.A.
	Soil Conservation	
117.	Is the need for soil conservation measures in the catchment of the project discussed?	Yes.

SECTION-2

SALIENT FEATURES

SECTION – II

SALIENT FEATURES

2.1 Name of the project : Ken – Betwa Link Project(Phase-I)

2.2 General

2.2.1 River basin

(a) Name: Ken basin

(b) Located in

(i)States : M.P/U.P.

(ii)Country : India

2.2.2 Name of

(a) River : Ken

(b) Tributary : --

(c) States : M.P./U.P.

(d) Districts :

i)Headworks	**:**	**Daudhan dam**
Districts		Chhatarpur & Panna (MP)
ii)Reservoir/Pondage	**:**	Chhatarpur & Panna (MP)
iii)Command area	**:**	
a) Ken command	**:**	Chhatarpur, Panna(MP), & Banda (UP)
b) Enroute command	**:**	Chhatarpur,Tikamgarh, (MP), Mahoba, Jhansi(UP)
iv) Power House-I & II	**:**	Chhatarpur (MP)

(e) Tehsils

i) Reservoir/ Pondage	**:**	Bijawar of Chhatarpur & Panna of Panna district(MP)
ii) Headworks	**:**	Bijawar, Panna
iii) Command area	**:**	
a)Ken command	**:**	Gaurihar,Laundi, Rajnagar, Chhatarpur, Nowgaon, Ajaygarh
b)Enroute command	**:**	Nowgong, Chhatarpur, Palera, Jatara, Niwari, Baldeogarh of MP & Kulpahar, Mauranipur, Tahrauli of UP
iv) Power house- I & II		Bijawar

f) Village near the Head works : Daudhan

2.2.3 Location of

2.2.3.1 Headworks	:	**Daudhan dam**
(a) Longitude	:	79⁰ 50′ 30″E
(b) Latitude	:	24⁰ 36′ 51″N

2.2.3.2 Project area reference to :

a) Degree sheets : 54L,54O,54P,55I,55M,63C,63D and 64A
b) Index plan : Plate No. 1.1

2.2.4 Access to the project

From / To	K-B Link canal	Daudhan dam
a) Airport	Khajuraho & Gwalior	Khajuraho (40 km)
b) Rail head	Khajuraho, Ranipur, Jhansi	Khajuraho (40 km)
c) Road head	Bamitha on NH-76 (Chhatarpur-Panna); Mauranipur on NH-76 and Jhansi	Bamitha on NH-76 (Chhatarpur-Panna) (28 km)
d) River head	Nil	Nil
e) Sea port	Nil	Nil

2.2.5 Estimated life of the projects (years) : 100

2.3 Type of project : Multipurpose project (Drinking water, Irrigation, Power Fishries, Tourism)

2.3.1 Irrigation (ha)

Details	Ken command			En route command			Total
	M.P.	U.P.	Sub-total	M.P.	U.P.	Sub-total	
Gross command area(GCA) :	321269	312073	633342	58164	17203	75367	701709
Culturable command area(CCA) :	241306	213610	454916	46531	13763	60294	515210
Annual Irrigation(ha)							
(a) Kharif :	144784	70534	215318	22368	6574	28941	244259
(b) Rabi :	178566	181483	360049	24231	7122	31353	391402
(c) Perenial :	--	--	--	--	--	--	--
Gross Irrigated area :	323350	252017	575367	46599	13695	60294	635661
Intensity of Irrigation (%) :	134	118		100	100		

(d) Cost per ha of Gross Irrigated area : Rs.1.48 lakh/ha

(e) i) **Cost per MCM of gross storage** : Rs.318.52 lakh

ii) **Cost per MCM of live storage** : Rs. 337.91 lakh

(f) Cost per 1000 cum of water delivered at the canal head/outlet : Rs.0. 875 lakh

2.3.2 Power

			Power House - I		Power House - II	
(a)	**Installed capacity**	:	60 MW		18 MW	
(b)	**Firm power(MW)**	:	--		--	
(c)	**Load factor(%)**	:	35.9		28.3	
(d)	**Seasonal(max.) power (MW)**	:	60		18	
(e)	**Annual energy(Mkwh)**		**Initial Scenario**	**Final Scenario**	**Initial Scenario**	**Final Scenario**
	(i) Firm	:	**--**	--	--	--
	(ii) Seasonal	:	188.51	158.32	50.14	41.10
	(iii) Total	:	188.51	158.32	50.14	41.10
(f)	**Cost per kw installed**	:	Rs.0.76 lakh			
(g)	**Cost per kwh at the bus bar**	:	Rs. 0.49			

2.3.3 Flood control

Daudhan dam

(a)	**Area protected from floods(ha)**	:	Due to the impoundment of water in Daudhan dam, there will be control of flood damages in d/s of this dam site in Ken river . However, the aspects like area protected, saving of flood damages,etc. have not been assesed in this DPR which can be studied at the pre-construction stage.
(b)	**Population protected from floods (No.)**	:	
(c)	**Average annual flood damage(Rs. Million)**		
	(i) Without project	:	
	(ii) With project (anticipated)	:	
(d)	**Safe carrying capacity of the river down stream (cumec)**		
	(i) Without project	:	
	(ii) With project (anticipated)	:	57202 cumec

2.3.4 Navigation : Not applicable

2.3.5 Water Supply — **Daudhan dam**

2.3.5.1 Domestic

(a)	**Names of towns/villages served**	:	Chhatarpur, Malhara, Jatara, Niwari, Pratvipur, Palera, Baldeogarh, Nowgaon, Lidhora, Ratausa
(b)	**Size of Population served (projected upto 2050AD)**	:	13.42 lakh
(c)	**Quantum of water made available (1000 cum)**	:	49000
(d)	**Quantum of water per capita (litre)**	:	Average demand considered 100 lpcd

2.3.5.2 Quantum of water for industrial use : Nil

2.3.6 Project performance

			Daudhan dam	
			Period of simulation months	**No. of failures months**
(a)	**Irrigation**	:	271	40
(b)	**Power**	:	271	
(c)	**Flood control**	:	--	--
(d)	**Water supply**	:	271	
(e)	**Navigation**	:	--	--

2.4 Hydrology

2.4.1 Catchment

2.4.1.1 Catchment area at head works site (km^2)

			Daudhan
(a)	**Gross**		19633
(b)	**Intercepted**		10194
	(i) By existing projects		
	(ii) By ongoing projects		
	(iii) By contemplated projects		
(c)	**Unintercepted**	:	9439

2.4.1.2 Catchment area

(a)	**Rainfed**	:	19633
(b)	**Snowfed**	:	Nil

2.4.2 Precipitation (mm)

2.4.2.1 Catchment - Period of record (1901-2005)

Weighted rainfall(mm) at Daudhan (1974-2003)

			Daudhan	
			Annual	**Mon-soon**
(a)	**Average**	:	1124	1054
(b)	**Maximum**	:	1604	1555
(c)	**Minimum**	:	560	503
(d)	**Co-efficient of variation**	:	0.24	0.25

2.4.2.2 Command

		Cropping season			
		Annual	Kharif (Jun-Oct.)	Rabi (Nov.-Feb.)	Hot weather (Mar.-May)
(i) Ken command					
(a) Average (mm)	:	1100.62	1018.99	61.87	19.76
(b) 80 percent dependable	:				
(c) ETo (mm)	:	1426.41	662.32	263.30	500.79
(ii) Enroute command					
(a) Average (mm)	:	1140.06	1058.20	59.88	21.98
(b) 80 percent dependable	:				
(c) ETo (mm)	:	1426.41	662.32	263.30	500.79

2.4.3 Gross Annual yield calculated at the proposed Daudhan site (MCM)
Period of record (from 1981 to 2004)

		Daudhan Gross
(a) Maximum	:	18304
(b) Minimum	:	3830
(c) Average	:	9289
(d) Annual Monsoon	:	

	Annual	Monsoon
(i) 50% dependable	8431	7799
(ii) 75% dependable	6590	5955
(iii) 90% dependable	4979	**4386**
(iv) 100% dependable	3830	**3355**

2.4.4 Climatic data

2.4.4.1 Command - Names of stations - Period of record

(i) Ken Command (Mean values)
Station : Banda
Period of record : 1951 - 80

		Normal	Maximum	Minimum
(a) Air Temperature(^{0}c)	:	33.3	43.1	9.1
(b) Humidity(Percent)	:	62	85	25
(c) Wind (km/hr)	:	2.3	4.5	0.8

(ii) En route command (Mean values)
Station : Nowgaon, Tikamgarh
Period of record : 1951 - 80

		Normal	Maximum	Minimum
(a) Air Temperature(^{0}c)	:	32.5	42.3	7
(b) Humidity(Percent)	:	65	88	15
(c) Wind (km/hr)	:	4.8	9.3	1.8

2.4.5 Utilisation within the State (MCM)

2.4.5.1 States share in case of interstate river **MP : 2379.62 UP:1700**

2.4.5.2 Committed utilisation

		Major	Medium	Minor	Total
(a) Upstream projects (Daudhan)					
(i) Projects completed	:	--	34	171	205
(ii) Projects under construction	:	--	--	38	38
(iii) Future projects	:	888	517	464	1869
(iv) Any other	:	--	--	--	--
(b) Down stream projects (Daudhan)		**Major**	**Medium**	**Minor**	**Total**
(i) Projects completed	:	1998	--	--	1998
(ii) Projects under construction	:	--	--	--	--
(iii) Future projects	:	1008	--	--	1008
(iv) Any other	:	--	--	--	--

2.4.5.3 Proposed utilisation by the project (MCM)

		Ken Command		En route command	
		U.P.	**M.P.**	**U.P.**	**M.P.**
(a) Kharif	:	1081.04	758.00	60.83	189.67
(b) Rabi	:	518.96	647.63	28.04	87.45
(c) Total	:	1600.00	1405.63	88.87	277.12

2.4.6 Floods near the head work site

2.4.6.1 Historical period of record

(a) Maximum water level (El-m)		240
(b) Maximum discharge estimated(cumec)		20150
(c) Year of occurence, date		2005

2.4.6.2 Observed period of record (Observed at Madla on Ken)

(a) Maximum water level (El-m)		185.45
(b) Maximum discharge estimated(cumec)		20150
(c) Year of occurence, date		6th July 2005

		Daudhan dam
2.4.6.3 Standard project flood (cumec)		55099.0
2.4.6.4 Maximum probable flood (cumec)	:	57202

2.4.6.5 Flood frequency		**Daudhan**
(a) 50 year	:	--
(b) 100 year	:	30794
(c) 1000 year	:	42675.2

2.4.6.6 Design flood(cumec)		
(a) Dam	:	57202
(b) Weir/Barrage	:	--
(c) Flood control works/ construction diversion	:	1118

2.4.6.7 River flows (Minimum observed)		
(a) Water level (El-m)	:	Not readily available
(b) Discharge(cumec)	:	
(c) Months of 'nil' flow	:	

			Daudhan dam
2.5	**Reservoir**		
2.5.1	**Water levels (El-m)**		
	(a) Maximum water level	:	288.000
	(b) Full Reservoir level/Pond level	:	288.000
	(c) Minimum draw down level	:	246.000
	(d) Dead Storage level	:	240.000
2.5.2	**Free Board (m)**	:	5.0
2.5.3	**Wave height (m)**	:	4.13
2.5.4	**Live storage (MCM)**	:	2683.74
2.5.5	**Capacity (MCM) at**		
	(a) Maximum water level	:	2853.01
	(b) Full Reservoir level	:	2853.01
	(c) Minimum draw down level	:	344.75
	(d) Dead Storage level	:	169.27
2.5.6	**Flood absorption capacity (MCM)**		
	(a) Below FRL	:	
	(b) Between FRL & MWL	:	

			Years	
2.5.7	**Sedimentation (MCM) after**		50	100
	(a) Above MDDL	:	85.7	98.0
	(b) Below MDDL	:	120.4	263.7
	(c) Encroachment of Live storage (percent)	:	4.4	9.58

2.5.8	**Assumed Annual Evaporation losses from the reservoir**		
	(a) Quantum (MCM) Average	:	91.90
	(b) Depth (m)	:	1.8352

			Daudhan dam
2.6	**Submergence**		
2.6.1	**Land and property submerged**		At MWL/FRL
	(a) Villages affected (No.)		
	(i) Full	:	10
	(ii) Partial	:	
	(b) Land affected(ha)		
	(i) Gross	:	9000
	(ii) Culturable	:	2473
	(iii) Irrigated	:	542
	(c) Building/houses(No.)	:	1585
	(i) Private	:	
	(ii) Communities	:	
	(d) Wells (No.)		
	(e) Road/Rail(km)	:	
	(f) Transmission	:	
	(g) Any other	:	
2.6.2	**Submergence ratio (with reference to CCA)**		0.0042
2.6.3	**Number of families affected**		1585

			Daudhan dam
2.6.4	**Number of persons affected**	:	7224
2.6.5	**Anticipated back water levels at important places along the periphery of the reservoir(m)**	:	288.000

2.7 Head works

2.7.1 Dam

2.7.1.1 Earth and Rock fill dam

		:	
(a)	**Type of dam (Homogenous/Zoned/Rock-fill)**		Earth dam(zoned)
(b)	**Length of dam at top (m)**		
	(i) Right flank	:	
	(ii) Left flank	:	1233
(c)	**Top width (m)**	:	8
(d)	**Maximum height above G.L.(m)**	:	
	(i) Right flank	:	77
	(ii) Left flank	:	--
(e)	**Dyke(s)**		
	(i) Number	:	Nil
	(ii) Total length	:	
	(iii) Maximum height (m)	:	
(f)	**Type of cut off and maximum**	:	18
	depth(m) (Upstream blanket/	:	Open trench
	Open trench/diaphragm/grout curtain combination of alternatives)		type

2.7.1.2 Masonry and Concrete dam (Non over flow section)

			Daudhan dam Left side
		:	
(a)	**Type of dam (Masonry/Concrete/ composite/any other**		Concrete
(b)	**El of top (m)**	:	293.000
(c)	**El of deepest foundation (m)**	:	232.000
(d)	**Length at top (m)**	:	262.00
(e)	**Length at the river bed (m)**	:	
(f)	**Width at top (m)**	:	8.00
(g)	**Width at deepest bed level(m)**	:	51.60
(h)	**Maximum height above deepest foundation level (m)**	:	61.00

2.7.1.3	**Spillway (over flow section)**			
	(a)	**Type of spillway (Ogee/chute/side channel/ tunnel/siphon/any other type)**	:	Side channel
	(b)	**Full reservoir level (El-m)**	:	288.000
	(c)	**Maximum water level (El-m)**	:	288.000
	(d)	**Length (m)**	:	536.000
	(e)	**Maximum height above the deepest foundation level (m)**	:	70m
	(f)	**Crest level (El-m)**	:	270.000
	(g)	**Number of gates**	:	27
	(h)	**Type of gate**	:	Radial
	(i)	**Size of gate (m)**	:	16 x 18.5
	(j)	**Maximum discharging capacity (cumec) at FRL and MWL**	:	57202
	(k)	**Flood lift (m)**	:	--
	(l)	**Tail water level (El-m)**		
		(i) Maximum	:	241.000
		(ii) Minimum	:	233.000
	(m)	**Type of energy dissipation arrangement**	:	Ski-jump bucket type
2.7.1.4	**River sluice(s), Irrigation, Power outlet(s)**			
	(a)	**Purpose**	:	Irrigation
	(b)	**Number**	:	2
	(c)	**Size(m)**	:	1.6 x 2.4
	(d)	**Sill level(El-m)**	:	237.200
	(e)	**Discharging capacity(cumec) at**		
		(i) Full reservoir level	:	
		(ii) Minimum draw down level	:	40 .00
2.7.2	**Barrage**		:	No barrage proposed
2.7.2.1	**Location with respect to dam**		:	
2.7.2.2	**Length (m)**		:	
2.7.2.3	**Spillway bays**			
	(a)	**Total length (m)**	:	
	(b)	**Full Pond Level (El-m)**	:	
	(c)	**Maximum water level (El-m)**	:	
	(d)	**Maximum height of spill way (crest) above deepest foundation level (m)**	:	
	(e)	**Length of bay (m)**	:	
	(f)	**Crest level (El-m)**	:	
	(g)	**Number of gates**	:	
	(h)	**Type of gate**	:	
	(i)	**Size of gate (m)**	:	
	(j)	**Type of energy dissipation arrangement**	:	
	(k)	**Maximum discharging capacity (cumec)**	:	
	(l)	**Tail water level (El-m)**		
		(i) Maximum	:	
		(ii) Minimum	:	

2.7.2.4 Under sluice bays

(a)	**Total length(m)**	**:**
(b)	**Maximum height of under sluice(crest above deepest foundation-m)**	**:**
(c)	**Length of bay (m)**	**:**
(d)	**Sill level (El-m)**	**:**
(e)	**Number of gates**	**:**
(f)	**Type of gate**	**:**
(g)	**Size of gate (m)**	**:**
(h)	**Type of energy dissipation arrangement**	**:**
(i)	**Maximum discharging capacity of under sluice (cumec)**	**:**
(j)	**Silt excluder tunnel(s)**	
	(i) Number	**:**
	(ii) Length(m)	**:**
	(iii) Size (m)	**:**
	(iv) Floor level (El-m)	**:**

2.7.2.5 Guide bunds/Afflux bunds

No guide bund is proposed in this project

(a)	**Guide bunds length(m)**	
	(i) Upstream	**:**
	(ii) Down stream	**:**
	(iii) Top level (El-m)	**:**
(b)	**Afflux bunds length(m)**	**:**
	and top level (El-m)	**:**
(c)	**Other protective works (if any)**	**:**

2.7.3 Weir

No weir is proposed in this project

2.7.3.1 Details of weir

(a)	**Type of weir (Concrete/Masonry/ Any other type)**	**:**
(b)	**Length of weir (m)**	**:**
(c)	**Deepest foundation(El-m)**	**:**
(d)	**Type of energy dissipation arrangement**	**:**
(e)	**Crest level (El-m)**	**:**
(f)	**Maximum water level (El-m)**	**:**
(g)	**Tail water level (El-m)**	
	(i) Maximum	**:**
	(ii) Minimum	
(h)	**Maximum discharging capacity (cumec)**	**:**

2.7.4 Head regulator(s) :

No head regulator is proposed since the link canal has been proposed to draw water through Upper Level Tunnel.

(a)	**Total length (m)**	**:**
(b)	**Height above deepest foundation (m)**	**:**
(c)	**Length of bay (m)**	**:**
(d)	**Sill level (El-m)**	**:**
(e)	**Number of gates**	**:**
(f)	**Size of gates**	**:**
(g)	**Number of silt excluder bays**	**:**
(h)	**Type of energy dissipation arrangement**	**:**

		Daudhan	
2.8	**Canal system**	Ken LBC	K-B link
2.8.1	**Main canal**		
2.8.1.1	**Purpose of canal (Irrigation/Power/Navigation/ Diversion/Water supply/ Multipurpose)**	Irrigation/ Power	Irrigation/ Diversion / Water Supply
2.8.1.2	**Type**		
	(a) Flow/Lift	Flow	Flow
	(b) Lined/Un lined	Lined	Lined
	(c) Discharging capacity(cumec) of the channel above which lining is proposed	65.19	76.23
	(d) Type of lining	C.C lining	C.C lining
2.8.1.3	**Main canal data**		
	(a) Length (km)	57.3	218.7
	(b) Full supply level at head (El-m)	246.340	257.000
	(c) Full supply depth at head (m)	3.81	3.44
	(d) Bed width at head(m)	11.59	13.2
	(e) Side slope at head	2:1 to 1.5:1	1.5 : 1
	(f) Bed slope (range)	1 in 6000	1 in 9000
	(g) Maximum Discharging capacity at head (cumec)	65.19	76.23
	(h) Total number of canal structures on main canal and branch canals	309 on Main canal	80 on Main canal
	(i) Total assumed losses across the structure(m)		3.01
	(j) Gross command area (ha)	323350	75367
	(k) Culturable command area (ha)	241306	60294
2.8.1.4	**Branch canal(s)**		
	(a) Number		29
	(b) Total length (km)		160.6
2.8.1.5	**Total length of distribution system upto minimum discharge capacity of 24 cusec**		
2.8.2	**Efficiencies (percent)**		
	(i) Conveyance	75	75
	(ii) Field application	65	65

2.9 Cropping pattern(%)

		Ken M.P. command		Ken U.P. command		En route command	
2.9.1 Name of crop season-wise		**Exi-sting**	**Pro-posed**	**Exi-sting**	**Pro-posed**	**Exi-sting**	**Pro-posed**
(a) Kharif							
(i) Paddy	:	3.18	12.0	3.2	18.5	3.6	27.0
(ii) Jowar	:		13.0		8.4	13.5	2.0
(iii) Bajra	:				1.1	1.1	2.0
(iv) Maize	:					0.9	2.0
(v) Pulses	:	3.0	15.0	3.0	5.1	4.9	4.0
(vi) Oil seeds	:		12.0			0.3	
(vii) Vegetables	:		8.0				4.0
(viii) Groundnut	:					1.4	5.0
(ix) Fodder	:						2.0
(x) Others	:	36.72		36.7		9.1	
Sub-total	:	**42.9**	**60.0**	**42.9**	**33.0**	**34.8**	**48.0**
(b) Rabi							
(i) Wheat(HYV)	:		40.0				
(ii) Wheat (Local)	:	21.29	5.0	21.3	38.4	31.6	32.0
(iii) Gram	:		8.0		32.2	25.8	2.0
(iv) Linseed	:		5.0				
(v) Sunflower	:		5.0				
(vi) Barseem	:		3.0				
(vii) Masoor	:		8.0		11.8	5.1	
(viii) Toriya	:				0.1		
(ix) Mustard	:				0.6		
(x) Alsi	:				1.2		
(xi) Barley	:				0.4	0.8	
(xii) Peas	:				0.2	0.7	
(xiii) Vegetables	:						6.0
(xiv) Pulses	:						4.0
(xv) Fodder	:						4.0
(xvi) Oil seeds	:					1.3	4.0
(xv) Others		38.68		38.7			
Sub-total	:	**59.97**	**74.0**	**60.0**	**85.0**	**65.2**	**52.0**
(c) Perennial							
(i) Sugarcane	:	0.13		0.1			
(d) Total	:	**103**	**134**	**103**	**118**	**100**	**100**

2.10 Power

2.10.1 Head Race

Tunnel for PH-II (Lower level tunnel)

- **(a) Length(m)** : 1.1 km
- **(b) Shape** : Modified horse shoe
- **(c) Size(m)** : 5.5
- **(d) Thickness of lining(m)** : 0.35
- **(e) Designed discharge(cumec)** : 65.19
- **(f) Invert level at (El-m)**
  - **(i) Inlet** : 244.60
  - **(ii) Outlet** : 243.20
- **(g) Free flow/Pressure(m)** : Free flow

2.10.2 Balancing Reservoir — No balancing reservoir is proposed.

(a)	Capacity(1000 cum)	:	
(b)	Full reservoir level (El-m)	:	
(c)	Maximum reservoir level (El-m)	:	
(d)	Live storage (1000 cum)	:	
(e)	Balancing periods(hrs)	:	

2.10.3 Forebay — No forebay is proposed.

(a)	Size of forebay(m)	:	
(b)	Sill level of forebay(El-m)	:	
(c)	Full reservoir level (El-m)	:	
(d)	Maximum reservoir level (El-m)	:	
(e)	Number of off takes	:	
	(i) Size (m)	:	
	(ii) Invert level(El-m)	:	
	(iii) Capacity (cumec)	:	
(f)	Maximum discharging capacity (cumec)	:	

2.10.4 Surge tank/shaft — At the end of Lower level tunnel

(a)	Type	:	Restricted orifice type,Circular
(b)	Size (m)	:	18 m dia
(c)	Height above foundation level (m)	:	60
(d)	Top level (El-m)	:	305.000
(e)	Capacity (1000 cum)	:	
(f)	Surge level (El-m)		
	(i) Maximum	:	295.000
	(ii) Minimum	:	255.000

2.10.5 Penstocks/pressure shafts

			P.H.-I	P.H.-II
(a)	Number	:	2	3
(b)	Diameter(m)	:	4.5	2.4
(c)	Length(m)	:	84.35	120
(d)	Size of gate (m)	:		
(e)	Bifurcations, if any, at lower end	:		
(f)	Invert level(m)	:	240.750	238.800

2.10.6 Power house

			P.H.-I		P.H.-II	
(a)	Type(Surface/underground)	:	Surface		Surface	
(b)	Head (m)		Gross	Net	Gross	Net
	(i) Maximum	:	54.0	52.92	42.00	39.90
	(ii) Minimum	:	18.0	17.28	14.00	12.88
	(iii) Average	:	43.3	41.60	32.67	29.70
	(iv) Design	:	42.0	41.00	32.67	30.50
(c)	Dimensions(m)	:	88.5 x 22		82.5 x 29	
(d)	Installed capacity(MW)	:	60		18	
(e)	Turbine(s)					
	(i) Type	:	Vertical shaft, Kaplan		Vertical shaft, Kaplan	
	(ii) Number	:	2		3	
	(iii) Capacity (hp)	:	30		6	
(f)	Type of generator	:	3 Phase, core or shell		3 Phase, core or shell	
(g)	Number of standby unit(s)	:	Nil		Nil	

2.10.7 Tail Race

			PH-I	PH-II
(a)	**Length(m)**	:	405	255
(b)	**Water level(El-m)**			
	(i) Maximum	:	234.000	246.000
	(ii) Minimum	:	234.000	246.000
(c)	**Size of draft tube gates(m)**	:	5 x 4.4	5 x 4.0

2.11 Cost

2.11.1 Cost of the project(Rs. Lakhs)(Unit wise)

Unit-I	Unit-II	Unit-III	Unit-VI	Total
623587.71	**281556.65**	**34154.20**	**18759.78**	**939298.56**

2.11.2 Allocated cost (Rs. Lakhs)

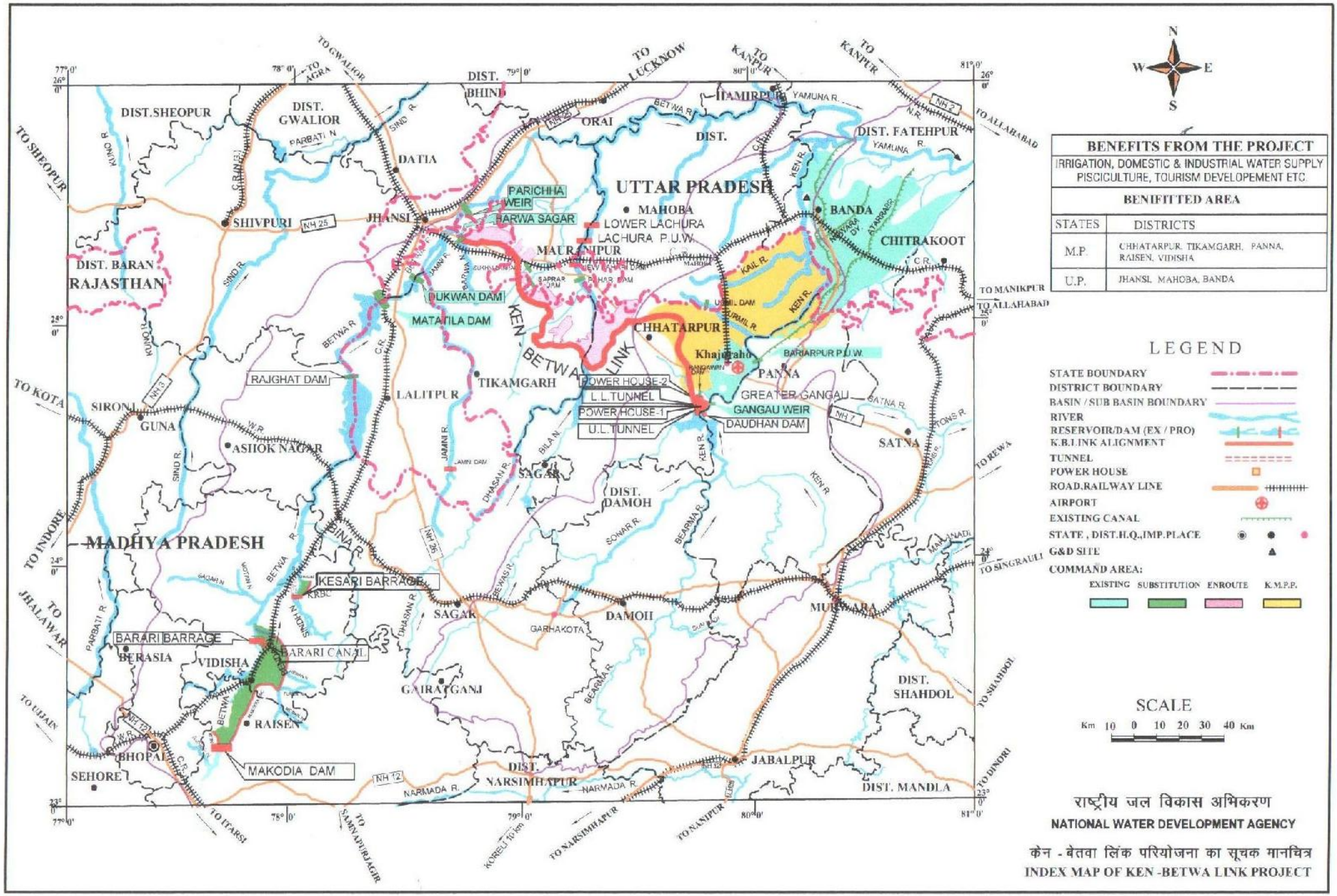
(a)	**Irrigation**	:	879951.64
(b)	**Power**	:	59346.92
(c)	**Flood control**	:	Nil
(d)	**Navigation**	:	Nil
(e)	**Water Supply**	:	Included in Irrigtion component above.
(f)	**Any other**	:	Nil.

2.12 Benefits/Revenue

			Quantity	Value (Rs.lakhs)	Revenue (Rs.lakhs)
(a)	**Food Production(Tonne)**	:	1902275	235126.52	136998.93
(b)	**Power (Mkwh)**	:	219.03		6570.90
(c)	**Flood Protection(ha)**	:	Nil		0.00
(d)	**Navigation (Tonnage)**	:	Nil		0.00
(e)	**Water Supply (Population served)**	:	13 lakhs		127.40
(f)	**Any other (fisheries)**	:	1300 tonnes		442.00
(g)	**Tourism**	;			100.00

2.13 Benefit cost ratio

(a)	**B.C. ratio**	:	1.56:1
	(i) Irrigation component	:	1.56:1
	(ii) Flood control component	:	Not worked out
	(iii) Power	:	1.46:1
(b)	**No. of years when accumulated deficit is wiped out.**	:	
(c)	**Percentage return per annum after the deficit is wiped out (shall not be less than 11.5 percent)**	:	12.00%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S
BENEFITS FROM THE PROJECT
IRRIGATION, DOMESTIC & INDUSTRIAL WATER SUPPLY
PISCICULTURE, TOURISM DEVELOPEMENT ETC.
BENIFITTED AREA
STATES
DISTRICTS
M.P.
CHHATARPUR, TIKAMGARH, PANNA, RAISEN, VIDISHA
U.P.
JHANSI, MAHOBA, BANDA
LEGEND
STATE BOUNDARY
DISTRICT BOUNDARY
BASIN / SUB BASIN BOUNDARY
RIVER
RESERVOIR/DAM (EX / PRO)
K.B.LINK ALIGNMENT
TUNNEL
POWER HOUSE
ROAD,RAILWAY LINE
AIRPORT
EXISTING CANAL
STATE , DIST.H.Q.,IMP.PLACE
G&D SITE
COMMAND AREA:
EXISTING
SUBSTITUTION
ENROUTE
K.M.P.P.
SCALE
Km 10 0 10 20 30 40 Km
UTTAR PRADESH
MADHYA PRADESH
RAJASTHAN
DIST. BHIND
DIST.SHEOPUR
DIST. GWALIOR
DIST. BARAN
DIST. FATEHPUR
DIST. DAMOH
DIST. NARSIMHAPUR
DIST. SHAHDOL
DIST. MANDLA
DATIA
ORAI
HAMIRPUR
BANDA
CHITRAKOOT
SHIVPURI
JHANSI
MAHOBA
LOWER LACHURA
LACHURA P.U.W.
MAURANIPUR
PARICHHA WEIR
HARWA SAGAR
DUKWAN DAM
MATATILA DAM
KEN - BETWA LINK
CHHATARPUR
Khajuraho
BARIARPUR P.U.W.
PANNA
GREATER GANGAU
GANGAU WEIR
DAUDHAN DAM
POWER HOUSE-2
L.L.TUNNEL
POWER HOUSE-1
U.L.TUNNEL
RAJGHAT DAM
LALITPUR
TIKAMGARH
SIRONJ
GUNA
ASHOK NAGAR
SAGAR
SATNA
KESARI BARRAGE
SAGAR
DAMOH
MURWARA
BARARI BARRAGE
BERASIA
VIDISHA
BARARI CANAL
GAIRATGANJ
RAISEN
BHOPAL
SEHORE
MAKODIA DAM
JABALPUR
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KEN R.
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TONS R.
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TO GWALIOR
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TO LUCKNOW
TO KANPUR
TO ALLAHABAD
TO MANIKPUR
TO SHEOPUR
TO KOTA
TO INDORE
TO JHALAWAR
TO UJJAIN
TO ITARSI
TO SAMNAPUR JAGIR
TO NARSIMHAPUR
TO NAIPUR
TO DINDORI
TO REWA
TO SINGRAULI
KORELI 10 km
राष्ट्रीय जल विकास अभिकरण
NATIONAL WATER DEVELOPMENT AGENCY
केन - बेतवा लिंक परियोजना का सूचक मानचित्र
INDEX MAP OF KEN -BETWA LINK PROJECT

SECTION-3

REPORT

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EXECUTIVE SUMMARY

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1.0 National Perspective for Water Resources Development

The erstwhile Union Ministry of Irrigation and Central Water Commission formulated, in the year 1980, National Perspective Plan (NPP) for water resources development comprising of following two components:

a) The Himalayan Rivers Development, and
b) The Peninsular Rivers Development

The distinctive feature of the National Perspective Plan is that the transfer of water from surplus basin to deficit basin would essentially be by gravity and only in small reaches, it would be by lifts not exceeding 120 metres. These two components are briefly outlined in the following paragraphs.

(a) Himalayan Rivers Development

Himalayan Rivers Development envisages construction of storage reservoirs on the principal tributaries of the Ganga and the Brahmaputra in India, Nepal and Bhutan, along with inter-linking canal systems to transfer surplus flows of the eastern tributaries of the Ganga to the west, apart from linking of the main Brahmaputra and its tributaries with the Ganga and Ganga with Mahanadi and augmentation of flow at Farakka.

(b) Peninsular Rivers Development

This component is divided into four major Parts:

(i) Interlinking of Mahanadi-Godavari-Krishna-Pennar-Cauvery rivers and building storages at potential sites in these basins
(ii) Interlinking of west flowing rivers, north of Mumbai and south of the Tapi
(iii) Interlinking of Ken-Chambal Rivers
(iv) Diversion of other west flowing rivers

National Water Development Agency (NWDA) has identified 14 links under Himalayan Component and 16 links under Peninsular Component for preparation of Feasibility Reports/Detailed Project Reports.

Third part of Peninsular link of NPP was firmed as two links viz, Ken-Betwa link and Parbati-Kalisindh-Chambal link.

2.0 MoU amongst Centre and concerned States for preparation of DPR & Inter-State Aspects

Ken-Betwa Link is one of the 16 links under Peninsular Component of National Perspective Plan for Water Resources Development for which feasibility report was prepared by NWDA in the year 1995 and circulated among all concerned. Since then efforts were being made by NWDA, CWC and Ministry of Water Resources to arrive consensus between two beneficiary States of Uttar Pradesh (UP) and Madhya Pradesh (MP). Finally consensus was arrived at among Centre and concerned States and a tripartite Memorandum of Understanding was signed by Madhya Pradesh, Uttar Pradesh and the Union Government on 25th August 2005 for preparation of Detailed Project Report (DPR) of Ken-Betwa link.

Subsequently, the work of preparation of DPR was entrusted to NWDA by Ministry of Water Resources in January 2006. NWDA has prepared the DPR with active cooperation of the concerned state Governments, Central Water Commission (CWC), Central Electricity Authority (CEA) and other Central Government Organizations like Central Soil & Material Research Station (CSMRS), National Institute of Hydrology (NIH), Geological Survey of India (GSI), National Remote Sensing Agency (NRSA), Indian Institute of Technology (IIT), etc. The comprehensive Environmental Impact Assessment (EIA) & Resettlement & Rehabilitation (R&R) studies have been carried out by AFC Ltd, as per the terms & conditions approved by Ministry of Environment & Forest. Ministry of Water Resources had constituted a Committee headed by Chairman, CWC to monitor and supervise the overall work of preparation of DPR of Ken-Betwa Link. This Committee held seven meetings during last 3 years and gave guidance to NWDA for expeditious completion of the DPR. Engineer-in-Chiefs of both the States of UP & MP were also represented in the said Committee to give their views from time to time. A Steering Committee headed by Secretary, Ministry of Water Resources also reviewed the progress of work from time to time.

Accordingly, DPR was completed by NWDA in December 2008 and was sent to the concerned States i.e. UP and MP for their concurrence. Govt. of MP sent an alternative proposal in Upper Betwa basin and Govt. of UP sent its comments with a request to include cost of renovation of Bariyarpur Barrage and Parichha weir in the Phase-I of Ken-Betwa Link Project.

In order to sort out various issues for the finalization of DPR and future strategy for implementation of Ken-Betwa Link, Secretary Level Meeting was held on 03.02.2010 at New Delhi under the Chairmanship of Secretary, MoWR with Principal Secretaries of UP & MP. Senior Officials of MoWR/CWC/NWDA and State Govt. of UP & MP also participated in the meeting. During the meeting various issues raised by both the states on the DPR were discussed and finalized. It was decided that the DPR of the project will be prepared in two phases. In Phase-I, Daudhan dam, two power houses, link canal and their other components will be completed by April, 2010. The projects suggested by the Govt. of MP for Upper Betwa basin, will be taken up in Phase-II after completion of their Survey & Investigation work and examining their techno economic viability.

The DPR of Ken-Betwa Link Project (Phase-I) is prepared in 3 parts viz., Report, Appendices and Drawings. The Report part including connected Annexures are contained in single Report Volume. The data & detailed reports of various expert agencies associated with the work are contained in Appendix Volume I to III, where as Appendix volume-IV contained details of cost estimate. All the relevant drawings are furnished in Drawing Volume I, II A & II B.

As per existing interstate agreement between Govts. of MP and UP signed in the meeting with Secretary, Irrigation, Govt. of India, held at New Delhi on 10.12.1981, the share of U P under Ken system is 1047.84 MCM(37 TMC) including share of Rangwan Dam. However, as per the proposed water sharing (agreed by both M P and U P) for Ken-Betwa link project, UP will now be entitled for enhanced allocation of 1700 MCM(60 TMC) based on 75% dependable yield of 6188 MCM at Daudhan dam. Rest of the water in Ken system will be utilized by M P including environmental releases.

3.0 Aim & Objective of the Project and Description of works

The main objective of the Ken-Betwa link project, Phase-I is to make available water to water deficit areas of upper Betwa basin through substitution from the surplus waters of Ken basin. As per NWDA study, the Ken river basin upto the Greater Gangau dam site was found to be water surplus. Accordingly, toposheet study and preliminary feasibility study of Ken-Betwa link were carried out. To firm up the proposal further, Survey & Investigation works were carried out for preparation of Feasibility Report of Ken-Betwa link for diverting surplus waters of Ken to water short areas of Betwa basin. As per Feasibility Report prepared in 1995, it was found that the proposal is techno- economically viable. The proposal comprised of a dam across the Ken river upstream of the existing Gangau Weir and a link canal for transferring the surplus waters from Ken river to Betwa river. However, several alternative schemes proposed by Govt. of MP to

utilise water by substitution in Betwa Basin will be taken up simultaneously under Phase-II of the Ken-Betwa Link Project. The quantity of water initially proposed to be diverted from Ken basin, after considering in-basin demands including upstream and downstream commitments at Feasibility study stage, was 1020 MCM. However, after updating of hydrological studies at DPR stage, it is now proposed to transfer 1074 MCM of Ken water through link canal, out of which 591 MCM of water will be delivered to Betwa river. This link project has made Upper Betwa Projects feasible by way of substitution which were earlier not feasible hydrologically.

4.0 Interlinking of the Proposed Project with other Existing and Future projects

Gangau weir is a pre-independence era major project on main Ken river. In its downstream, another weir has been constructed at Bariarpur. From its right bank, Ken canal takes off to provide irrigation in Banda district of U P Left Bank canal from Bariarpur headworks is under construction to provide irrigation to command area in M P In Ken-Betwa Link Project, it has been proposed to release 1600 MCM of water through Daudhan dam to provide irrigation to Right Bank Canal command of Ken lying in Banda district of U P and 398 MCM of water to provide irrigation to Left Bank Canal command of MP which was originally proposed by Govt. of M P for their Ken Multi-Purpose Project. Govt. of U P may decide to utilize the 1600 MCM of water for other purpose also viz. to meet the requirement of d/s projects, needs of domestic & industrial water supply, etc. in addition to irrigation requirement in their territory. Similarly, major portion of Ken command lying in M P at higher elevation is proposed to be provided 1007 MCM of irrigation water through Lower Level Tunnel of Daudhan dam. The irrigation projects above Daudhan dam site are listed below:

Sl.no.	Category	Existing	Ongoing	Proposed
1.	Major	Nil	Nil	7 nos.
2.	Medium	1 no.	Nil	19 nos.
3.	Minor	172 nos.	23 nos.	368 nos.

In order to ensure availability of water for existing, ongoing and proposed projects in upper catchment of Daudhan dam, a quantum of 2266 MCM of water has been earmarked so that even after construction of these projects in future, there would be no adverse impact in planning of Ken-Betwa Link Project.

5.0 Methodology Adopted

Feasibility Report prepared by NWDA formed the basis for proceeding further for preparation of DPR and make suitable changes based on detailed

survey & investigations, updated hydrological studies, irrigation planning studies and other studies. DPR of this project has been prepared by NWDA utilizing the services of Government Departments like CWC, CEA, CSMRS, NIH, GSI and Reputed Educational Institutions/other Govt. Organizations like Indian Institute of Technology, Roorkee & Delhi, NRSA, Hyderabad and Agricultural Finance Corporation Limited, Hyderabad. Topographical surveys of dam axis, canals, tunnels, barrage axis, command area surveys, etc. were done departmentally by NWDA. However, private parties were engaged where Government agencies were not available for completing the work in time bound manner like drilling work and submergence area survey. Under this model, the work of preparation of DPR was monitored and supervised by the Committee headed by Chairman, Central Water Commission which helped NWDA in accomplishing this task in a given time frame. A steering committee under Secretary (WR) also reviewed the progress of various works from time to time.

5.1 Data Collection

The preparation of DPR of the Ken-Betwa link project required various data/ information. Data/information required by Design Organisation of CWC was collected during field surveys. Rainfall and Meteorological data were collected from IMD, Pune whereas hydrological observation data and ground water data were collected from CWC and CGWB respectively and supplied to NIH, Roorkee for Hydrological Studies and IMO, CWC for Irrigation Planning Studies. Data regarding cropping pattern, Yield of crop per ha, Cost of produce, Cost of cultivation etc were collected from State Agriculture Departments and made available to CWC. DPR of Ken Multi Purpose Project (KMPP) was collected from State Water Resources Department for its use in case of planning of Ken command in M P Test Results/Outputs given by CSMRS, GSI, IIT, Roorkee and Delhi formed inputs for Designers of the project. The Working Table finalized by CWC formed input for Power Potential Studies by CEA whereas output given by CEA in the form of Power potential Studies formed input for Civil Design of hydel power structures. Thus there were many inter-dependent activities, apart from normal data collection. All these activities were successfully managed by NWDA Officers and various data required by the Consultants were supplied to them for the preparation of DPR of Ken Betwa link project.

5.2 Planning and Layout

Daudhan dam proposed across Ken river is 2031 m long, out of which 1233 m length of dam will be earthen and rest 798 m length of dam will be of concrete. Concrete portion of dam alongwith spillway has been proposed on the left flank of the dam. A penstock is proposed in left concrete portion of dam for taking water to Power house(PH-I) located at the toe of the dam. Tail Race

Channel off-taking from PH-I will join Ken river again in d/s of the Dam on left bank.

For providing irrigation water to enroute command of link canal, an Upper Level Tunnel (1.929 km long) with Invert level and Crown level of 256.0m and 262.0m respectively at the mouth of Daudhan reservoir has been proposed. Diameter of the proposed tunnel is 6.0 m whereas slope of the tunnel is 1:800. This tunnel takes off from the left bank of Ken river in upstream of Daudhan dam. Invert level of Upper Level Tunnel at the exit point is 253.5m. After provision of energy dissipation device at the exit of tunnel, the link canal will take off with FSL of 257.0m and Full supply depth of 3.44 m.

From the left bank of Ken river in upstream of Daudhan dam but in the downstream of Upper Level Tunnel, another tunnel i.e. Lower Level Tunnel of 5.5m dia. takes off. Invert level and Crown level of Lower Level Tunnel at its inlet are 244.6m and 250.1m respectively. Power house-II (PH-II) having installed capacity of 18 MW is proposed at its outlet. After generation of power, water will be taken through Ken LBC to provide irrigation water to 1.73 lakh ha., out of total 2.41 lakh ha. of Ken command in M P as proposed in KMPP. Rest of Ken command will be provided irrigation through canal taking off from Bariarpur Headworks. Provision of bye pass channel has also been made for supplying water to the canal directly from tunnel in case PH-II does not run. However, to take care of similar situation in PH-I, sluices have been provided in the dam.

5.3 Surveys & Investigations

Just after signing of MOU, in August 2005, a team of officers started reconnaissance survey of Daudhan Dam area and link canal where NWDA has carried out surveys & investigations at feasibility stage in early nineties. This team located alignment pillars fixed along dam axis and link canals and bench marks. Team of Senior Officers of NWDA & CWC also visited the site.

Based on site visit, two Sub-Divisions at Chhatarpur, Jhansi were initially opened by NWDA in December 2005 to co-ordinate various activities of preparation of DPR of Ken-Betwa link project Phase-I. This work was assigned to NWDA in January 2006. In April 2006, Jhansi sub-division was upgraded to Division. Permission was required to be obtained for doing surveys & investigations in Park as well as Non-Park area from Forest Authorities as Daudhan dam falls in the area of Panna Tiger Reserve. Though permissions for doing surveys & investigations in Non Park area was received in February 2006, the same for Park area was received in November 2006. Surveys and investigation works were started from the tail end of link canal. Later surveys & investigation of Dam axis of Daudhan, were taken up and completed. Command

area survey & reservoir survey were also taken up and completed. Most of the survey works particularly topographical surveys were completed departmentally by NWDA whereas drilling works were got completed through private Agencies. For specialized surveys & investigations like construction material survey, borrow area survey, geological survey, etc. Govt. Agencies like CSMRS, GSI, etc. were engaged.

6.0 Climate

The climate of project area around Daudhan complex is semi-arid to dry sub-humid. Summer is hot and winter is generally mild. The air is mostly dry except during south west monsoon season. About 90% of the annual rainfall is received during the monsoon period i.e. from June to October. The average maximum and minimum temperatures are 44.2^0C and 6.7^0C respectively. The average annual rainfall of the command area is 950 mm while that of catchment area of Daudhan dam is 1177mm. The maximum and minimum relative humidity is 95% & 9% during monsoon and non-monsoon seasons respectively. The maximum and minimum wind velocities are 16.1 km/hr and 1.0 km/hr respectively. The maximum cloud cover is observed during the month of July or August whereas the minimum cloud cover is observed during December. The monthly average co-efficient of sunshine varies from 0.469 to 0.736. The monthly average evaporation varies from 6.35 cm(in December) to 40.01 cm (in May).

7.0 Topography & Physiography

The topography of Daudhan dam site area is of rolling undulations on both the flanks of the Ken river exhibiting elevations roughly between deepest river bed level 216.20m. and 300m(right abutment hill). The river span is fairly wide with flood plain deposits forming sandy-clay terraces on either bank of Ken river. The abutment slopes are gentle and stable with sporadic talus and slope wash material. The colluvial boulders of chert breccia and slope wash are more frequent on right side. The upper reaches of Ken river are flanked by undulating plateau with sandstone, shale and limestone. Down below, recent alluvium engrosses the river upto the Gangau dam. The stratigraphy of rock formations found in the region is mostly alluvial soil, Deccan traps, Lameta beds and Vindhyan system.

8.0 Population

The human population in Chhatarpur, Panna and Tikamgarh, districts of Madhya Pradesh and Mahoba, Jhansi and Banda districts of Uttar Pradesh will be benefited due to the assured irrigation supply, domestic & industrial water supply and power.

The total population as per 2001 census in the catchment area of Daudhan dam site was 31,25,831. About 1585 nos. of families comprising of 7224 persons living in the 10 villages will be affected due to the submergence by Daudhan reservoir. However, population of about 13.42 lakhs living in Khajuraho, Chhatarpur, Nowgong, Tikamgarh towns and enroute villages will be benefited due to supply of drinking water and irrigation facilities. In addition, sizeble population depending on agriculture in the command areas will also be benefitted due to increased agricultural activities.

9.0 Geology, Geophysical , Geotechnical & Seismic study

Daudhan dam

a) Geology

As per the geological investigations conducted for the proposed Daudhan dam, the reservoir area comprises pink granite rock free from faults etc. and is reported to be fully watertight. It comprises of very hard, compact and dense quartz-arenite, which appear to be very competent from the foundation grade point of view.

The Daudhan dam site area is more or less flat with rolling undulations on both the flanks of the Ken river displaying elevations roughly between 216.20 m (river bed level) and 300 m (right abutment hill). It is occupied by and inter-bedded sequence of arenaceous and argillaceous sediments represented by hard, compact and massive sandstone exposed on the left flank of the Ken river, thinly bedded sequence of sandstone, siltstone and shale exposed sparingly in the river section and thinly bedded to laminated porcellanite with black shale and chert beds on the right abutment hill in succession. These rocks have been classified under the Semi Group of the Vindhyan Super group. A considerable part of the dam alignment is occupied by flood plain alluvium forming sandy terraces on either side of the Ken river.

But for gently homoclinal beds, structurally the Daudhan dam site is free from major tectonic features such as fold, fault, shear or lineament. Further, continuity of outcrops from left to right abutment with thin cover of overburden rules out the presence of any buried channel along the axis of the dam.

(b) Geophysical Investigation

Geophysical investigations along the Daudhan dam axis carried out at feasibility stage by CSMRS has revealed existence of sound rock within a depth of 3m on the left bank except in two small reaches, where the depth may be 7-8

m. On the right bank hard strata (consolidated materials) exist at about 4-8 m depth in a length of about 100 m starting from the river bank beyond which groutable strata is available within 2-8 m.

(c) Geotechnical Investigations

In all, 26 bore holes have been drilled along the axis of the Daudhan dam for ascertaining the foundation conditions. The interpretation of surface and subsurface data has revealed that foundation grade rock has sufficient areal spread to house the concrete/masonry structure. Total water loss was not reported in any of the drill holes either in the rock mass or at their contacts. There were no sudden fall of drill rods or holes collapse except in one hole on right embankment signifying absence of open cavities, shear or fracture/fault zone along the drill holes. At preconstruction stage, more drilling on right embankment will be required to ascertain the cause of hole collapse.

(d) Seismicity

According to the seismic zone map of India prepared under the auspices of Bureau of Indian Standard (BIS Code IS : 1893-Part-I 2002) , the project area and its neighbourhood lies in zone- II and is broadly associated with seismic intensity VI on MMI scale. It may be mentioned here that the seismic intensity VI on MMI scale corresponds to horizontal ground acceleration range of 5 – 176 cm/sec^2 or and average acceleration of 40 cm/sec^2 in any direction.

As per the preliminary report for site specific earthquake parameter studies of Daudhan dam furnished by IIT, Roorkee, Maximum Considered Earthquake(MCE) for the Daudhan site is recommended to be 0.11g based on the preliminary studies and the seismotectonic modeling of the region. Accordingly, the Design Basis Earthquake(DBE) is recommended as 0.06g for the site.

10.0 Hydrology and Water Assessment

The 75% dependable yield of Ken river at the proposed Daudhan dam site has been assessed as 6,590 MCM. After meeting upstream and downstream requirements of existing, ongoing and proposed projects, domestic needs, industrial and environment & ecological needs, the surplus water available for diversion is assessed as 1,074 MCM, out of which 591 MCM is proposed to be transferred to the Betwa river in the upstream of Parichha Weir and 366 MCM to be utilized in the enroute command. The link will also provide 49 MCM of water for enroute water supply and there will be transmission loss of 68 MCM in the link canal.

11.0 Flood Control & Drainage

No flood cushion has been provided in the Daudhan reservoir in this project. However, storage of water in Daudhan reservoir and its regulated release in downstream will provide incidental benefit of flood moderation in downstream area of Ken river. Since topography of area is having mild slopes, drainage problem is not expected.

12.0 Reservoir & Power

Daudhan dam is proposed under the Ken-Betwa link project. The gross capacity of Daudhan dam at FRL of 288.0 m is 2853 MCM .

Two powerhouses have been proposed in Daudhan Dam Complex under the project. The PH-I will have an installed capacity of 60 MW (2 x 30 MW) whereas the PH-II will have an installed capacity of 18 MW (3 x 6 MW). The average annual generation of power from PH-I & II has been estimated to be 219.03MU.

13.0 Irrigation & Command Area Development

Out of the total divertible quantity of 1074 MCM, 366 MCM of water (277 MCM for M P and 89 MCM for U P) will be utilized for enroute irrigation of 0.60 lakh ha. in the districts of Tikamgarh and Chhatarpur of M P and Mahoba & Jhansi of U P with 100% intensity of irrigation. After taking into account the requirement of enroute water supply needs (49 MCM) and transmission loss of 68 MCM, the balance 591 MCM of water will be delivered in Betwa river, upstream of Parichha weir. The CCA of existing Ken command in UP under Bariarpur pick-up weir is 213610 ha. Presently, 87754 ha of area is being irrigated during Kharif and Rabi seasons. This Ken command which is presently getting 850 MCM of water will get stabilized to an extent of 1600 MCM after implementation of the project. It is proposed to provide 398 MCM of water to MP for irrigation in Ken command through Bariarpur pick-up weir across Ken river, located d/s of Daudhan dam. This will irrigate an area of 0.683 lakh ha. Similarly, 1007 MCM of water will be provided for irrigation of 1.73 lakh ha in M P through left bank canal (taking off from the tail end of lower level tunnel), u/s of Daudhan dam. The district wise details of CCA under the project (entirely lying in water short Bundelkhand region), irrigation intensity, annual irrigation and utilization are furnished below:

Sl. no	Name of command/ District	CCA	Irrigation intensity	Annual irrigation	Annual Utilisation
		ha	%	ha	MCM
I	Ken command (MP)				
1	Chhatarpur	219122	134	293623	
2	Panna	22184	134	29727	
	Total	241306		323350	1405.63
II	Enroute command Madhya Pradesh				
1	Chhatarpur	23225	100	23225	
2	Tikamgarh	23306	100	23306	
	Sub-Total	46531		46531	
	Uttar Pradesh				
1	Mahoba	4650	100	4650	
2	Jhansi	9113	100	9113	
	Sub-Total	13763		13763	
	Total	60294		60294	365.97
III	Ken command (UP) (Existing)				
1	Banda	213610*	118	252017	1600.00
	Grand Total	515210		635661	3371.60

(*) This will be commanded through RBC taking off from Bariarpur.

14.0 Navigation & Tourism

Full supply depth of Ken-Betwa link canal is 3.44m whereas its bottom width and top width are 13.2m and 25.77m respectively in head reaches. The section goes on reducing in lower reaches. Keeping in view, the availability of water in the link canal as well as numerous major CD structures (55 nos), it may not be feasible to utilize it for navigation purpose. Hence, no provision for development of navigation aspect has been kept in this project.

As far as the development of tourism is concerned, this project has got full potential, particularly, because of its close proximity of Daudhan dam with Khajuraho and that of tail end of link canal with Orchha Temple(near Jhansi). Provision for development of tourist huts, picnic spots has been made on the periphery of Daudhan reservoir and Barwasagar reservoir. Existing Barwasagar reservoir into which link canal will fall, remains dry for most of the period. However, after implementation of this project, it would have water round the

year. So, all the aforesaid reservoirs can also be developed for boating by tourists as well as for pisciculture. Necessary provisions for the aspects have been made in this project report.

15.0 Design Features

Daudhan dam will have a height of 77.00 m. The length of the dam will be 2031m. Top and bottom width of dam will be 8.00m and 48.80m respectively. The FRL and MWL of the Daudhan reservoir are kept same at 288.0 m.

The length of the link canal is 218.695 km. The design discharge at head of the link canal is 76.23 cumecs. The canal has been designed as a trapezoidal section with rounded corners and lined for entire length. The bed width & full supply depth of canal at its head is 13.2m & 3.44m with bed slope varying from 1 in 9,000 to 1 in 12,000 in different reaches. The side slopes of canal are 1.5 (H): 1 (V). The bed width and full supply depth at tail end is 10.75m & 3.44m.

The length of upper level tunnel will be 1.929 km with 6 m dia. and that of lower level tunnel will be 1.1 km with 5.5 m dia. The shape of tunnels is modified horse shoe.

16.0 Construction Materials

The requirement of construction materials for the project can be met from the nearby quarries. The quality of the materials available in these quarries have been tested by CSMRS, New Delhi and found suitable for usage as construction materials. Further, the requirement of construction materials like cement, steel, etc. can be brought to the nearest railhead i.e. Khajuraho for Daudhan dam.

17.0 Accessibility & Infrastructure

The project is approachable by rail from Jhansi to Khajuraho which is about 35 km from dam site. The project area is also approachable by dry weather motorable road from Chhatarpur-Panna state highway near Bamitha and dam site is about 23 km from this place. The existing approach road from Bamitha to Daudhan dam site can not be used for transporting heavy construction materials and machineries such as turbines, generators, transformers, etc. Further, it is not possible to widen the road stretch between Bhusar to dam site due to hilly terrain. In view of this, the following alternate routes have been explored during the communication survey carried out by NWDA.

1. Chhatarpur – Deogaon mod-Jhamtuli-Silon-Daudhan (53 km)
2. Chhatarpur – Bijawar-Kishangarh-Daudhan (110 km)
3. Chhatarpur-Satai-Armouniya-Salaiya-Silon-Daudhan (76 km)

4. Chhatarpur-Satai-Armouniya-Majhgawan-Daudhan (78km)

All these roads are maintained by Public Works Department, Govt. of Madhya Pradesh and can be used for project purpose after necessary widening for which necessary provision is kept in the cost estimate. Similarly the command area is also having good net work of roads which facilitate transport of heavy machinery and construction materials to the various locations.

Various infrastructure facilities like buildings for offices, residences, stores, workshops, laboratories, hospital, schools, etc. would be provided near the project site to ensure smooth implementation, operation and maintenance of the project.

18.0 Construction & Equipment Planning

The schedule of construction of the link project is planned for a period of 8 years. The infra-structural development like project colonies, approach roads, workshop, haul roads, stores, office buildings, etc, pre-construction surveys & investigations, preparation of design/specifications and tender documents have been proposed to be completed during first two years. In addition, the construction of all civil structures has been proposed to be completed within 1st quarter of 8th year. The requirement of important construction equipments as assessed by Construction Management Organisation, CWC is furnished below:

S.N.	Name of Equipment	Size/Capacity	Quantity required(Nos)
1.	Hydraulic excavator	2.5 cum	73
2.	Front End loader	2.5 cum.	11
3.	Front End loader	1.5 cum	9
4.	Crawler dozer	180 HP	37
5.	Crawler dozer	90HP	12
6.	Heavy duty rock hammer/jack hammer	120cfm	163
7.	Rock drill mounted on platform jumbo	4x120 cfm	2
8.	Wagon drill/Crawler Drill	600cfm	36
9.	Rear dumper	18/20 t	450
10.	Tipper	4.5 cum	46
11.	Vibratory compactor(pad foot)	10 t	18
12.	Vibratory compactor(Smooth drum)	10 t	8
13.	Water sprinkler	8000L	28

S.N.	Name of Equipment	Size/Capacity	Quantity required(Nos)
14.	Transit mixer truck mounted	4.5 cum	140
15.	Filter processing plant	500 tph	1
16.	Filter processing plant	350 tph	1
17.	Aggregate processing plant	350 tph	1
18.	Aggregate processing plant	250 tph	4
19.	Aggregate processing plant	100 tph	3
20.	Aggregate processing plant	70 tph	1
21.	Batching and mixing plant	180 cum/hr	1
22.	Batching and mixing plant	90 cum/hr	4
23.	Batching and mixing plant	45 cum/hr	3
24.	Batching and mixing plant	30 cum/hr	1
25.	Mobile batching and mixing plant	18 cum/hr	12
26.	Concrete pump with boom	38 cum/hr	14
27	Concrete pump with boom	20 cum/hr	3
28	Grout pump 20Kg/m2	20 kg/m2	18
29	Concrete shutter(Tunnel)	10x5.5 m	1
30	Concrete shutter(Surge Shaft)	2x6 m	4
31	Tower crane, traveling type	10 t/30 m	4
32	Tower crane	5 t/30 m	1
33	Electric Winch	20 t	2
34	Dewatering pump	LS	LS
35	Shotcrete m/c	10-15 cum/hr	2
36	Compressed air	cfm	40000
37	Mobile crane	20 t	5
38	Crawler crane	30 t	1
39	Ventilation system	LS	LS
40	Truck	8/10 t	48
41	Concrete vibrator (electrical/pneumatic)		110
42	Hydraulic rock breaker excavator mounted	10 t	2

Suitable provisions for the above construction equipments have been kept in the estimate.

19.0 Environmental and Ecological Aspects of the Project

The objective of EIA study is to identify the possible beneficial & adverse environmental impacts due to proposed Ken-Betwa link project & to suggest measures to minimize to the extent possible the anticipated adverse impacts.

This study has been carried out by M/s Agricultural Finance Corporation (AFC) Limited, Hyderabad on the following lines:

(A) Base line study & EIA study

The baseline environmental data like study area, climate, rainfall, water, land, biological environments, socio-economic and public health, geology, etc. were collected & the likely impacts due to the project during construction and operation phases have been studied on the following aspects like land, water and air environments in addition to aquatic and terrestrial ecology, socio-economic , air & noise pollution, impact on public health, risk on failure of dam structures, fire hazards in power plants, unprecedented floods, etc.

(B) Flora & Fauna

The impacts on flora and fauna like increased pressure on aquatic ecology due to indiscriminate fishing, reduced productivity due to increase in turbidity, migratory fish species, spawning & breeding grounds, degradation of riverine ecology and increased potential for reservoir fishes have also been studied. In addition, impact on rare, endangered and threatened species, access to food and shelter for animals, increased pressure on wood & timber due to labour force, migratory labour population, terrestrial flora, wildlife movement specially in tiger reserve, wildlife habitat, diversity and productivity of flora, economically/ genetically/ biologically important plant species, compensatory afforestation, reservoir rim treatments, etc. were also studied.

(C) Land use pattern

The land use pattern in the catchment area, submergence area, command area of Daudhan (covering 10km radius from the dam site & 1km on either side of the link canal) have been studied. The cropped area in the catchment of Daudhan dam is found as 47.98% . The soils in the command area are characterized with good surface drainage. The water holding capacity is low to medium except in some clay patches. No water logging problem is anticipated due to the provision of sufficient field channels and drains.

(D) Environmental Management Plan(EMP)

Aspects like catchment area treatment, Land Management Plan, Command area management, Bio-diversity management & Fisheries development plan, Surface and groundwater management, Public Health Management, Environmental monitoring programme, dam break analysis and disaster management, implementation schedule have been considered and suitable provisions have been kept in the estimate.

As a result of implementation of this project, a large new area of Bundelkhand (3.7 lakh ha. of M P and 0.14 lakh ha. of U P excluding stabilization of existing area under UP) will come under assured irrigation which will increase agricultural production & productivity in the area. No major adverse impact due to the project except submergence of Panna Tiger Reserve area is anticipated on environmental and ecological angle. No significant rich mineral deposits have been identified in the catchment and hence no acidification of the Daudhan reservoir is anticipated. Necessary minimum flows in the Ken river during lean season will flush the untreated sewage and hence no impact is forthcoming on river water quality. The flooding of previously forested and agricultural land in the submergence area will increase the nutrients resulting from decomposition of vegetative matter. Enrichment of impounded water with organic and inorganic nutrients will be main water quality problem which will last for a short duration of few years from the filling up of the reservoir. No eutrophication problem is anticipated due to controlled use of fertilizers in the command. The ground water level will increase in the adjoining area due to assured water supply to the fields. No possibility of leakage in the bed of the reservoir is anticipated as it is covered by semi quartzitic sand stone which is compact & hard. Hence, reservoir can be considered as water tight. The water samples tests indicate that organic and heavy metal components in the water are within permissible limits.

No historic monuments of Archaeological importance will come under submergence under the Daudhan reservoir. A provision of Rs.3495.16 crore has been kept in the estimate towards Environment Management Plan.

20.0 Socio-economic aspects & R&R

The details of socio-economic aspects of the project are furnished below:

Sl.no.	Item	Daudhan dam
1.	Submergence area at FRL	9000 ha
2.	No. of villages affected	10 nos. (including 4 nos. in park area)
3.	No. of households affected	1585
4.	Total population	7224
	Males	3872
	Females	3352
5.	Sex ratio(females : males)	866:1000
6	Literacy rate	
	Male	42.3%
	Female	31.4%
7	SC & ST households	
	SC	13.2%
	ST	35.1%

Sl.no.	Item	Daudhan dam
8	Landuse in submergence area	
	Area sown with agrl. Crops	24.12%
	Area under dense forest	6.56%
	Open forest	2.9%
	Scrub forest	46.31%
	Open scrub	1.67%
	Built up area	0.99%
9.	Total live stock population affected	23637
10.	Houses affected	
	Semi pucca houses	65.43%
	Kutcha houses	33.31%
	Pucca houses	1.26%
11.	Children upto 6 years	12.06%
12.	Population above 60 years and above	4.84%
13.	Young & Old persons	83.1%
14.	Occupational distribution	
	Agricultural labourers	56.38%
	Cultivators	38.00%
	Trade and commerce	0.65%
	Industry	0.04%
15	Sources of income	
	Agricultural based activities	90%
	Selling of Minor forest produce	8%
16	Expenditure pattern	
	Expenditure on food	36.64%
	Recurring cost on agricultural and livestock	24.63%
	Expenditure on health	10.00%
17.	Land acquisition	
	i)Submergence area	2171 ha
	ii)Along link canal	2492 ha
	iii)For Ken LBC(KMPP)	1563.37 ha
	iv)For Power houses I & II	11.00 ha

Resettlement & Rehabilitation Plan

The cost of relief, resettlement and rehabilitation of the affected households under the Ken-Betwa link project, Phase-I were worked out in accordance with the R & R Policy guidelines of the Government of India -2007 as the same is better than R&R Policy guide lines of Madhya Pradesh - 2002.

Broadly, the issue has three major components : i) land compensation; ii) resettlement and economic rehabilitation of displaced persons; and iii) economic rehabilitation of PAFs who have lost only land but not house / house site.

i) Land Acquisition

According to the Socio-economic survey (SES), the total land acquisition required for the project is estimated to be 6237.37 ha. The displaced persons will be settled in colonies near the areas where the affected persons are currently staying. Necessary provision has been made for housing plots, infrastructure like schools and other civic amenities. The total compensation for land acquisition was estimated to be Rs 314.28 crore considering voluntary as well as involuntary acquisition costs of irrigated/ unirrigated lands from PAFs, solatium (30%), standing crop loss, interest, demarcation, legal and establishment charges, etc.

(i) Resettlement

The implementation of the Ken-Betwa Link Project, Phase-I results in the involuntary displacement of 806 families as their houses get submerged under the Daudhan reservoir. The establishment of colonies including assistance for house construction, schools and other infrastructure, etc. to the families was estimated to cost Rs.3.45 crores.

(iii) Economic Rehabilitation

The Economic Rehabilitation package for 806 PAF households identified under the SES was estimated to cost about Rs. 8.11 crore. Considering a 5% increase for indicative budget, the total cost of economic rehabilitation programme of PAF households would be about Rs. 8.52 crore.

(iv) Compensation to Properties

Under the R & R, compensation for loss of 419 cattle sheds, 967 productive trees and 40 farm houses has also been made. The total cost for compensation of properties works out to Rs. 5.88 crore.

Total Financial Requirement

The total financial requirement for the implementation of Resettlement and Economic Rehabilitation Plan including training to staff and land for colonies would be about Rs. 333.77 crore. Socio-economic condition of the people living in command area as well as in near vicinity of the project will improve in general.

No major adverse impacts are anticipated due to the link project on the socio-economic front. In fact, positive impacts due to provision of assured water supply for irrigation to the fields will increase the production of crops which in turn will improve the social set up of farmers/ cultivators, etc. The impact on occupational pattern will be low to medium. Tourism will develop in the project area.

21.0 Cost estimate

Unit-I: The cost of head works like Daudhan dam, Bariyarpur weir, Paricha weir including spillway, outlet works, energy dissipation devices, regulator including intake structures and diversion works have been worked out under this head and estimated as Rs.6235.88 crore at 2007-08 price level.

Unit-II: The cost of Ken-Betwa link canal, Ken Left Bank Canal, branches, distributaries, channels upto strata works inclusive of all pucca works, fold embankments, drainage works, etc. have been worked out and estimated as Rs.2627.97 crore at 2007-08 price level.

Unit-III: The cost of hydroelectric installations like powerhouse and its appurtenant civil works and power equipment, transmission lines, sub-stations, etc. have been worked out under this head and estimated as Rs.341.54 crore at 2007-08 price level.

Unit-VI: The cost of command area development like land leveling, etc, have been worked out to be Rs.187.60 crore.

Thus, the total cost of the project has been estimated as Rs.9393 crore. The apportioned cost of head works of Daudhan dam to the power component has been estimated as Rs.251.93 crore based on proportionate benefits method. The details are furnished in the following table:

Sl. no	Item	Estimated cost Rs. in crore
1.	Unit-I Headworks	6235.88
2.	Unit-II Canals and Conveyance system	2627.97
3.	Unit-III Power installations	341.54
4.	Unit-VI Command area development	187.60
	Total cost of the project	9392.99

22.0 Economic & Financial Evaluation

The economic & financial evaluation is tabulated below:

Sl.no	Description	Rs. in lakh
1.	Net return from agricultural produce	
	Pre-project	7704.46
	Post-project	144703.39
	Total net return from agricultural produce	136998.93
2.	Revenue from sale of power @ Rs.3.00/kwh for 219.03MU	6570.90
3.	Revenue from Water supply @ Rs. 2.60 lakh per MCM for 49 MCM	127.40
4.	Revenue from Fisheries	442.00
5.	Revenue from tourism	100
	Total Revenue	144239.23
6.	Annual cost like interest, depreciation, charges of operation & maintenance (O&M) for command area and head works, power plants, etc.	92741.43
7.	Benefit cost ratio	1.56
8.	Internal Rate of Return	12.00%

23.0 Clearances Required

Ken-Betwa Link Project will require the following clearance from the Agencies indicated against each:

Sl.no.	Clearance	Agency
(i)	Techno-economic	Central Water Commission
(ii)	Forest Clearance	Ministry of Env. & Forests
(iii)	Environmental clearance	Ministry of Env. & Forests
(iv)	R&R Plan of Tribal Population	Ministry of Tribal Affairs
(v)	Wildlife clearance	Central Empowered Committee

Investment clearance will be accorded by Planning Commission based on the clearance by above mentioned Agencies.

24.0 Database

Action is being taken to prepare data base at field level as well as headquarters to keep all the data & information collected during the preparation of DPR.

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CHAPTER – I
INTRODUCTION

CHAPTER- I

INTRODUCTION

1.0 General

National Water Development Agency (NWDA) was set up by Government of India as an Autonomous Society under Ministry of Water Resources in July, 1982 to study the feasibility of National Perspective Plan and give concrete shape to it. Accordingly, after carrying out detailed technical studies, NWDA identified 16 links under Peninsular Component and 14 links under Himalayan Component in the country for feasibility studies. Ken-Betwa Link is one of the 16 links under Peninsular Component of National Perspective Plan for Water Resources Development for which feasibility report was prepared by NWDA in the year 1995 and circulated among all concerned. Since then continuous efforts were made by NWDA, Central Water Commission (CWC) and Ministry of Water Resources to arrive consensus between two beneficiary States of Uttar Pradesh (UP) and Madhya Pradesh (MP). Finally consensus was arrived at among Centre and concerned States and a tripartite Memorandum of Understanding was signed by Madhya Pradesh, Uttar Pradesh and the Union Government on 25th August 2005 for preparation of Detailed Project Report (DPR) of Ken-Betwa link. Subsequently, the work of preparation of DPR was entrusted to NWDA by Ministry of Water Resources in January 2006 and accordingly NWDA has prepared DPR with active support and co-operation of Central Water Commission, Central Electricity Authority and other reputed Organizations like CSMRS, NIH, GSI, etc.

The DPR was completed by NWDA in December 2008 and was circulated to the Governments of Madhya Pradesh and Uttar Pradesh in February, 2009 for their suggestions/observations, that were received subsequently. Govt. of Madhya Pradesh had suggested an alternative proposal for utilising the water in Upper Betwa reach according to which the height of the proposed Makodia dam is proposed to be reduced to avoid large scale submergence in the vicinity of Bhopal city and proposed several medium and minor schemes to utilize equivalent quantity of water in Upper Betwa reaches.

To discuss various issues raised by both the Govts. of Madhya Pradesh and Uttar Pradesh, a Secretary level meeting was convened by MoWR on 03.02.2010 at New Delhi between the officials of both the Governments & MoWR. During the meeting, it was opined that the Survey & Investigation of the alternative projects/schemes proposed by Madhya Pradesh in Upper Betwa region will take about 2 years time. Therefore, in order to avoid undue delay in implementation of Ken-Betwa Link Project, it was decided to reframe the DPR

into two separate parts viz., DPR of Ken-Betwa Link Project (Phase-I) comprising components of Daudhan complex and DPR of Ken-Betwa Link Project (Phase-II) comprising Upper Betwa projects. Accordingly, the first part i.e. present DPR of Phase-I is prepared including the cost of remodeling/ renovation of Bariyarpur weir and Parichha weir.

1.1 Outline of the project

Ken-Betwa Link Project mainly envisages transfer of surplus water from Ken basin to Betwa basin to provide water to water short areas of upper Betwa basin by substitution, keeping the needs of the in-basin requirements of Ken basin involving the States of Madhya Pradesh and Uttar Pradesh in view and ensuring equity, optimization of water use and cost effectiveness.

The Phase-I of the link project envisages construction of 77.00 m high dam, namely Daudhan across river Ken (about 2.5 km upstream of existing Gangau Weir), 218.695 km long link canal including cross drainage structures, two tunnels, two Power Houses (one at the toe of Daudhan dam (60 MW)and the other at the exit of lower level tunnel(18 MW)). The gross storage capacity of the Daudhan dam is 2853 MCM from which it is proposed to provide irrigation to enroute command of link canal lying in Madhya Pradesh as well as Uttar Pradesh, the command area envisaged under the proposed Ken Multipurpose Project (KMPP) of Madhya Pradesh and existing Ken Command of Uttar Pradesh lying in Banda district and being irrigated through Bariarpur head works.

75% dependable yield of Ken river at proposed Daudhan dam site has been assessed as 6,590 MCM. After accounting for upstream and downstream requirements of existing, ongoing and proposed projects, the surplus water to be diverted through the link annually was assessed as 1,074 MCM, out of which 591 MCM is proposed to be transferred to the Betwa river in the upstream of Parichha Weir and 366 MCM to be utilized in the enroute command. The link will also provide 49 MCM of water for enroute drinking water supply whereas there will be transmission loss of 68 MCM.

An area of 3.01 lakh ha is proposed to be brought under irrigation (0.60 lakh ha in the enroute command, 2.41 lakh ha in KMPP command) in Chhatarpur, Tikamgarh, Panna districts of Madhya Pradesh and Mahoba and Jhansi districts of Uttar Pradesh with different intensity of irrigation for each command. Apart from this, 1600 MCM of water through Daudhan dam will also be released for stabilization of irrigation in 2.13 lakh ha in Banda district in Uttar Pradesh under existing Ken command. Index map of Ken-Betwa Link Project showing important features is at Plate:1.1 of Drawing Volume-I.

The total cost of the project at 2007-08 price level has been estimated as Rs. 9443.46 crores. The benefit cost ratio for the project has been worked out to 1.55:1 and the Internal Rate of Return (IRR) as 12.00%.

1.2 Justification and objective of the project

The main objective of Ken-Betwa Link Project(Phase-I) is to make water available to Betwa basin at Parichha from the surplus waters of Ken basin which will substitute the water from water presently received from Upper Betwa region. An equivalent quantum of water will be utilized in water deficit Upper Betwa region through proposed projects under Phase-II of this link project.

A preliminary water balance study of the Ken river upto the Greater Gangau dam site (Technical Study No. 29) was carried out by NWDA, which indicates that surplus water is available in the Ken basin. Accordingly, a preliminary feasibility study for diverting surplus waters of Ken to water short areas of Betwa basin was carried out to ascertain whether the proposal was feasible. It was found that the proposal is techno- economically viable and accepted by TAC of NWDA. The proposal included construction of a dam across the Ken river upstream of the existing Gangau Weir, for storing and transferring of the water through a link canal from Ken river to Betwa river. The quantity of water initially proposed to be diverted from Ken basin, after considering in-basin demands including upstream and downstream commitments was 1020 MCM. However, after updating of hydrological studies at DPR stage, it has been proposed to transfer 1074 MCM of Ken water through link canal, out of which 591 MCM (excluding transmission losses of 68 MCM) of water will reach Betwa river. Since this link project has taken into consideration in-basin requirements of all the existing, ongoing and proposed projects of Ken basin (whether it is in upstream or downstream of proposed Daudhan dam) while working out surplus water at Daudhan dam, the proposed diversion of water from Ken to Betwa through this link project seems justified.

Further, the enroute as well as Upper Betwa projects (to be taken up under Phase-II of the project) command area identified under the link project lies in drought prone & backward area of Bundelkhand region. This link project will definitely bring economic prosperity to this backward area due to increased agricultural activities. The Ken command in Uttar Pradesh will also get stabilized due to the additional water made available to it through this proposal.

1.3 Lesson learned from Previous Projects

A few examples of Interlinking of Rivers Project in the past as well as recent past are as under:

Periyar Project: The project is the most notable endeavor of the 19th century in transbasin diversion. The Periyar Reservoir Project is a major venture of Inter basin water transfer designed and executed by Col. Pennycuick, to divert waters of the West flowing Periyar river to the East to extend irrigation in the Vaigai Basin. The source of the Periyar is in the Sivagiri hills of Western Ghats range in Tamil Nadu. It flows north through Periyar National Park into Periyar Lake, a 55 km^2 artificial reservoir created in 1895 by the construction of a dam across the river. Water is diverted from the lake into the Vaigai River in Tamil Nadu via a tunnel through the Western Ghats.

A masonry gravity dam of 47.28 m high has been constructed across a gorge on west flowing Periyar river. A 1,740 m long tunnel with a discharging capacity of 40.75 cumecs has been driven across the mountain barrier to convey the water eastwards to Vaigai basin. The project was commissioned in 1895 and provided irrigation to 57,923 ha initially, which has since been extended to 81,069 ha. There is also a power station of 140 MW capacity. Through the Periyar Lake dam and tunnel, the river serves as the major water source for drought-prone districts in the state of Tamil Nadu.

It is a source for power generation, agriculture and industrial development, inland navigation, tourism promotion and fishing. With this project, the entire area got transformed from drought prone to a flourishing green belt and the standard of living improved beyond expectation. The project originally envisaged benefits for 36,423 ha of first paddy crop and 22,282 ha of second paddy crop. The power scheme was taken up in 1955 and completed in 1965 with four units of 35 MW. Now, the total ayacut has reached 81,036 ha. The secondary benefits like setting up of several industries in Madurai and other areas, tourism etc., have developed. The reservoir is serving as a flourishing breeding area for fresh water fish which is being marketed by the Fisheries Department of the Kerala Government. The benefits each year in terms of money value have far exceeded the total amount spent on the project.

Parambikulam - Aliyar Multipurpose Project: The project envisages transfer of water from Chelakudi basin to Bharatapuzha and Cauvery basins. The project is a complex multi-basin multi-purpose project of seven streams, five flowing towards the west and two towards the east, have been dammed and their reservoirs interlinked by tunnels.

This project consists of a series of dams interconnected by tunnels and canals at various elevations in order to harness the Parambikulam, Aliyar, Nirar, Sholiyar, Thunkadavu, Thenkkadi and Palar rivers, laid for irrigation and power generation. The scheme is an outstanding example of engineering skill.

The water is ultimately delivered to drought prone areas in Coimbatore district of Tamil Nadu and the Chittur area of Kerala states. The command area for irrigation is presently about 1,62,000 ha. There is a total of 185 MW power generation capacity at four power houses.

The project was commissioned in September 2002 to generate Hydro Electric Power.

Aliyar Reservoir: Aliyar reservoir is a 6.48 km^2 reservoir located near Pollachi town in Coimbatore District, Tamil Nadu. The dam offers some ideal getaways including a park, garden, aquarium, play area and a mini Theme-Park maintained by Tamil Nadu Fisheries Corporation for visitors enjoyment. The scenery is beautiful, with mountains surrounding three quarters of the reservoir. Aliyar reservoir was studied by the Central Inland Fisheries Research Institute (CFRI) for eleven years from 1982 to 1992. The rate of energy conversion at primary producer level and at the fish production level at Aliyar is considered higher than in any other Indian reservoir.

Kurnool Cudappah Canal: A private company started this scheme in 1863. The project envisages transfer of water from Krishna basin to Pennar basin. A 8.23 m high anicut was built on the river Tungabhadra upstream of Kurnool town. A 304 km long canal with a capacity of 84.9 cumecs at its head extends from Krishna to Pennar basin and irrigates 52,746 ha. The scheme was taken over by Govt. of India in 1882.

Telugu Ganga Project: This project has been recently implemented primarily to meet the pressing need of water supply to Chennai metropolitan area. It brings Krishna water from Srisailam reservoir through an open canal, first to Somasila reservoir in Pennar valley. This involves rock cuts upto 35 m deep. From Somasila, the water is taken through a 45 km canal to Kandaleru and then to Poondi reservoir in Tamil Nadu through another 177 km long canal. By mutual agreement, 12 TMC of water will be delivered to Tamil Nadu at the border from Krishna basin. This will greatly augment the water supply to Chennai city. The canal also irrigates 2.33 lakh ha. in Andhra Pradesh enroute. The project was made possible by Maharashtra, Karnataka and Andhra Pradesh voluntarily foregoing 5 TMC. each from their entitlement. This project is a fine example not only of hydraulic engineering but also of Inter- State co-operation.

Ravi-Beas-Sutlej- Indira Gandhi Nahar Project: Beas-Sutlej link in combination with the Indira Gandhi Nahar Project is a standing example of how the large inter basin transfers brought about all round socio-economic growth with overall enhancement in the ecology and environment of the region. Under the Indus Water Treaty, the water of three eastern rivers viz. Sutlej, Beas and Ravi were allocated to India. As the land to be benefited in India, lies mostly to

the east and south of these rivers, the rivers had to be interlinked and the water conveyed to canal systems for serving vast tracts in India. The main storage on Sutlej is at Bhakra, while that on Beas is at Pong. Bhakra system provides irrigation to 26.3 lakh ha. of new area besides stabilization of existing irrigation of 9 lakh ha. The aggregate generation capacity of power on Bhakra Nangal Project is 1,354 MW. A diversion dam, Pondoh, 140 km upstream of Pong on Beas, enables diversion of water from Beas to Bhakra reservoir and generates 165 MW of power. The Beas-Sutlej link is 37.25 km long of which 25.45 km is tunnel through difficult rock formations. The capacity of the tunnel is 254.70 cumecs. Another dam on Ravi namely, Ranjit Sagar dam will provide additional water to Beas and also generate a large block of power. Subsequently, it was decided to link the Indira Gandhi Nahar Project with the river systems to provide 9.36 BCM of water to Rajasthan Canal for irrigating the areas of Thar Desert.

It is no exaggeration to say that the transfer of surplus waters of Ravi, Beas and Sutlej to Rajasthan right upto Jaisalmer and Barmer through Indira Gandhi Nahar Pariyojana has eliminated drought conditions, provided power benefits, transformed desert waste land into an agriculturally productive area by bringing irrigation and vegetation to about 2 million hectare area. Contribution in agricultural production due to implementation of the project is worth Rs. 1,750 crores annually. Canal water is also available for meeting domestic needs.The project has substantially changed the living standard and socio-economic conditions of the people in the area.

These examples show that for countries like India having such a huge population with uneven distribution of rainfall with respect to space and time, Interlinking of Rivers Projects are need of the future.

Ken-Betwa link project is the first Inter Basin Water transfer Project to be taken up by NWDA for which MoU has been signed among the concerned States and the Union government for preparation of Detailed Project Report. DPR of this project has been prepared departmentally by NWDA utilizing the services of Government Departments like CWC, CEA, CSMRS, NIH, GSI and Reputed Educational Institutions/other Govt. Organizations like IIT-Roorkee & Delhi, NRSA, Hyderabad and Agricultural Finance Corporation, Hyderabad. Wherever Government agencies were not available for completing the work in time bound manner like drilling work and submergence area survey, private parties were engaged. This model of preparation of DPR has yielded good result as it has got inputs from all the expert organizations in their respective field. Under this model, the work of preparation of DPR was monitored and supervised by the Committee headed by Chairman, CWC which helped NWDA in accomplishing the task in a given time frame.

1.4 National Perspective Plan for Water Resources

The erstwhile Union Ministry of Irrigation and Central Water Commission formulated, in the year 1980, National Perspective Plan (NPP) for water resources development comprising of following two components:

a) The Himalayan Rivers Development, and
b) The Peninsular Rivers Development

The distinctive feature of the National Perspective Plan is that the transfer of water from surplus basin to deficit basin would essentially be by gravity and only in small reaches, it would be by lifts not exceeding 120 metres. These two components are briefly outlined in the following paragraphs.

(a) Himalayan Rivers Development

Himalayan Rivers Development envisages construction of storage reservoirs on the principal tributaries of the Ganga and the Brahmaputra in India, Nepal and Bhutan, along with inter-linking canal systems to transfer surplus flows of the eastern tributaries of the Ganga to the west, apart from linking of the main Brahmaputra and its tributaries with the Ganga and Ganga with Mahanadi and augmentation of flow at Farakka.

(b) Peninsular Rivers Development

This component is divided into four major Parts:

(i) Interlinking of Mahanadi-Godavari-Krishna-Pennar-Cauvery rivers and building storages at potential sites in these basins

This is the major interlinking of the river systems where surpluses from the Mahanadi and the Godavari are intended to be transferred to the needy areas in the south.

(ii) Interlinking of west flowing rivers, north of Mumbai and south of the Tapi

This scheme envisages construction of as many optimal storages as possible on these streams, and interlinking them to make available appreciable quantum of water for transfer to areas, where additional water is needed. The scheme provides for taking water supply canal to the metropolitan areas of Mumbai. It also provides irrigation to the coastal areas in Maharashtra.

(iii) Interlinking of Ken-Chambal Rivers

The scheme provides for a water grid for Madhya Pradesh, Rajasthan and Uttar Pradesh and Interlinking canal backed by as many storages as possible.

(iv) Diversion of other west flowing rivers

Heavy rainfall on the western side of the 'Western Ghats runs down numerous streams which empty into the Arabian Sea. Construction of an interlinking canal system, backed up by adequate storages, could be planned to meet all requirements of Kerala as also for transfer of some water towards east to meet the needs of drought affected areas.

Third part of Peninsular link of NPP was firmed as two links viz, Ken-Betwa link and Parbati-Kalisindh-Chambal link.

1.5 MoU between Centre and States & Inter State Aspects

Ken river from which diversion of water to Betwa has been proposed is an interstate river between MP and UP. Upper part of the catchment lies in MP whereas lower part of the catchment lie in UP. Gangau weir across river Ken is a pre-independence era project, having gross storage capacity of 40 MCM. Water stored in Gangau weir is utilized through Bariarpur Head works located about 45 km in its downstream. UP has got canal network spread over Banda district to utilize this water. However, MP is still in the process of constructing canal network. Sharing of Ken water between these two States is governed by Interstate Agreement of 1981. However with construction of proposed Daudhan dam across Ken with gross storage of 2853 MCM, utilization of Ken water in optimum & efficient manner is possible. Uttar Pradesh desired more share of Ken water for utilization in their existing Ken command as well as enroute command after preparation of feasibility report by NWDA. Series of meetings were organized by NWDA, CWC and MoWR to arrive at consensus between UP and MP over sharing of Ken water so that action for preparation of Detailed Project Report of Ken-Betwa link could be initiated. The concurrence of the State Governments of UP and MP were received vide their D.O. letter nos. 3742/05-27-Irrigation dated 16.8.2005 and no. 22(A) 148/MPS/31/1358 dated 5.8.2005 respectively (copy placed as Annexure: 1.1 & 1.2 respectively). This paved the way for signing of a tripartite Memorandum of Understanding (MoU) by Hon'ble Chief Ministers of UP and MP and Hon'ble Union Minister for Water Resources on 25th August 2005 in the presence of Hon'ble Prime Minister of India (copy placed as Annexure: 1.3).

The MoU was entered into understanding as follows:-

Signing of tripartite MOU for preparation of DPR of Ken - Betwa Link Project by Uttar Pradesh, Madhya Pradesh & Centre on 25.08.2005 in presence of Hon'ble Prime Minister

1. Union Government shall identify and decide the organizational framework necessary for completion of the 'Detailed Project Report' (DPR) and 'Implementation of the Link Projects'.

2. Specific MoUs as required will be entered into amongst the States of UP, MP and Union Government based on the DPR and Agreement reached on scope of the link, sharing of costs and benefits and arrangements for management and control of water etc.

3. Both the State Governments will gain multipurpose benefits through the Ken-Betwa Link Project as per the Feasibility Studies completed by NWDA. In pursuance of the said objective, broad consensus and 'in principle' understanding was arrived at through consensus building efforts of the Union Government and the States as reflected in the Chief Engineer (HQ), NWDA's letter no. NWDA/Tech-III/122/17/2004(Vol.V) dated 5.1.2005 in order to ensure optimum and integrated planning, successful implementation and effective monitoring and operation of Ken-Betwa interlinking project under National Perspective Plan. The apprehensions on water sharing, control mechanism and compensation of power loss etc. raised by States will be addressed at DPR stage.

4. Both the States shall enter into and abide by Agreements with the Union Government and amongst themselves in the larger interest of combating natural calamities of floods and droughts in different regions of the country.

5. Any review/amendment of the MoU shall be done if agreeable to by all the parties.

6. This is being concluded amongst the State of MP, State of UP and Union Government for proceeding ahead on the Ken-Betwa Link Project and taking up the project for preparation of DPR.

Both the States agreed for the sharing of water upto Daudhan in a meeting taken by the Chief Engineer (IMO), CWC on 5.1.2005 and communicated vide NWDA's letter No. NWDA/TECH-III/122/17/2004 (Vol.V) dated 5.1.2005 and formed part of aforesaid MOU. The agreed sharing of water between MP & UP for various uses is given in Table-1.1.

Table-1.1
Project Water sharing of Ken Basin upto Daudhan Dam

Sl. No	Particulars	Proposed by NWDA	
		MCM	TMC
1	Gross Water available at proposed Dam	6188	218.54
2	MP requirement in U/S of dam	2266	80.03
3	Balance Water available	3922	138.48
	Regeneration (+)	442	15.61
	Net Water Balance Available	4364	154.12
4	Total requirement of MP		
	(a) D/s of Ex Daudhan	1375	48.56
	(b) Enroute use	263	9.29
	(c)Domestic enroute utilisation & transmission losses	49	1.73
	Total	1687	59.58
5	Total Requirement of UP		
	D/s of Daudhan including enroute command	1700	60.04
6	Proposed Water Transfer to Betwa Basin	659	23.27
7	Requirement for D/s of dam for ecological needs	318	11.23

1.6. Selection of Proposed schemes

(a) Earlier Proposals

The Government of MP formulated proposals for Ken Multi-Purpose Project (KMPP) on the Ken river which is also known as Greater Gangau dam and accordingly a DPR (1982) was prepared. As per this DPR, the project envisaged construction of a dam across the Ken river about 210 m down stream of the existing Gangau weir. The proposed FRL of the Greater Gangau dam was 278.89 m and corresponding live storage was 2062 MCM. This project was expected to provide annual irrigation on 3.23 lakh ha in Chhatarpur and Laundi tehsils of Chhatarpur district and Ajaigarh tehsil of Panna district. In these proposals hydro power generation was also envisaged through construction of two Power Houses, one (PH-I) at the foot of the dam and the other (PH-II) on the left bank of Ken river at 630 m downstream from the first power house. The installed capacities of the Power Houses were proposed as 2 x 15 MW for PH -I and 2 x 10 MW for PH-II.

Front view of existing Gangau weir located down stream of proposed Daudhan dam during floods, 2008

As an alternative to the KMPP Project proposed by the State Water Resources Department, Govt. of MP, Ken-Betwa link was studied. As per studies carried out by NWDA, it was proposed earlier that the above said Greater Gangau dam would be utilized as the head works for the link. For this purpose, the reservoir at Greater Gangau was planned with FRL of 284.2 m with live storage 2544 MCM, keeping the other features similar as per KMPP of MP. The Ken-Betwa link was proposed to off take from the tail race of the PH-I with FSL 245.5 m to transfer (1100 MCM) surplus waters of Ken basin to water short Betwa basin. Accordingly the preliminary feasibility report on Ken-Betwa link was prepared in 1990 by NWDA and circulated to all the concerned basin States. Based on the comments and discussions in the TAC and with basin states, these proposals were further reviewed and modified whereby it was opted to provide link canal alignment to off take at FSL 260.0 m as against the earlier proposed FSL 245.5 m. It was proposed mainly to serve the command area at higher elevations where the present level of irrigation is seen to be low. However it was observed that by the construction of the Greater Gangau dam, the existing Gangau weir which has been functioning well since 1915 will be submerged. It was, therefore, felt better to locate the dam upstream of Gangau weir with possibility of utilizing the arrangement for generation of hydropower as a pumped storage scheme.

(b) Proposals at FR stage

Keeping above suggestion in view, it was decided to realign the Ken-Betwa link with higher offtake level. To ascertain the potential reservoir sites on Ken river, toposheet studies of Ken basin were carried out in the upper reaches of Greater Gangau dam site. Three reservoir sites were identified viz., Jhalar reservoir (CA 18205 sq km), Ghari Ghat reservoir (CA 18055 sq km) and Daudhan reservoir (CA 19534 sq km) as shown in Plate:1.1 of Drawing Volume-I, were identified on Ken river in the downstream of its confluence with Sonar and Bearma tributaries with Ken with the obvious advantage of having adequate yield for the proposed irrigation in Ken basin as planned, as well as transfer of the requisite quantity of water through the link canal. Several parameters like submergence area, capacity of the reservoir at different elevation, number of villages affected, forest and culturable areas under submergence etc. were studied and finally Daudhan dam site was found suitable, which is located near Daudhan village at 2.5 km upstream of Gangau weir. The catchment area at Daudhan site is 19534 sq km, which is only 0.16% less than that at Greater Gangau. Therefore, the same annual yield at Greater Gangau was adopted for Daudhan site also at feasibility level. This link envisaged construction of dam at Daudhan, 231.45 km long link canal including 2 km long tunnel at the beginning, two power houses and four upper Betwa Projects, viz., Neemkheda, Richhan, Barari and Kesari.

The FRL of Daudhan dam site was proposed as 287.0 m and the corresponding gross storage capacity was 2755 MCM. The project was planned to provide irrigation to 4.97 lakh ha (3.23 lakh ha in command area as envisaged KMPP project, 0.47 lakh ha in enroute command and 1.27 lakh ha in upper Betwa command). Apart from this, provision of 850 MCM of water was kept to meet the demand of Ken command in Banda district of Uttar Pradesh being irrigated through Bariarpur head works. Provision of 12 MCM of water was kept to meet drinking water requirement of enroute village of 231.45 m long link canal. While keeping the general operational features of the State KMPP proposal more or less the same, the power generation was proposed as under.

Power House at toe of dam was proposed to utilize the irrigation releases from the reservoir at the tail race water level at 234.75m. This Power House is proposed to function as a pumped storage power plant i.e. the water released would be further picked up by Gangau weir which can be pumped back to generate additional power during peak period. The other power house was planned at the exit of tunnel on the right bank of Pukhreha Nalla, 2 km away from the dam with a tail water level 259 m from where Ken-Betwa link canal offtakes. The other details of the proposal are already discussed above. It can be seen that this was preferable to the Greater Gangau dam site because (i) it would not submerge the existing Gangau weir, (ii) it would provide enroute irrigation to higher level command along the canal alignment and (iii) additional power generation by pumped storage scheme during peak period.

(c) Present proposal at DPR stage

A DPR as per outline of the project has been described in Para no. 1.1 has been prepared effecting certain changes in the proposal of FR and the same was circulated during February, 2009. Consequent to the comments of Govt. of MP in respect of proposed Upper Betwa projects, a Secretary level meeting between Governments of MP and UP was convened by the Ministry of Water Resources on 03.02.2010 at New Delhi to arrive at consensus and as per the decisions taken during the meeting, it has been proposed to reframe the DPR into two phases viz., Phase-I comprising of components of Daudhan dam complex and Phase-2 comprising of Upper Betwa projects as proposed by Govt. of MP. In order to avoid undue delay in implementation of link project, the present DPR of Phase-I of the Ken-Betwa link project is reframed with following changes in the proposal of FR.

(i) FRL of Daudhan dam has been raised from 287 m to 288 m without changing its location & orientation.

(ii) Two tunnels have been proposed instead of one tunnel at FR stage. First one is Upper Level tunnel from the exit of which, the Ken-Betwa link canal takes off and other is Lower Level tunnel (newly proposed) from which the Ken LBC catering KMPP command takes off through proposed PH-II.

(iii) Length of link canal has been reduced from 231 km to 219 km approximately due to realignment.

(iv) PH-II proposed earlier at the exit of the Upper Level tunnel has been shifted to Lower Level tunnel.

1.7 Project planning and optimization of Benefits

Ken-Betwa Link Project, Phase-I has been planned as a multipurpose project with irrigation as a major benefit whereas power, drinking water supply and flood moderation are other incidental benefits. Planning of the project has been done in such a way that 75% available yield at Daudhan will be utilised first for in-basin requirement of Ken. Accordingly, command area of 2.41 lakh ha proposed under KMPP by Govt. of Madhya Pradesh is proposed to be provided for irrigation at 134% intensity of irrigation, thus achieving annual irrigation of 3.23 lakh ha utilizing 1405 MCM of water. Apart from this, about 2266 MCM of water has been earmarked for existing, ongoing & proposed projects of MP in upstream of Daudhan dam and 1600 MCM of water has been earmarked for existing Ken command in downstream of Daudhan dam to provide assured irrigation to a CCA of 2.13 lakh ha in Banda district of UP.

After meeting these requirements, 1074 MCM of water is proposed to be transferred through Ken-Betwa link, out of which 366 MCM of water (277 MCM for MP and 89 MCM for UP) will be utilized for irrigating 0.60 lakh ha. in enroute command at 100% intensity of irrigation and 49 MCM of water will be provided for drinking water supply to enroute villages & towns. Remaining 591 MCM (excluding transmission losses of 68 MCM) will be delivered to Betwa river through Barwa Sagar reservoir & Barwa nallah (natural stream) in the upstream of Parichha weir.

During the course of above planning, it was found that two Power Houses can also be installed one at the toe of the dam and the other at the exit of lower level tunnel to generate 78 MW of power (2x30 MW + 3x6 MW). Thus, benefits from the project have been optimized in following manner:-

I.	Irrigation Benefit	Annual Irrigation
	New Command	
(i)	Ken command (MP)	3.234 lakh ha
(ii)	Enroute command (MP+UP)	0.603 lakh ha
(iii)	Existing Ken command i.e. 2.13 lakh of UP (which is presently getting 850 MCM of water will get 1600 MCM of water after implementation of project, thus helping in stabilization of irrigation.)	2.520 lakh ha
	Total	6.357 lakh ha

II. Power Benefits

Powerhouse-I	2x30 MW
Powerhouse-II	3x 6 MW
	78 MW

III. Drinking water supply

Provision of 49 MCM has been kept for providing drinking water to enroute villages & towns, out of which 38 MCM has been earmarked for MP and 11 MCM for UP.

IV. Flood control benefits

Flood cushion will have to be maintained below MWL in the reservoir for which care will have to be taken while framing reservoir rule curves of the project year to year. Flood cushion above MWL has not been provided to reduce submergence of forest area. Release of water to link canal and regulated release of water in downstream of Daudhan dam will provide incidental benefit of flood moderation in Ken river in downstream area of the dam.

V. Other benefits

Many other incidental benefits like pisciculture, recharge of ground water in command area, development of agro based industries/food processing units, employment generation in construction phase and afterwards, development of tourist spots, development of infrastructure etc. will accrue from the project though enumeration and tangisation for these benefits has not been done due to time & data unavailability constraint. In any case they will increase the Benefit/Cost ratio calculated in this report after tangisation of these benefits. This will result in upliftment of socio-economic condition of people in general living in water scarce areas of Chhatarpur, Panna and Tikamgarh districts of MP and Banda, Mahoba & Jhansi districts of UP state lying in Bundelkhand region.

1.8 Methodology adopted

1.8.1 Surveys & Investigations works done departmentally

NWDA has adopted two pronged action for preparation of DPR of Ken-Betwa Link Project (Phase-I). Major part of the detailed surveys & investigations of the project for which in house capability was available, has been done by NWDA itself whereas other specialized surveys & investigations along with technical studies were outsourced, mostly to other Government Agencies.

Surveys & Investigation works carried out departmentally by NWDA are as under:-

1. Dam/Barrage Axis Surveys of Daudhan dam
2. Link canal survey
3. Submergence area survey of Barwa sagar reservoir into which link canal is proposed to outfall.
4. Survey of about 8 km stretch of Barwa Nalla from Barwa sagar reservoir to Betwa river.
5. Survey for PH-I & PH-II, Upper Level and Lower Level tunnels near Daudhan dam including connection canal from PH-II to Ken LBC.
6. Cross-section of Ken River in the downstream of Daudhan dam for Dam Break analysis.
7. Survey required in upstream of Daudhan dam for alternative studies by Designers.
8. Sample Command Area Survey for enroute command.
9. Digging of Trial pits and collection of samples in upstream of Daudhan and along Ken-Betwa link canal for borrow area survey.
10. Digging of pits and collection of samples for stone quarry sites & sand sites for construction material survey.
11. Hydrological observation of newly opened site on Ken.

1.8.2 Surveys & Investigations carried out by other agencies

1.8.2.1 Borrow area survey, geotechnical investigation, construction material survey, testing of rock samples

The work of borrow area survey, geotechnical investigation, construction material survey, testing of rock samples, etc. in respect of the main project was carried out by Central Soil & Material Research Station (CSMRS), New Delhi. However, testing of rock samples of upper Betwa Projects was got carried out by IIT, Delhi.

1.8.2.2 Geological Survey

Geological Surveys for geological mapping of alternate sites, locating the overflow section of dam, water tightness study of reservoir, rim analysis/landslide study of reservoir, power houses, tunnels, canal alignment, CD/CM works, and for other important project components were done by Geological Survey of India, Govt. of India, Bhopal.

1.8.2.3 Drilling Works

Attempt was made to get the works done through GSI, Bhopal, CWC & MECON (Mineral Exploration Corporation of India), Nagpur which could not materialize due to their own constraints, therefore, the work was got done through Private parties to complete the DPR on schedule.

1.8.2.4 Reservoir Survey of Daudhan Dam and Command area survey of Ken command in MP

Survey of India was initially approached for doing these surveys, which due to time & manpower constraints, agreed to undertake above survey using ALTM technology, available with NRSA. However, time frame of 38-40 months given at a later date by Survey of India, did not match with the time frame of preparation of DPR of Ken-Betwa Link Project which was initially 30 months only, therefore, later on, NRSA was also approached to take up this work using ALTM technology. Time frame given by NRSA also did not meet the requirement of schedule of NWDA to complete the DPR. Therefore, it was decided to use the submergence map as well as command area map prepared by Survey of India for KMPP Project in Madhya Pradesh which was about 3 km downstream of NWDA's proposed Daudhan Dam.

1.8.3 Technical Studies

1.8.3.1 Design of important project components and writing of Design chapters

As mentioned earlier, the project envisages construction of important structures viz. one dam, link canal, CD structures along canals, Power house-I&II, Tunnels etc. Design of these important structures along with preparation of Design chapters was done by Design Organisation of Central Water Commission. Following five Design Directorates of CWC were involved in this work:

1. HCD (NW&S) Dte.
2. CMDD (NW&S) Dte.
3. Embankment Design (NW&S) Dte.
4. Gates Design (NW&S) Dte.
5. BCD (NW&S) Dte.

1.8.3.2 Irrigation Planning studies

Irrigation Planning Studies of Ken-Betwa Link Project were done by Irrigation Planning (South) Directorate of Irrigation Management Organisation, CWC.

1.8.3.3 Construction Planning, Equipment Planning and Manpower Planning

Construction Planning, Equipment Planning and Manpower Planning were done by Construction Machinery Consultancy Directorate of Central Mechanical Organisation, CWC.

1.8.3.4 Hydrological Studies

Hydrological studies of Ken-Betwa Link Project were carried out to National Institute of Hydrology, Roorkee. In order to review & monitor the progress of hydrological studies of the project, a Hydrology Committee consisting of Members from CWC, NWDA and IIT, Delhi was constituted. Composition of the Committee is placed at Annexure: 1.5 (a & b).

1.8.3.5 Power Potential and E&M Studies

Power Potential and Electrical & Mechanical (E&M) Studies was undertaken by Central Electricity Authority. Hydro-Electric & Project Investigation Division of Central Electricity Authority carried out Power Potential Studies whereas Hydro-Electric & River Management Division carried out Electrical & Mechanical design studies.

1.8.3.6 Study of Seismic Parameters

Seismic Parameters studies of Daudhan were done by Department of Earthquake Engineering, IIT, Roorkee.

1.8.3.7 Petrographic Analysis of Silt samples

Petrographic analysis of Silt samples of Ken river required for turbine of Powerhouses was done by IIT, Delhi.

1.8.3.8 Socio-economic Survey, Environmental Impact Assessment Study

For award, monitoring and review of progress of Socio-economic Survey & Environmental Impact Assessment Study, an Environmental Committee under Chief Engineer, Environment Management Organisation (EMO), CWC with Chief Engineer (North), Director (MDU), Superintending Engineer, NWDA & Director(EIA), CWC as members was constituted. Composition of the Committee is placed as Annexure: 1.6(a) to 1.6(c). This Committee invited Expression of Interest from various agencies involved in such studies and short listed the consultants. Terms of Reference (TOR) for Comprehensive EIA Study was got

vetted from Ministry of Environment & Forests. Based on approved TOR, RFP (Request for Proposal) was invited from short listed consultants and finally, the consultancy for Comprehensive Environmental Impact Assessment study was awarded to M/s. Agricultural Finance Corporation Ltd., Hyderabad.

1.8.3.8.1 Monitoring Mechanism

In order to monitor and supervise the overall work for preparation of DPR of Ken-Betwa link project, a Committee under the chairmanship of Chairman, Central Water Commission, New Delhi was constituted vide MOWR's office order No.2/56/2003-BM/250-268, dated 16.02.2006(copy enclosed as Annexure:1.7). Committee consisted representatives of State Govts. of MP & UP apart from representatives of various Central Govt. Departments.

Apart from above, a High Level Committee in the form of Steering Committee, headed by Secretary, Ministry of Water Resources was formed vide MOWR's letter no.2/56/2003-BM/795-800, dated 07.06.2006 (copy enclosed as Annexure:1.8) to review the progress of works.

1.8.3.8.2 Methodology adopted

Feasibility Report prepared by NWDA formed the basis for proceeding further for preparation of DPR and make suitable changes based on detailed surveys & investigation and updated hydrological, irrigation planning and other studies.

1.8.3.8.3 Data collection

The preparation of DPR of the Ken-Betwa link project required various data/information. Data/information required by Design Organisation of CWC were collected during field surveys. Rainfall and meteorological data were collected from IMD, Pune whereas hydrological observation data and ground water data were collected from CWC and CGWB respectively and the same were provided to NIH, Roorkee and IMO, CWC for Hydrological Studies and Irrigation Planning Studies. Data regarding cropping pattern, Yield of crop per ha, Cost of produce, Cost of cultivation etc were collected from State Agriculture Departments and made available to IMO, CWC. DPR of KMPP was collected from State Water Resources Department for its use in case of planning of Ken command in MP. Test Results/Outputs given by CSMRS, GSI, IIT, Roorkee and Delhi formed Inputs for Designers of the project. Even the Working Table finalized by IMO, CWC formed input for Power Potential Studies by CEA whereas output given by CEA in the form of Power potential Studies formed input for Civil Design of hydel structures. Thus there were many inter-dependent activities, apart from normal data collection. All these activities were successfully managed

by NWDA officers and various data required by the consultants were supplied to them for the preparation of DPR of Ken Betwa link project.

1.8.3.8.4 Planning and Layout of Daudhan dam complex

As mentioned earlier, one of the main objectives is to provide irrigation to various commands. For providing irrigation water to enroute command of link canal, an Upper Level Tunnel (1.929 km long) with Invert level and Crown level of 256.0m and 262.0m respectively at the mouth of Daudhan reservoir has been proposed. Diameter of the proposed tunnel is 6.0 m whereas slope of the tunnel is 1:800. This tunnel takes off from the left bank of Ken river in upstream of Daudhan dam. Invert level of Upper Level Tunnel at the exit point is 253.5m. After provision of energy dissipation device at the exit of tunnel, the link canal will take off with FSL and Full supply depth of 257.0 m and 3.44 m respectively. Layout plan of Daudhan reservoir showing the positioning of Upper Level Tunnel is shown in Fig.1.1.

From the left bank of Ken river in upstream of Daudhan dam but in the downstream of Upper Level Tunnel, another tunnel i.e. Lower Level Tunnel takes off. Invert level and Crown level of Lower Level Tunnel at its inlet are 244.6m and 250.1m respectively. Power House-II (PH-II) having installed capacity of 18 MW is proposed at its outlet. After generation of power, water will be taken through canal to provide irrigation water to 2.32 lakh ha. of Ken command in MP as proposed in KMPP. However, this canal will not cater to the entire needs of Ken command. Provision of bye pass channel has also been made for supplying water to the canal directly from tunnel is case PH-II does not run.

Daudhan dam proposed across Ken river is 2031m long, out of which 1233m length of dam will be earthen and rest 798 m length of dam will be of concrete. Concrete portion of dam along with spillway has also been proposed on the left flank of the dam. A penstock is proposed in extreme left portion of concrete portion of dam for taking water to Power House-I (PH-I) located at the toe of the dam. Tail Race Channel off-taking from PH-I will join Ken river again in d/s of the Dam on left bank.

1.8.4 Surveys & Investigations

Just after signing of MoU, in August 2005, a team of officers started Reconnaissance Survey of Daudhan Dam area and link canal where NWDA has done preliminary surveys & investigations at feasibility stage in early nineties. This team located alignment pillars fixed along dam axis and link canals and bench marks. Team of Senior Officers of NWDA & CWC also visited the site.

Based on site visit, three Sub-Divisions at Chhatarpur, Jhansi & Vidisha were opened by NWDA in December 2005 to co-ordinate various activities of preparation of DPR. When this work was assigned to NWDA in January 2006, NWDA was fully geared up to take up the work. However permission was required to be obtained for doing surveys & investigation in Park as well as Non-Park area from Forest Authorities as Daudhan dam falls in the area of Panna Tiger Reserve. Though permissions for doing surveys & investigation in Non Park area was received in February 2006,(copy placed as Annexure:1.9) whereas the same for Park area was received in October/November 2006(copy placed as Annexure:1.10(a) & (b)). Surveys & investigation works was started from the tail end of link canal. Later in April 2006, Jhansi sub-division was upgraded to Investigation Division to manage the work efficiently. Investigation Circle, Gwalior with its three Field Divisions located at Gwalior, Jhansi and Bhopal and two Field Sub-divisions located at Chhatarpur (under Jhansi Division) and Vidisha (under Bhopal Division) completed the entire work of surveys & investigations listed in para 1.8.

1.8.5 Engineering assessments and Front end engineering

Dam & Headworks

The height of Daudhan dam has been designed as 77m and the top and bottom width as 8m and 51.6 m respectively. The concrete dam will be 798 m long whereas the earthen part will be 1233 m long. The spillway will have 27 nos. of radial gates of size 16 m x 18.5 m. The dia. of upper & lower level tunnel has been designed as 6 m and 5.5 m respectively and shape of both the tunnels will be modified horse shoe type. The length of the upper & lower level tunnel is 1.929 km and 1.1 km respectively. The PH-I will have 2 units of 30 MW each and the PH-II will have 3 units of 6 MW each. Vertical axis Kaplan turbines have been proposed for both units. The tail race channel of length 405 m and size 32 m x 1.7m has been proposed at the end of PH-I to meet the spillway channel and then to the Ken river. A connecting canal of 2.2 km long has been proposed from PH-II to the Ken LBC.

Link canal

The length of link canal is 218.695 km offtaking from the end of Upper Level tunnel. The head reach of canal has been designed for a capacity of 76.23 cumecs. The canal will have 13.2 m bed width & 3.44m full supply depth at its head and 10.75m bed width & 3.44m full supply depth at its tail end.

1.8.6 Ecological, Socio-economic and Financial Aspects

M/s. Agricultural Finance Corporation Limited, Hyderabad has carried out extensive surveys, studies, etc. for Comprehensive Environmental Impact Assessment Studies of Ken-Betwa Link Project. The results/ recommendations of the studies are furnished below:

A) Ecological

The impacts on flora and fauna like increased pressure on aquatic ecology due to indiscriminate fishing, reduced productivity due to increase in turbidity, migratory fish species, spawning & breeding grounds, degradation of riverine ecology and increased potential for reservoir fishes have been studied. In addition, impacts on rare, endangered and threatened species, access to food and shelter for animals, increased pressure on wood & timber due to labour force, migratory labour population, terrestrial flora, wildlife movement specially in tiger reserve, wildlife habitat, diversity and productivity of flora, economically/ genetically/ biologically important plant species, compensatory afforestation, reservoir rim treatments, etc. were also studied. The soils in the command area are characterized with good surface drainage. The water holding capacity is low to medium except in some clay patches. No water logging problem is anticipated due to the provision of sufficient field channels and drains. Aspects like catchment area treatment, Land Management Plan, Command area management, Bio-diversity management & Fisheries development plan, Surface and groundwater management, Public Health Management, Environmental monitoring programme, dam break analysis and disaster management, implementation schedule have been considered and suitable provisions have been kept in the estimate.

No significant rich mineral deposits have been identified in the catchment and hence no acidification of the Daudhan reservoir is anticipated. Necessary minimum flows in the Ken river during lean season will flush the untreated sewage and hence no impact is forthcoming on river water quality. The flooding of previously forested and agricultural land in the submergence area will increase the nutrients resulting from decomposition of vegetative matter. Enrichment of impounded water with organic and inorganic nutrients will be main water quality problem which will last for a short duration of few years from the filling up of the reservoir. No eutrophication problem is anticipated due to controlled use of fertilizers in the command. The ground water level will increase in the adjoining area due to assured water supply to the fields. No possibility of leakage in the bed of the reservoir is anticipated as it is covered by semi quartzitic sand stone which is compact & hard. Hence, reservoir can be considered as water tight. The water samples tests indicate that organic and heavy metal components in the water are within permissible limits. No major adverse impact due to the project

except submergence of Panna Tiger Reserve area is anticipated on environmental and ecological angle.

B) Socio-Economic aspects for Daudhan reservoir

The Daudhan reservoir submerges about 9000 ha of land (at MWL of 288 m). A total of 10 villages will get submerged fully, out of which 4 villages falls within the Panna Tiger Reserve Park. M/s AFC Ltd., Hyderabad has studied the impact on project affected people in all the ten villages. The total no. of Project Affected Households and population has been estimated as 1585 & 7224 under Daudhan reservoir. The average literacy rate in the area is 37.4%. The male & female literacy rates are 42.3% and 31.4% respectively. The SC and ST households of the Project Affected Areas have been found out as 13.2% and 35.1% respectively. The prominent occupation is agricultural labour which accounted for about 56.38% of total workers and is followed by cultivators (38%). About 63% of female workers and 52% of male workers are dependant on agriculture.

The most predominant animals in the project area are cows and goats with 4.87 and 6.25 animals per household respectively. To a lesser extent, it is buffaloes (1.9) and sheep (0.09).

The agricultural implements of the project area mainly consist of yokes, electrical pumps and diesel pumps.

The main source of income for the project families is from the Agriculture based activities which account nearly 90% of the overall income. The income and expenditure patterns of the project area are furnished in Table-1.2.

Table- 1.2
Income and Expenditure patterns of the project area

Sl No	Income particulars	%	Sl No	Expenditure Particulars	%
1	Agriculture	59.78	1	Food	36.64
2	Agri. Labour	20.16	2	Fuel	0.83
3	Non-Agriculture	0.87	3	Clothes	7.93
4	Livestock	8.47	4	Housing	2.26
5	Business	0.58	5	Education	3.90
6	Sericulture	0.08	6	Health	9.77
7	Minor Forest Produce	7.99	7	Transport	5.86
8	Govt / Private Service	1.40	8	Social Ceremony	7.03
9	Others	0.66	9	Debt Clearance	1.14
			10	Agri and Livestock	24.63
			11	Others	0.01
	Total	100.00			100.00

The major part of the Daudhan reservoir submergence area falls in Semi pucca houses category accounting for about 65.43%, which is covered with GI or AC sheets followed by kutcha(hut) houses made of agricultural waste covered roof which accounts to 33.31%and very small percentage of 1.26% of houses are pucca houses.

The caste wise distribution of affected population in Daudhan reservoir is given below in Table-1.3.

Table-1.3

Castewise distribution of households under Daudhan reservoir

Sl.no.	Caste	Total population	% of total
1	SC	958	13.26
2	ST	2607	36.09
3	BC	2725	37.72
4	OC	934	12.93
	Total	7224	100.00

The age wise distribution of population within Daudhan reservoir area is furnished in Table-1.4.

Table- 1.4

Agewise distribution of households under Daudhan reservoir

Age Group					
0-6	7-17	18-35	36-60	Above 60	Total
871	2042	1996	1965	350	7224

C) Financial aspects

After extensive surveys/studies on the project affected families and land acquisition, the Resettlement and Economic Rehabilitation Plan for the families were suggested by the consultant based on the Policy entitled “National Rehabilitation and Resettlement Policy-2007” of Department of Land Resources, Ministry of Rural Development, Govt. of India and Ideal Rehabilitation Policy for Madhya Pradesh-2002 (IRPMP-2002) & the guidelines issued by the MORD, GOI and GOMP at the prevailing (during 2006-2007) minimum agricultural wage of Rs. 64/- per day per person. For the Environment Management Plan, a provision of Rs. 3495.16 crores has been kept as suggested by M/s AFC Limited, Hyderabad in their report on Comprehensive Environmental Impact Assessment studies. The total cost of Project Affected Families Rehabilitation and Economic Resettlement Plan for the Ken-Betwa Link Project, Phase-I was worked out to be Rs. 333.77 crores. Complete details of the Comprehensive Environmental Impact

Assessment of Ken-Betwa Link Project, Phase-I are furnished in Chapter-VIII & IX of DPR.

1.8.7 Financial and economic analysis

The total cost of the Ken – Betwa Link Project, Phase-I including R&R plan works out to Rs. 9393 crores at 2007-08 price level. The annual cost of the project including cost of maintenance of headworks, dam appurtenants, power houses, raising mains, depreciation, etc. works out to Rs.927.41 crores. The net benefit from agricultural produces & generation of power annually have been worked out to Rs. 1369.99 crores & Rs.65.71 crores respectively. Accordingly, the benefit – cost ratio has been worked out to 1.56 and the Internal Rate of Return works out to 12.00%.

1.9 Clearances required

Ken-Betwa Link Project, Phase-I will require the following(Table:1.7) clearances from the agencies indicated against each:

Tabel:1.7

Clearances required from other agencies

Sl.no.	Clearance	Agency
(i)	Techno-economic	Central Water Commission
(ii)	Forest Clearance	Ministry of Env. & Forests
(iii)	Environmental clearance	Ministry of Env. & Forests
(iv)	R&R Plan of Tribal Population	Ministry of Tribal Affairs
(v)	Wildlife clearance	Central Empowered Committee

Based on above, Investment clearance will be accorded by Planning Commission.

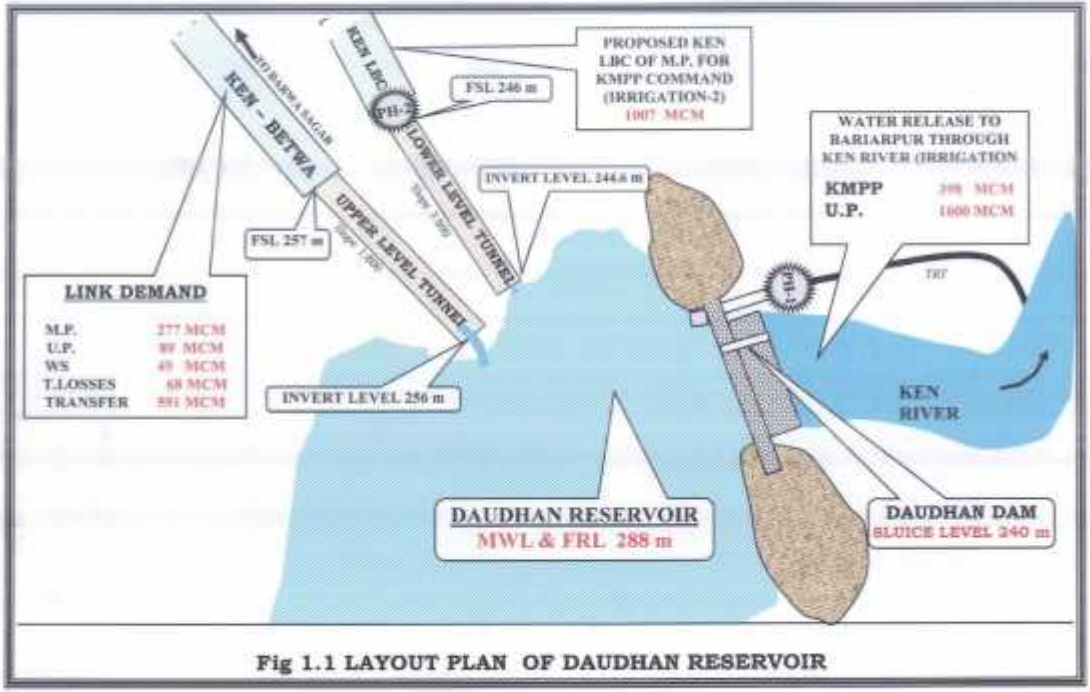


Fig 1.1 LAYOUT PLAN OF DAUDHAN RESERVOIR

CHAPTER-II
SURVEYS & INVESTIGATIONS

CHAPTER – II

SURVEYS & INVESTIGATIONS

2.0 Introduction

As per the feasibility studies carried out by NWDA in 1995, the main component of Ken-Betwa Link Project (now Ken-Betwa Link Project Phase-I) envisaged construction of the following components:-

I DAUDHAN DAM

1. An earth fill-cum-concrete dam across Ken River at Daudhan with FRL 287 m.
2. A 2 km long tunnel from the left bank of Daudhan dam for taking water to the Ken-Betwa Link canal.
3. Power House-I (PH-I) (2x30 MW) to the left of the spillway at the toe of the dam.
4. Power House-II (PH-II) (2x6 MW) at the tunnel outlet.

II LINK CANAL

1. A link canal (231.45 km long including length of tunnel) with off take FSL 259 m to existing Barwa sagar reservoir on Barwa Nallah.
2. Cross-drainage/ Cross-masonry works (59 Nos).

Surveys and investigations were carried out for the above components at FR stage.

At the DPR stage, in light of the various detailed studies carried out through different expert organizations, certain changes in the project planning have been made by NWDA. The Ken-Betwa Link Project Phase–I now envisages construction of following components:-

I Head works

DAUDHAN DAM

1. An earthfill cum concrete dam across Ken River at Daudhan with FRL 288 m.
2. An Upper Level Tunnel (1.929 km long including transition length) about 170 m from the left bank of Daudhan dam for taking water to the link canal.
3. A Lower Level Tunnel (1.1 km long) about 100 m from the left bank of Daudhan dam axis for taking water to the PH -II and from there to the LBC of earlier proposed KMPP.
4. PH-I (2x30 MW) to the right of spillway at the toe of Daudhan dam.
5. PH-II (3X6 MW) at the outlet of Lower Level Tunnel.

Bariyarpur barrage

A 850 m long barrage with crest level of 181 m across the Ken river about 1.0 km d/s of existing Bariyarpur pick up weir.

Parichha weir

A 1.3 km long weir with 702 m long spillway with 184.64 m crest level across Betwa river about 100 m d/s of existing Parichha weir.

The proposal of the above Bariyapur barrage and Parichha weir have been considered as per details provided by Govt. Of UP.

II LINK CANAL

1. A link canal (220.624 km long including length of Upper Level Tunnel) with off take FSL 257 m to existing Barwasagar with FRL 219.20 m across Barwa Nallah, a tributary of Betwa River.
2. A 7.1 km long Barwa Nallah to carry link waters from Barwa Sagar to Betwa river at 12.75 km u/s of existing Parichha weir
3. A 2.2 km long canal for connecting PH-II to Ken LBC at FSL 246.00 m
4. Ken LBC (57.3 km long, modified) proposed under KMPP (which is replaced by Daudhan dam)
5. A bye pass channel from Lower Level Tunnel to meet irrigation requirements of Ken LBC when PH-II will not be in operation.
6. Major Cross-drainage/Cross-masonry works (55 Nos.).

The background behind making changes/not making any changes in various components proposed earlier in FR is briefly given below:-

(i) Daudhan dam and Spillway

While finalizing the location of dam site on Ken River, various alternatives for locating the dam both u/s and d/s of the existing Gangau weir had been considered in light of KMPP report prepared by the Madhya Pradesh, Water Resources Department. Out of these alternatives, the option of locating the dam 2.5 km u/s of the existing Gangau weir near Daudhan village was finally selected by NWDA and details of surveys and investigations conducted at this site had been incorporated in the FR of this link project prepared during March 1995. The dam site is located at latitude 24^{o} 36' 51'' N and longitude 79^{o} 50' 30'' E.

The location of dam site had again been reviewed jointly by the officials of CWC, GSI and NWDA in June, 2006 and it was decided after joint field visit to keep the location of dam axis same as finalized at the time of preparation of FR. It was, however, decided to explore the possibility of keeping the spillway at the centre of the river gorge instead of left bank of the river as proposed earlier in the FR. Accordingly, as per the suggestions of GSI, few exploratory holes in the river gorge for specified depth were drilled to find out the preconstruction geological conditions for locating the spillway at the centre of the river gorge. After carrying out the mapping of the area & logging of the drill cores, GSI vide its preconstruction geological notes dated

24.8.2007 & 22.01.2008 recommended that the location of spillway on the left flank as proposed at feasibility stage of the project is preferable to centrally located spillway. However, this may still need a review at pre-construction stage to minimize rock excavation for approach channel. Earlier in the FR, the FRL and MWL of the dam were considered at 287 m & 288 m respectively. Now, at DPR stage, the FRL and MWL both have been kept same at 288 m.

(ii) Power House I , Power House II and Tunnels

The location of PH-I and TRC proposed at left side of spillway at FR stage has been relocated by Hydel Civil Design (NW&S) Directorate, CWC and GSI to the right side of the spillway in view of geological condition, available space and reduction in the length of tail race channel. Its installed capacity (2X30 MW) will, however, remain the same.

At feasibility stage, the aspect of providing water to KMPP command (Ken command) of Madhya Pradesh through Daudhan dam was not studied in the absence of detailed information in respect of the command. The general impression was that water for Ken command in Madhya Pradesh portion would be withdrawn from Bariyarpur head works only. However, after receipt of detailed surveyed sheets of KMPP command (prepared by SOI) and other relevant records from State Govt., this aspect was examined in detail. It was decided to introduce an additional tunnel, named as lower level tunnel from Daudhan dam to connect the proposed LBC of KMPP (for which the detailed surveys and investigations had already been carried out by Govt. of Madhya Pradesh) for providing water to major part of its command. The PH-II proposed at the exit of tunnel providing water to Ken-Betwa Link Canal (now renamed as upper level tunnel) has been shifted to the exit of lower level tunnel in view of availability of water for longer duration and possibility of generation of more power due to increase in the head. The proposed installed capacity of PH-II is 3X6 MW. After generation of power in PH-II, the water will be released through 1.929 km long canal connecting to proposed LBC of KMPP. The alignment of Ken LBC as per surveyed maps collected from State Govt. has been modified in the initial reaches so as to meet the requirement of its command from Daudhan dam. During the periods when PH-II is not being operated owing to constraint of minimum head requirement, the waters meant for Ken LBC command are proposed to be passed through a bypass channel taking off from lower level tunnel.

(iii) Link Canal

The link canal has been realigned considering number of alternatives for its optimization in the reach from RD 94.65 km to RD 215.8 km (RD's of FR stage) for minimizing the cutting depth. It's off take FSL has been lowered to 257 m now from 259 m as proposed in FR.

2.1 Topographical Surveys

Various field S&I viz. Topographical, Geological, Construction material, Geo technical investigations & Borrow area surveys (soils) for dams and canals,

etc. in respect of Daudhan dam and Ken-Betwa Link canal have been carried out as per the TOR for preparation of DPR of Ken-Betwa Link project, 2006 and the guidelines given in the Working Group Report for preparation of DPR prepared by the erstwhile Ministry of Irrigation, Govt. of India, 1980.

The proposed Daudhan dam and the initial reach of Ken-Betwa Link canal are located in Chhatarpur and Panna districts of Madhya Pradesh Field survey works were started by transferring nearby GTS bench mark value available with Survey of India on the Chhatarpur- Panna Road where the link crosses this road near the kilometre stone No. 47/4. The work of establishing adequate number of PBM at different locations by precision levelling was carried out departmentally by connecting the nearest GTS BM already established by SOI in the vicinity of the project. The GTS BM was connected to the dam as well as link alignment and also to different components of the project by precision levelling using double levelling method. The locations of permanent bench marks established in and around the project site are given in Annexure 2.1.

Brief particulars of the various topographical surveys carried out for different components of the project are given below:

2.1.1 River

During the feasibility stage, the portion of Ken River between the proposed Daudhan dam axis and the existing Gangau weir had been surveyed. Chain and compass surveys parallel to the centre line of the Ken River both left and right bank were done. Levels were taken at an interval of 25 m by double levelling and deepest bed level was connected. The cross sections of the river at every 200 m interval were taken up to HFL +2 m on either side of the firm bank with the help of sounding technique for measuring the depth of water in the river at 25 m interval along each cross section line. The aim of this survey was to determine the capacity of the pondage between the Daudhan dam and the existing Gangau weir, which was proposed to be utilised as the tail pond for the pumped storage scheme. The purpose of this survey was also to find suitable location of PH-I and TRC. The L-section of this portion of Ken river is placed as Plate 2.1.1 in Drawing Volume-I.

In addition to the above, at DPR stage, cross section survey of river Ken has been carried out in d/s portion of the Daudhan dam up to Banda as desired by NIH, Roorkee for carrying out the dam break analysis and other hydrological studies of this project. In total, 18 number of river cross sections in the d/s of proposed dam site have been taken across Ken River between Daudhan dam and Banda up to HFL + 2m on both river banks. These cross sections have been plotted in 1:2500 H and 1:100 V scale and supplied to NIH, Roorkee. The Drawings of these 18 cross sections are given as Plate 2.1.2 in the Drawing Volume-I. No river survey in the u/s of Daudhan dam has been carried out. The SOI maps available for KMPP have been used to

generate the river longitudinal and cross sections and supplied to NIH for back water computations.

2.1.2 Reservoir

Madhya Pradesh, Water Resources Department had formulated KMPP during 1965. This project was proposed about 200m d/s of existing Gangau weir across river Ken. SOI had carried out submergence area survey of this project during the period 1965-67 on the request of Madhya Pradesh, Water Resources Department. Submergence area maps, in the scale of 1:15846 (1 inch to 1 mile) showing contours from RL 234.6 m to 295.5 m (770 ft to 970 ft) with contour interval of 3.048 m (10 ft), available with Madhya Pradesh, Water Resources Department, have been collected by NWDA. These maps have been utilized by NWDA for preparing the submergence area maps of Daudhan reservoir as Daudhan dam is proposed on Ken River about just 2.7 km u/s of KMPP with MWL/FRL at 288 m.

Attempts were also made by NWDA to get the survey of Daudhan reservoir done afresh through SOI or NRSA, using ALTM technique. However, time demanded by them for this work did not fit in the time schedule for preparation of DPR of this link project. Thus, the submergence area survey of Daudhan reservoir could not be carried out. Submergence area map of Daudhan reservoir is furnished as Plate 2.1.3 in Drawing Volume-I.

2.1.3 Headworks (Dam including dykes, barrages, weirs etc.)

Survey work on the dam axis was taken up departmentally by NWDA. Topographical survey for a strip of 800 m width (300 m u/s and 500 m d/s) of the dam axis was carried out upto an elevation of MWL (288m) +5 m on both the banks at 10 m grid basis. This included the cross section of the river at the dam axis by taking levels at 10 m interval and fixing stones at every 50 m interval along the main dam axis. A detailed contour plan of Daudhan dam area showing tentative locations of spillway, PH-I & PH-II and proposed tunnels is given in Plate 2.1.4 of Drawing Volume-I. A contour plan in the scale of 1:2500 H with 1 m contour interval has been prepared for the surveyed site of Daudhan dam and the same is appended as the Plate 2.1.5 in the Drawing Volume-I.

At Daudhan dam, a side channel spillway of length 536 m has been proposed by CMDD Directorate of CWC for passing the flood discharge of 57202 cumec computed by NIH in hydrological studies carried out for this project. Ski jump bucket type energy dissipater has also been proposed. The survey of the dam axis as described above also covers areas of spillway, sloping floor, ski jump bucket, PH–I, TRC, switchyard etc.

2.1.4 Plant and Colony Layout

A site for temporary colony has been proposed during feasibility level investigations near the proposed Daudhan project site along the Gangau-Palkohan road covering an area of 0.24 sq km. Block survey of this area was carried out during that time and a plan was prepared on 1 : 2,000 scale. The same site is found reasonably good for plant and colony area and is therefore kept unchanged. It is proposed that the above colony site will be finally converted into operational staff colonies, after the project construction is completed. Contour Plan of Plant and colony layout area is enclosed as Plate 2.1.6 in Drawing Volume-I.

2.1.5 Canal & Water Conductor System and Canal Structures

a) Canal & Water Conductor System

Strip surveys with levelling grid interval of 50 m or less depending upon the slope of land covering 500 m width (250 m on either side of centre line of the canal) along the 218.695 km long alignment of the Ken-Betwa Link from its off take point near exit of upper level tunnel from Daudhan dam to the terminal point at the existing Barwa Sagar reservoir on Barwa Nallah were carried out. Canal has been realigned in the reach from RD 94.65 km to RD 215.8 km for minimizing deep cutting considering of alternative alignments for its optimization. Alignment of the link canal in the remaining reach is the same as finalized in the FR. The alignment was first marked on the field with the help of bearings measured from the toposheet's and after making necessary corrections for the true-meridian and magnetic meridian as indicated in each toposheet as well as taking into account the actual site conditions for fixing proper alignment wherever necessary, marking of the alignment was done by fixing RCC pillars at 100 m interval. RCC TBM pillars were also erected at every one km distance of the canal and also at each turning point. The pillars were painted with red colour and chainage written with white paint. Double levelling survey was carried out and the elevations of the link canal alignment at every 25 m interval were ascertained. Cross sections of link canal were taken at every 50 m interval by single levelling. About 100 km of the Ken-Betwa Link canal survey was completed during the first working season i.e. from October, 2006 to June 2007 and the survey of remaining length was completed in the following working season i.e. from October 2007 to January 2008. The combined contour plan and L-section of the link canal covering 88 plates have been prepared in 1: 2500 H scale and 1:100 V scale with 1 m contour interval. Condensed Longitudinal sections of the link canal have been prepared and appended as Plate 2.1.7 in the Drawing Volume-I.

Strip surveys, L-section and cross-section surveys for remodelling of 7.1 km long Barwa Nallah through which the waters from Barwa Sagar will be discharged to Betwa River u/s of Parichha weir have also been carried out. The cross sections were taken at 100 m interval. The Longitudinal sections

Field visit of DG, NWDA at Daudhan dam near tunnel entry point

Field visit of DG, NWDA along the Ken Betwa Link near Bedri village(near Gunj)

Performing of Water permeability tests at drilling location downstream of proposed Daudhan dam site

and cross-section of Barwa Nallah are appended as Plate 2.1.8 in Drawing Volume-I.

b) Canal structures

The link canal on its way crosses a number of rivers, streams and Nallah's besides National & State highways, district & village roads and railway lines. Total 309 cross drainage/cross masonry structures are identified across the link canal out of which surveys have been carried out for 55 major CD/CM structures. Details of CD/ Masonry structures across Ken-Beta Link canal is given in Annexure: 2.2.

Grid survey at 50 m or less interval depending on the slope of land was carried out at each canal structure site to cover an area up to 300 m on either side of the centre line of the canal, up to 100 m d/s of the point of exit of water and 100 m u/s of the point of water inlet. Contour plans were prepared in 1: 2500 H scale with 1 m contour interval on the basis of grid surveys to facilitate the design work of cross drainage structures, besides marking of final link canal alignment. Cross sections of the drain have also been taken along the centre line of the canal and the same have been plotted to the scale of 1: 2500 H & 1:100 vertical.

Drainage surveys have also been carried out with levelling at grid interval of 50m or less depending on the slope of land for u/s & d/s of centre line of canal for adequate length as required for hydraulic calculations of canal structures. Plan of the same have been plotted in the scale of 1:2500 H. The grid surveys, Longitudinal sections and cross-section of various canal structures along the link canal are furnished as Plate 2.1.9 in Drawing Volume-I.

2.1.6 Powerhouse, Switchyards, Surge-Shaft, Tailrace, etc.

(a) Power House PH-I

A dam toe Power House is proposed in the project to the right side of the spillway just adjacent to earthen dam & non over flow section of Daudhan dam. Committed requirement for irrigation to Uttar Pradesh (1600 MCM) and water for feeding remaining part of KMPP command which is not covered through lower level tunnel (398.2 MCM) is proposed to be provided through this Power House. Its location was finalized by the Hydel Civil Design (HCD) Directorate of CWC considering the geological mapping and pre-construction stage geotechnical investigations of Daudhan dam area carried out by GSI in consultation with CEA, which is engaged in the design & power potential and E & M studies of the Power House.

Detailed survey has been carried out for an area to include about 100 m on all sides of the Power House including its various components taking levelling at grid interval of 10 m or less depending on the slope of

land. Contour plan of the PH-I site has been plotted in the scale of 1: 2500 H scale with 1 m contour interval which is given as Plate 2.1.10 in Drawing Volume-I.

(b) Power House PH-II

This Power House is proposed at the exit of the 1.1 km long lower level tunnel. Detailed survey has been carried out for block area of about 310 m x 300 m for the Power House including all its components taking levelling grid interval of 10 m or less depending on the slope of land. Contour plan of the PH-II site has been plotted in the scale of 1: 2500 H scale with 1 m contour interval. The same is given as Plate 2.1.11 in Drawing Volume-I.

Detailed survey has also been carried out for the 2.2 km long connecting canal from PH-II to the Ken LBC. Contour plan and L-section has been prepared for this connecting canal and appended as Plate 2.1.12 in Drawing Volume-I.

(c)Switchyard

The location of the switchyard has been finalised by CEA in consultation with HCD of CWC and NWDA. A single switchyard is proposed at a suitable site between the PH-I & PH-II for power evacuation from both the Power Houses to power transmission grid on the basis of details provided by Madhya Pradesh Power Transmission Corporation. The surveys carried out for Head works cover the areas for planning & erection of switch yard also.

(d)Surge Tank/ Shaft

A surge tank of 18 m dia is proposed at the exit of the lower level tunnel u/s of PH-II to take care of pressure fluctuations in the penstocks and to prevent additional water hammer pressures being exerted on the walls of the tunnel. The grid survey carried out for tunnel and PH-II covers the area required for surge tank also.

(e) Tail Race Channel(TRC)

One TRC is proposed at the exit of PH–I to carry the waters to the Ken River after power generation. The grid surveys carried out for dam axis as well as PH-I, have adequately covered the TRC portion also.

2.1.7 Tunnels, Adits and Penstocks

(a) Upper Level Tunnel

A 1.929 km long upper level tunnel including length of transition, has been planned in this project with an invert level at 256 m to divert water to

Drilling work in progress at power house-I location down stream of Daudhan dam

Field visits of GSI and Rock Mechanics officials during the drilling at Daudhan dam axis along with NWDA officers

the proposed Ken-Betwa Link with off take FSL 257 m for diverting water to the Betwa river and also for enroute water requirements. Detailed grid survey has been carried out for this tunnel area with levelling grid interval of 50 m or less depending on slope of land. Contour plan of the area covering the length of tunnel and 500 m on either side of centre line of tunnel including approach portal and dump areas have been prepared to the scale of 1: 2500 H with 1 m contour interval. L-section of tunnel has also been prepared to the scale of 1:2500 H & 1:100 V. The same have been appended as Plate 2.1.13 in Drawing Volume-I.

(b) Lower level tunnel

As mentioned earlier, a lower level tunnel of length 1.1 km, has been proposed from Daudhan reservoir with an invert level of 244.6 m for connecting/ feeding the KMPP command through Ken LBC proposed earlier by Madhya Pradesh, Water Resources Department at 246.0 m FSL. This lower level tunnel will carry about 1007.4 MCM, of water for irrigation to major part of KMPP command. Detailed grid survey has been carried out for this tunnel area with levelling grid interval of 50 m or less depending on slope of land for preparing L-section and contour plan of the area. Contour plan of the area covering 1.1 km length of tunnel and 500 m on either side of centre line of tunnel including approach, portal and dump areas has been prepared in the scale of 1: 2500 H with 1 m contour interval. L-section of the tunnel has been prepared in the scale of 1:2500 H & 1:100 V. The same have been appended as Plate 2.1.14 in the Drawing Volume-I.

(c) Adit Tunnel

Since the length of lower level tunnel is only 1.1 km, no adit tunnel is required. Boring of the tunnel from inlet as well as outlet may be adequate. However, the same may be required for upper level tunnel, having a length of 1.929 km. Survey of Adit tunnel has not been done at DPR stage. Its requirement may be reviewed at preconstruction stage.

(d) Penstocks

Two penstocks of 4.5 m diameter are proposed to carry water from Daudhan dam to PH -I. Another 3 penstocks for PH -II are proposed from the surge tank located at the exit of lower level tunnel. The grid surveys carried out for PH-I & II cover the area required for laying penstocks.

2.1.8 Command Area

The command area proposed to be served in Phase–I of the Ken-Betwa Link project consists of the following three parts which lie under the Daudhan dam.

(i) Enroute Command (Madhya Pradesh & Uttar Pradesh)

(ii) Ken Command (Uttar Pradesh)
(iii) Ken Command (Madhya Pradesh)

(i) Enroute Command (MP & UP)

It is proposed to provide irrigation to 60294 ha area in the enroute of Ken-Betwa Link canal in Chhatarpur, Tikamgarh districts of Madhya Pradesh and Mahoba, Jhansi districts of Uttar Pradesh. This command is termed as 'Enroute command'. Detailed sample command area survey has been carried out in six patches of about 1000 ha each (total 6150 ha) with block levelling on 50 m or less grid basis, by NWDA. Contour maps have been prepared in the scale of 1:10000 H for the sample command area and in 1:2500 H scale with contour interval of 0.25 m for OFD works. Map showing the enroute command area including the surveyed area is shown in Plate 2.1.15 (1/4) & (2/4) in Drawing Volume-I.

(ii) Ken Command (UP)

Irrigation Department of Uttar Pradesh has informed that the command area being irrigated from existing Gangau weir through the existing Bariarpur head works is about 0.85 lakh ha in Banda district. This command area is to be taken up now through Phase–I of Ken-Betwa Link project. This command is termed as Ken command (Uttar Pradesh). Since this existing command is fully developed, only stabilization is proposed utilising 1600 MCM which is the allocated share of Uttar Pradesh under this project. As such, no survey has been done for this command. Command area map of existing Ken command in Uttar Pradesh through Bariarpur (PUW) is enclosed as Plate 2.1.15(3/4) in Drawing Volume-I.

(iii) Ken Command (MP)

Madhya Pradesh, Water Resources Department had earlier proposed 2.41 lakh ha of culturable command area under KMPP project with irrigation intensity of 134% (annual irrigation-3.23 lakh ha). This command area is to be taken up now through Ken-Betwa Link project Phase-I. This command is termed as Ken command (Madhya Pradesh). SOI has already carried out detailed survey of this Ken command at the request of Madhya Pradesh, Water Resources Department. Command area sheets (140 nos.) of this Ken command prepared by SOI on the basis of detailed survey have been collected from Madhya Pradesh, Water Resources Department. These sheets are available in the scale of 1:10000 and with 1 to 0.5 m contour interval. These maps have been utilized for preparation of command area maps including OFD maps of this command to the scale of 1:1000 H with contour interval of 0.25 m. Command area maps of Ken LBC are enclosed as Plate 2.1.15(4/4) in Drawing Volume-I.

2.1.9 Soil Conservation

M/s AFC Ltd., Hyderabad has been assigned the comprehensive EIA, EMP and R&R study of Ken-Betwa Link project. In order to contain soil erosion in the catchment and reduce the silt being carried out by the rivers and streams leading to Daudhan reservoir and also to compensate for the loss of forest land under its submergence, soil conservation measures and development of forest would be taken as suggested by the consultant. Likewise, in the command area based on the soils, land use, slope, land irrigability etc., soil conservation measures such as land levelling, effective water conductor system & drainage will be under taken as per recommendation of the consultant. Necessary provision for this work has been kept in the project estimate.

2.1.10 Any other

The existing Barwa Sagar reservoir across Barwa Nallah, a tributary of Betwa River is the terminal reservoir of the Ken-Betwa Link project. It is located near village Barwa in Jhansi district of Uttar Pradesh. Grid levelling was carried out at 50 to 100 m interval and the contour plan of the submergence area of Barwa Sagar reservoir is prepared with 1 m contour interval and is appended as Plate 2.1.16 in the Drawing Volume-I.

2.2 Other Allied Surveys

2.2.1 Archaeological Surveys in the Reservoir Area

The ASI and Department of Archaeology, Madhya Pradesh have informed vide letter no: Gen/NWDA/74/06-monuments/505 dated 17.04.07 (Copy enclosed as Annexure 2.3.1) that no sites of archaeological, historical and cultural importance maintained by them are present in the submergence area of Daudhan reservoir and enroute the Ken-Betwa Link canal.

2.2.2 Mineral (useful and harmful) Surveys in the Catchment/ Reservoir Areas

The Mines Officer, Chhatarpur vide his letter no. Mines/2009 dated 27.01.2009 and the Mines Officer, Panna vide his letter no. 243/II/M/3/6/09 dated 28.01.2009 have communicated that no minerals of economic importance are present in the submergence area of Daudhan reservoir and its vicinity as well as enroute the link canal.(Copy enclosed as Annexure 2.3.2 & 2.3.3 respectively).

2.2.3 Right of Way surveys for the Reservoir

No road communication of significance is existing in the proposed submergence area up to FRL of Daudhan reservoir for which right of way needs to be provided. Therefore, no such surveys have been carried out.

2.2.4 Communication Surveys

There is an existing bitumen approach road maintained by Uttar Pradesh Irrigation department from Chhatarpur-Panna road (NH-76) at Bamitha to the existing Gangau weir across the Ken River. The distance from Chhatarpur to Bamitha along NH-76 is 32 km while from Bamitha to Gangau, it is 28 km. This approach road is however, not appropriate for transport of heavy construction material and machinery. It is also not possible to widen this road from Bhusar to dam site due to hilly terrain. In view of this, the following alternate routes are explored during the communication survey carried out by NWDA.

1. Chhatarpur-Deogaon mod-Jhamtuli-Silon-Daudhan (53 km)
2. Chhatarpur-Bijawar-Kishangarh-Sukhwaha-Daudhan(110 km)
3. Chhatarpur- Satai-Armouniya-Salaiya-Silon-Daudhan (76 km)
4. Chhatarpur- Satai-Armouniya-Majhgawan-Daudhan (78 km)

All these roads are maintained by Madhya Pradesh, PWD and can be used for the project purpose after necessary widening for which suitable provision is kept in the cost estimate.

The nearest railway station and airport is at Khajuraho in Chhatarpur district located at about 40 km from the dam site. Satna Railway Station situated on Mumbai-Howrah rail route is about 110 km from the dam site.

The command area is well approachable from NH-76, Mauranipur -Jatara State Highway and other district roads. The major CD structures proposed across rivers Barne, Banne, Dhasan and Ur are well connected by road net work. A map showing the communication network of the project area of Daudhan complex is appended at Plate 2.1.17 in Drawing Volume-I.

All the villages in the vicinity of Daudhan dam, Link canal and command area are 100% electrified. Further, suitable provision is made in the project estimate for laying telephone lines etc.

In addition, the existing NH-76 is being developed into a 4/6 lane express highway connecting Jhansi to Khajuraho which would be very much useful for the project purposes during construction.

2.2.5 Drainage surveys

The command area enroute the link canal is drained by a network of rivers/streams namely Dhasan, Sadhni, Ur, Saprar, Sukhnai, etc. while the Ken command is drained by Urmil, Kutri, Kusjar, Khurar, Kali, etc in addition to number of small Nallah's. The commands have quite good draining facilities. However, with the introduction of irrigation, as the

command area develops, drainage problem may crop up in the course of time for which suitable provision is, therefore, made in the project estimate towards chak and collecting drains in the command area.

2.2.6 Soil surveys

(i) Ken Command

Soil survey in the Ken command area was carried out by the State Agriculture Department, Madhya Pradesh and a preliminary report had been submitted by the Joint Director of Agriculture, Sagar district. According to this report, the soils of the proposed Ken command possess slight to moderate erosion and few areas with severe erosion. The water holding capacity is low to medium. The pH value of the soil is from 7 to 8. The soils have good response to fertilizers and irrigation.

Further, as per the information provided by NBSS & LUP, Nagpur/ Delhi, these are good cultivable lands with very deep soils having medium to high fertility suitable for irrigation with moderate limitations due to heavy texture and thus need drainage.

(ii) Enroute Command

No soil survey has been carried for the enroute command of the link canal. However, based on the information provided by the NBSS & LUP, Nagpur/ Delhi, the soils of the area are broadly classified into five categories viz. soils on hills and hill ridges, plateau soils, pediment soils, soils of level alluvial plain and undulating flood plain and soils of dissected flood plain. These are good cultivable lands with very deep soils having medium to high fertility suitable for irrigation with moderate limitations due to heavy texture and topography requiring land shaping and drainage.

2.3 Geology, Geophysical & Seismic Investigations

2.3.1 Geology

In order to ascertain the feasibility of the project, an area of 45000 sqm was mapped by GSI on 1:12500 scale on the left flank of the proposed Daudhan dam in April, 1993, in addition to a couple of reconnoitre traverses in different reaches along the proposed link canal alignment. The litho units met with in the mapped area comprise hard, compact and fresh quartz- arenite/sandstone of the Semri Group of the Vindhyan Super group overlain partly by flood plain alluvium. The proposed dam site area comprises of very hard, compact and dense quartz-arenite, which appears to be very competent from the foundation grade point of view. Traverses taken in a couple of reaches along the proposed canal alignment have revealed presence of Bundelkhand granite and rock of the Bijawar Group overlain in the flood plain parts by riverine deposits. Since only a small part of the area has been mapped, no assessment with regard to the foundation condition in the dam site area has been made.

As a part of DPR, the preconstruction stage Geotechnical and geological investigation of Daudhan dam was carried out through GSI, Bhopal. Geological mapping of 1.84 sq km area was done on scale 1:2500. The investigation was aimed at evaluation of the geological set up and subsurface rock condition along the proposed axis of the main Daudhan dam for deciding the location of the spillway section vis-à-vis dam toe Power House, tentative depth of foundation grade for spillway, cut off grade for earthen embankments and extent of grouting etc. The note on pre-construction stage Geotechnical investigation of Daudhan dam site prepared by GSI is enclosed at Appendix-2.1 in Appendix Volume-I. The geology of the project area is discussed below in brief:

(i) Regional Geology

The Ken-Betwa Link Project is located in the Bundelkhand region of Madhya Pradesh and Uttar Pradesh which is characterized by typical peneplained topography comprising extensive plains, linear ridges and isolated hills forming various landforms such as mesa, hogback, cuesta and escarpments etc. The rivers mostly flow from southwest to northeast with dendritic to subdendritic pattern.

The Chhatarpur-Jhansi sector of the region is occupied by rocks of various geological formations ranging in age from the Archaean to Quaternary period. The major part of the area is occupied by a variety of granites with enclaves of meta-sediments and metabasics belonging to the Bundelkhand Gneissic Complex. These are overlain by ENE-WSW trending volcano sedimentary sequence of the Bijawar Group and an alternating sequence of arenaceous, argillaceous and subordinate calcareous sediments of the Vindhyan Supergroup in the southern parts. The Lacustrine Lametas and the overlying Deccan Traps cover Vindhyan rocks at various levels. Soils and alluvium of the quaternary-Recent period is mostly confined along the banks of Major River. Soil profile ranges from a few cm to 5 m.

The Bundelkhand block is reported to have been a very stable block which has not suffered any major tectonic episodes. There is no large scale folding and faulting recognizable in this block. The area of the Ken-Betwa link scheme displays two prominent trends of fractures that have been emplaced by quartz reefs and dolerite dykes. One of them trends NE-SW and the other trends NW-SE. The drainage in the area is controlled by these fractures.

(ii) Local Geology

The topography of Daudhan dam site area is conspicuous of rolling undulations on both the flanks of the Ken river exhibiting elevations roughly between 216 m (deepest river bed level) and 300 m. The river span is fairly wide with flood plain deposits forming sandy-clayey terraces on either bank of the Ken river. The abutment slopes are gentle and stable with sporadic talus and slope wash material. The colluvial boulders of chert breccia and slope wash are more frequent on right flank. The dam seat area is

Drilling work in progress at down stream of Daudhan dam axis

occupied by an inter-bedded sequence of hard, fine grained, thinly to thickly bedded sandstone with intermittent shale partings exposed in a major part on the left flank of the Ken river (Litho unit A), inter-bedded repeated sequence of siltstone/flagstone with shaly partings in the river section (Litho unit B), thinly bedded to laminated, black siltstone and carbonaceous shale with porcellanite beds (Litho unit C) and chert breccia with thin bands of dolomitic limestone (Litho unit D) exposed on the right abutment hill in stratigraphic succession. The above sequence of rocks belongs to the Semri Group of the Vindhyan Supergroup. A considerable part of the dam alignment is covered by alluvial soil. The abutment slopes are gentle defined by the dip of the bedrocks. Seepage of water through joints is anticipated.

Geology around the proposed link alignment indicate the presence of ferrugineous breccia of Bijawar group sand stone, silt stone, lime stone and shales belonging to semri group (Vindhyan super group). Pink, fine to medium grained, dense granite is exposed sporadically in the reaches between 75000 m to 75400 m of the canal alignment. Good quality sand mixed with pebbles and kankars are found in some of the rivers crossed by the link. In the reach near the terminal point of the link canal, presence of pink, coarse-grained massive granite (Bundelkhand Granite) are found. It is characterized by 3 sets of Vertical joints and 1 set of Basal joint with sub-horizontal dip. The joint openings are upto 50 m wide filled with weathered clayey material.

(iii) Geophysical Investigations

At FR stage, geophysical investigations along the dam axis were carried out by the teams of CSMRS during 1993. The investigation has revealed existence of sound rock within a depth of 3 m on the left bank except in two small reaches, where the depth may be around 7-8 m. On the right bank, hard strata (consolidated materials) exist at about 4-8 m depth in a length of about 100 m starting from the river bank beyond which groutable strata is available within 2-8 m. The report of CSMRS on Geophysical investigations carried out at proposed Daudhan for the FR of the Ken-Betwa Link project is enclosed as Appendix 2.2 in Appendix Volume-I.

2.3.2 Seismicity

The studies for site-specific design earthquake parameters for the proposed Daudhan Dam area have been carried out by the Department of Earthquake Engineering, IIT, Roorkee in 2008. As per these seismotectonic modeling studies, the site specific design earthquake parameter is estimated to be of magnitude 6.5. The PGA values for MCE and DBE conditions are estimated to be 0.11g and 0.06g respectively.

According to the above study, the proposed Daudhan dam site in Chhatarpur district of Madhya Pradesh lies in seismic zone-II as per the seismic zoning map of India as incorporated in IS Criteria for Earthquake

Resistant Design Structures [IS:1893-(Part-I) 2002]. Historical and instrumentally recorded earthquake data provided by IMD shows that in Chhatarpur and surrounding region moderate to strong earthquakes have occurred. The prominent amongst them are:-

(i) The earthquake of May 27, 1846 near Damoh (Magnitude - 6.5)
(ii) The Sone valley earthquake of June 2, 1927 (Magnitude - 6.5) and
(iii) The Jabalpur earthquake of May 22, 1997 (Magnitude - 6.0)

The region has also experienced fringe effects of some of the great earthquakes originating in the Great Himalayan Boundary Fault Zone. However, the effects of earthquakes in the Himalayan region were not significant at Chhatarpur and its neighbourhood.

In the region around Daudhan dam site bounded by latitude 21.6^0 to 27.6^0 N and longitude 76.8 to 82.9 E, around 90 earthquakes having small, moderate to strong intensity have occurred up to July, 2006. Among these, 21 earthquakes are of magnitude less than 3, while 3 earthquakes are in the range of more than 6 and the rest are in the intermediate range.

The site-specific design Earthquake parameters for Daudhan dam site prepared by IIT, Roorkee is enclosed at Appendix 2.3 in Appendix Volume-I.

2.4 Foundation Investigations

The work of foundation investigations (geotechnical) was carried out through GSI, Bhopal in association with CSMRS, New Delhi. Geotechnical assessment of surface and subsurface data along the axis of the Daudhan dam gathered through geological mapping (1:2500 scale) of an area of about 1.84 sq km and core logging of 26 exploratory drill holes at different chainage points along and across the dam axis aggregating to a total depth of 1006.50 m to precisely assess the subsurface rock condition. The laboratory testing of rock core samples has been carried out by Rock mechanics wing of CSMRS, New Delhi and the test results are appended in Appendix 2.4 of Appendix Volume-I. Summarized details of drill hole logs are given in Annexure 2.4. The findings and test results of the GSI and CSMRS are used in the design of suitable foundations for various components of the project by the Design Directorates of CWC. The details of the foundation investigations carried out are discussed below in brief.

2.4.1 Earth Dam

Subsurface explorations for the 1233 m long earth dam proposed on the right flank of the Daudhan dam has been done by drilling 17 boreholes (DH-10 to DH-26). The total depth of drilling is about 750 m. Based on the subsurface explorations, it is inferred by GSI that the right earthen

abutment hill of the Daudhan dam is composed of geo-technically inferior grade of rock mass which are considered suitable for earthen structures of low magnitude with adequate strengthening measures for ensuring full reservoir competency.

2.4.2 Concrete dam in Spill Way Portion

The subsurface exploration of the 536 m long overflow portion of the Daudhan dam has been done by drilling nine drill holes (DH-1 to DH-9). The total depth of drilling is about 256 m.

The GSI has concluded that based on the interpretation of surface and subsurface data, competent foundation grade sandstone(litho unit A) is available at much higher elevation on the left flank where the location of the spill way can be safely fixed on techno-economic considerations. The foundation grade rock has sufficient areal spread to house the concrete/masonry structure. The height of the concrete/masonry spillway in case of the flank spillway would considerably be lesser than that of the centrally located spillway. The side spillway, however, may have to be supplemented with approach and spill channels of considerable length due to topographical features of the area. A geotechnical note on sub-surface exploration of central spillway of Daudhan dam is enclosed as Appendix 2.5 of Appendix Volume-I.

2.4.3 Canal and Canal Structures

Subsurface exploration of the major canal structures across Ken-Betwa Link canal alignment was carried out by GSI, Bhopal and testing of rock core samples has been carried out by CSMRS, New Delhi. A total of 50 drill holes had been drilled at different chainage points along the axis of various CD structures to assess the subsurface geological conditions. A geotechnical note on sub-surface exploration of CD structures across link canal is enclosed as Appendix 2.6 in Appendix Volume-I. The depth of exploratory drill holes ranges from 3.50 m to 24.00 m. Except the Pukhraha Nallah aqueduct envisaged at RD 0.00 km of the main link canal, all other CD structures, road and railway crossings and deep canal sections located at different chainages are occupied by granite gneisses belonging to the Bundelkhand Gneissic Complex. At Pukhraha Nallah, geological section along the alignment reveals the presence of dull to off white, fine grained, hard, compact, thinly to thickly bedded quartzite on the right bank and basic rock on the left bank, the latter being intrusive into the former rock mass.

Based on interpretation of exploratory data, it is inferred that the foundation of the CD structures at different chainages of the main link canal is composed of hard, compact, foliated and massive granite gneiss with favourable geotechnical features. Geo-technically, this rock mass at foundation grade is considered suitable and competent for the imposed load of the superstructures with adequate treatment measures for ensuring safety

and stability. The foundation grade rock has sufficient areal and depth persistence to house the structure.

2.4.4 Power House and Tunnels

a) PH-I and TRC

The proposed site of PH-I along with TRC is located at the toe region of the main Daudhan dam between RD 700 m and 800 m. It shows undulatory topography exhibiting elevations roughly between RL 248 m and 237 m. Results of in-situ permeability test has revealed that the rock mass is slightly to moderately permeable. Seepage of water through joints, therefore, is anticipated during construction. A geotechnical note on sub-surface exploration of the major structures of Daudhan components is attached as Appendix 2.7 in Appendix Volume-I.

The proposed site has been explored by 4 drill holes (DH -27 to DH-30) aggregating to 168.50 m depth. The depth of drill hole ranges from 15 m to 50.30 m. The explored stratigraphic column is composed of massive sandstone with frequent shaly partings (Litho unit A) right from the ground level. The rock mass in the entire column is inherently hard, compact, strong and geotechnically considered to be very competent for the proposed Power House in view of good to excellent core recovery, poor to good RQD, lower grades of weathering and impervious nature (0.00 - 0.80 Lugeons) of bed rocks. The foundation at PH-I is sufficiently strong to house the underground/surface structures due to inherently favourable genetic properties. Frequent intercalations of weak rock mass, however, locally affect the strength characteristics requiring treatment measures for improvement of foundation grade.

b) PH –II

The proposed site of PH-II is located at the exit end of lower level tunnel connecting to Ken LBC. It lies roughly at 1900 m along the tunnel alignment (FB 1˚). The Power House area shows peneplained topography with rolling undulations exhibiting elevations roughly between RL 240 m and 260 m. A note on pre-construction stage geotechnical investigation of the PH-II is enclosed as Appendix 2.8 in Appendix Volume-II.

The proposed site of PH-II has been explored by 4 drill holes of 25.3 m depth (DH-1 to DH -4) aggregating to 101.2 m depth. The rock mass in the entire depth of borehole is in combination of alternate hard and soft layers which are geotechnically considered to be moderately strong and competent for the proposed small Power House in view of poor to very good core recovery, very poor to poor RQD, moderate grades of weathering and impervious nature (0.10-1.30 Lugeons) of bedrocks.

The foundation at PH-II would be located in moderately strong to weak rock mass needing elaborate treatment measures for improvement of rock mass characteristics.

c) Upper Level Tunnel

Modified horseshoe tunnel of 6 m dia and length 1929 m including transition length has been envisaged to transmit the designed discharge of 76.23 cumecs from Daudhan dam to the Link canal. The proposed alignment (FB 332 °) of the tunnel has been explored with 5 exploratory drill holes (DH-1 to DH-5) aggregated to 322.50 m depth. The depth of the holes ranges from 27 m to 102 m. The tunnel would have a overburden of maximum 120 m.

The exploratory drill holes indicate that in DH-4, a wide fracture zone of about 27 m thickness between RL 313.45 m and 286.45 m has been intersected with no core recovery. This zone may continue up to the tunnel between RD 1250 m and 1525 m. Water loss during drilling has been reported in this fracture zone. 27-102 m thick stratigraphic column explored at the tunnel is occupied by different rock mass units. The results indicate that tunnelling would be through good to poor rock mass having stand up time between 6 months and one week only.

d) Lower level tunnel

About 1100 m long and 5.5 m dia modified horse shoe tunnel has been envisaged to transmit the designed discharge of 65.194 cumecs from the Daudhan dam to the Ken LBC. The proposed alignment (FB 1°) of the tunnel has been explored with 7 drill holes (DH-LT1 to DH – LT3) aggregating to 189.30 m core depth. The depth of the holes is 25.3 m. In addition, the data from the drill holes located at PH-II are also utilised for exploration of the subsurface strata for the Lower level tunnel. The tunnel would have a overburden of maximum 100 m. The tunnelling media for the Lower level tunnel has been classified into “Fair to Good” and “Poor to Fair” categories as per Rock Mass Rating (RMR) values.

Laboratory investigations of rock samples collected from PH-I & II, Upper and Lower level tunnels, CD/CM structures carried out by CSMRS, New Delhi are enclosed as Appendix 2.9 in Appendix Volume-II. The bearing capacity of massive sandstone of litho unit ‘A’ and orientation and frequency of joints in massive sand stone of litho unit “A” forming foundation media for major structures are enclosed as Appendix 2.10 and Appendix 2.11 respectively in Appendix Volume- II.

2.5 Construction Material Investigations

2.5.1 Soils

The work of borrow area soil investigations for the proposed Daudhan Dam & link canal was carried out through CSMRS. Representative bulk soil samples from potential borrow areas in the vicinity of Daudhan dam were collected by CSMRS in May, 2007 and investigations carried out in its laboratory to characterize the collected borrow area materials for their suitability in the construction of the earthen portions of the dam. 48 soil samples were collected from pits excavated manually in the borrow areas viz. Daudhan, Palkohan and Kharyani. Disturbed soil samples were collected up to a maximum depth of 3 m.

S.No.	Name of Borrow Area	No. of samples collected
1.	Daudhan	23
2.	Palkohan	13
3.	Kharyani	12

Map showing location of borrow area pits of Daudhan Dam site with IS soil classification of these representative soil samples collected are given as Plate 2.1.18 in Drawing Volume I.

Laboratory tests such as Mechanical analysis and Atterberg Limits, Specific Gravity, Standard Proctor Compaction, Triaxial Shear Test with Pore water pressure measurement, One Dimensional Consolidation, Laboratory Permeability, Chemical Analysis, Soil Dispersivity Tests (Crumb, SCS Double Hydrometer, Pin Hole and Chemical Analysis on pore water extract) were carried out on the collected Borrow area materials. Based on these tests, it is inferred that all the tested borrow area soil samples in general exhibit plasticity characteristics and are suitable for construction of earthen dam. The soil samples are capable of achieving good compaction densities and possess fairly good shear strength characteristics. The soil samples in general are impermeable and exhibit basic characteristics in nature and fall under normal category (As per total soluble salts). Further, the soil samples tested in general possess low to medium (slightly higher side) compressibility characteristics and can be categorized as Non dispersive.

The report on soil investigations for samples of Borrow areas of Daudhan dam & Link canal is furnished as Appendix 2.12 & 2.13 respectively of Appendix Volume-II.

2.5.2 Sand

CSMRS, New Delhi had carried out construction material survey and laboratory investigations of sand samples for their use as fine aggregate

in concrete during construction of the project. 21 sand samples were collected from different sand quarries and the physical tests viz. specific gravity, grading and fineness modulus, silt and clay content, organic impurities, petrographic analysis etc. were conducted on the representative sand samples as per BIS (IS : 2386-latest version) for assessing their suitability as per IS : 383-2002 for use in concrete. Based on the test results of physical properties, it was found that the sand samples collected from the following quarries are suitable for use in concrete as fine aggregate.

1. Imalia sand quarry
2. Nuna Lugasi river sand quarry
3. Satana village sand quarry
4. Gangoha sand quarry
5. Karaola sand quarry
6. Nawada village sand quarry
7. Budaur village sand quarry
8. Pipal ghat villagesand quarry

Report on the Construction Material Survey and Laboratory investigations of rock & sand samples for use as coarse & fine aggregates by CSMRS, New Delhi are furnished as Appendix 2.14 in Appendix Volume-II.

2.5.3 Rock and Aggregates

CSMRS, New Delhi carried out construction material survey and laboratory investigations of rock samples for their use as coarse aggregate in concrete during construction of the project. 21 rock samples were collected from different rock quarries and the physical tests viz. specific gravity, water absorption, soundness loss(5 cycles), aggregate impact, crushing & abrasion values, petrographic analysis etc. were conducted on the representative rock samples as per BIS (IS:2386-latest version) for assessing their suitability as per IS:383-2002 for use in concrete. Based on the results of the tests, the following rock quarries are found suitable for use in wearing as well as non-wearing surfaces.

1. Pira village rock quarry
2. Laxamanpura rock quarry
3. Dauria rock quarry
4. Khajwa village rock quarry
5. Karare village rock rock quarry
6. Gova-Kuriate rock quarry
7. Katholic Maharaj rock quarry

Further, it was also found that the Khajwa Rock Quarries are suitable for use in non-wearing surfaces only. The petrographic examination report received from GSI, Faridabad & Lucknow reveals that rock consists of strained quartz 12 % to 73% and undulatory extinction angle varying between 18˚ to 32˚. Presence of strained quartz in higher percentages and

/or undulatory extinction angle beyond 15% may cause alkali aggregate reaction at the later stages of construction. The confirmatory tests such as mortar bar tests, Accelerated Mortar Bar Tests have not been carried out but the same shall have to be carried out with the then existing rock and sand samples to be actually used in the construction works. Suitable remedial measures shall have to be taken to control alkali aggregate reaction and also to minimize deleterious effects of any other minerals such as potash, feldspar, etc. present in the rock sample. The test results of the above rock samples are furnished in the report of CSMRS, New Delhi and enclosed as Appendix 2.14 in Appendix Volume-II.

2.5.4 Bricks, Tiles

Soil of suitable quality is available near the proposed colony sites and along the canal for manufacture of bricks and tiles for use in building construction. Also, bricks can be transported to the colony sites from the nearest kilns available in the vicinity of project area at Chhatarpur, Nowgong and at other towns enroute the link canal.

2.5.5 Pozzolona

The pozzolonic materials are not considered to be used in the construction of the project.

2.5.6 Cement/Lime Stone

Extensive geological survey made by the Madhya Pradesh State and Mining Department for KMPP revealed that large quantities of lime stone occur in the project area. These areas are highly silicious and magnesious and do not fetch much economic value.

2.5.7 Cement and Steel

The quantity of cement required for the construction of the project can be brought from nearest cement plants located in Satna and Damoh districts of Madhya Pradesh State to the nearest railhead i.e., Khajuraho. Similarly, the steel required for the project can be brought from Bhilai steel plant located in Chhattisgarh State to the nearest rail head i.e. Khajuraho. Khajuraho is connected by broad gauge railway line from Mahoba railway station situated on the Allahabad – Jhansi broad gauge Central Railway line.

2.5.8 Scarce Material

No scarce materials are anticipated to be used in the project which may cause hindrance to the construction of the project.

Samples of core boxes collected from the drilling of tunnels at Daudhan dam site

SE, IC, Gwalior, viewing the core samples of Drilling for tunnels

2.5.9 Any other Material

There has been adequate quantity of soil, sand and stone of suitable quality in the identified quarries for construction of the project. Cement and steel will be transported by rail and stacked at the nearest rail head points in the proposed stock yards/stores all along the canal and from there, these will be transported to the site stores with minimum lead.

2.6 Hydrological and Meteorological Investigations

2.6.1 Rainfall and Runoff

There are 16 rain gauge stations located in the catchment of Ken basin upto Daudhan dam site and the rainfall data are available for varying periods from 1901 to 2004 as collected from IMD. About 90% of the annual rainfall is received during the monsoon period i.e. from June to October. List of rain gauge stations located in the catchment and respective period of availability of data considered for hydrological studies is given at Annexure 2.5.

2.6.2 Sunshine, Cloud Cover and Visibility

Based on the data of three IMD observatories located in and around the project area viz. Satna, Jabalpur and Guna, the monthly average coefficients of sunshine vary from 0.469 to 0.736. Similarly, considering the normal monthly cloud cover data of three stations viz. Chhatarpur, Jabalpur and Sagar, the maximum cloud cover is usually observed during the months of July or August whereas the minimum cloud cover is observed during December.

2.6.3 Wind and Cyclones

The normal monthly wind velocity data of five IMD stations viz. Nowgong, Sagar, Damoh, Panna and Jabalpur have been collected from IMD. The maximum and minimum wind velocities are 16.1 km/hr and 1.0 km/hr respectively at both Sagar and Nowgong IMD stations. As the project area is not situated in the coastal areas, the effect of cyclones is not considered significant.

2.6.4 Humidity

From the monthly relative humidity data of the above five stations, it is seen that the maximum and minimum values of humidity are 95% and 9% during monsoon and summer seasons respectively.

2.6.5 Temperature

Similarly, based on the temperature data of the five stations, it is seen that the average maximum and minimum temperatures vary between 44.2 °C and 6.7 °C respectively.

2.6.6 Discharge

No G&D site is available on the Ken river nearer to Daudhan dam site. There are however, four G&D sites in entire Ken basin as detailed below:

Sl. No	Name	River	Catchment area(sq km)	Data availability	
				From	To
1.	Patheria*	Sonar	1634	1974	1982
2.	Garhakota	Sonar	1313	1982	2005
3.	Gaisabad	Bearma	5758	1974	2005
4.	Madla	Ken	20680	1981	2005
5.	Banda	Ken	25452	1960	2005

* site shifted to Garhakota.

The hydrological studies upto Daudhan dam site have been carried out by using the data of Banda & Madla G&D sites located about 31 km & 150 km respectively d/s of Daudhan dam. However, in order to observe the actual runoff data at the proposed dam site, one G&D site has been established by NWDA at Bhusor, on river Ken d/s of existing Gangau weir near Daudhan dam site and observations have been started w.e.f. 1.10.2006, and continued till 31.10.2009.

2.6.7 Sedimentation

There is a silt observation site on the main Ken river at Banda which is about 150 km d/s of the proposed Daudhan dam site. At this site, sediment data for 36 years (1962 to 2004 excluding 1975-1981) was available and is used to arrive at the silt rate to the Daudhan reservoir. The average silt rate has been worked out as 329.8 m^3/sq km/year. Accordingly, the total sediment deposition in the proposed reservoir during 50 and 100 years are estimated to be 206.1 and 361.73 MCM respectively. However, silt samples are being collected at Bhusor G & D site and the same are being analysed at the silt laboratory set up by NWDA with effect from 25.07.2007 and continued till 31.10.2009, to observe the actual silt rate at the dam site.

Petrographic analysis of two silt samples of Ken River has also been carried out through IIT, Delhi in September, 2008. It is found that both the samples have high percentage of coarse (>7500 microns) and very fine

fraction (<75 microns) more in percentage followed by sieve fractions 150 microns. The most predominant mineral is quartz (ranging 74% to 84%) in the samples. It is also seen that angular to sub angular shape particles are predominant with considerable amount of sub-round to round minerals. The samples further indicate the presence of calcareous minerals in the silt. This information has been supplied to CWC for appropriate use in the design of hydro power components of PH-I & PH-II. The report on Petrographic analysis of Ken river silt by IIT, New Delhi is enclosed as Appendix 2.15 in Appendix Volume-II.

2.6.8 Water Quality

Different parameters of water quality are observed regularly at Banda G&D site of CWC. It is observed that quality of water of Ken River is, in general, fit for domestic, industrial and agricultural purposes. However, water samples are being collected every month by NWDA from the Ken River at Bhusor near Daudhan dam site with effect from 1-2-2008 and got tested at the water quality testing laboratory of CWC at Agra/ Delhi till October, 2009.

2.6.9 Evaporation

There is no pan evaporimeter installed near the Daudhan dam site. The monthly average evaporation of two nearby stations (Sagar and Damoh) varies from 6.35 cm (in December) to 40.01 cm (in May). The monthly normal evaporation depths considered for Daudhan reservoir in the hydrological studies (Phase-I) of Ken-Betwa Link Project are given in Table 2.1.

Table 2.1
Monthly normal evaporation considered for Daudhan reservoir

S.no.	Month	Normal evaporation depth(m)
1.	January	0.0699
2.	February	0.0889
3.	March	0.1714
4.	April	0.2921
5.	May	0.4000
6.	June	0.2603
7.	July	0.1143
8.	August	0.0953
9.	September	0.1143
10.	October	0.0953
11.	November	0.0699
12.	December	0.0635
	Total	1.8352

CHAPTER-III
HYDROLOGY &
WATER ASSESSMENT

CHAPTER-III

HYDROLOGY AND WATER ASSESSMENT

3.0 General climate and hydrology

The project area under study is semi-arid to dry sub-humid. The climate is tolerable except during the months of May and June. The air is mostly dry except during south-west monsoon season. Summer is hot and winter is generally mild. So far hydrology of the of the Ken-Betwa Link project Phase-I is concerned, it is mainly based on hydrology of Ken river at Daudhan. Ken River has been found to be surplus at 75% dependability and as such after meeting in-basin requirement of Ken, surplus water of 1074 MCM has been proposed for diversion to Betwa basin. Hydrological studies of Ken-Betwa Link project were got carried out by NIH, Roorkee in four parts.

Phase-I of these study deals with assessment of yield, water balance, design flood & diversion flood, sedimentation studies & simulation studies for Ken river at Daudhan dam whereas Phase-II(a) deals with the same studies in respect of Upper Betwa Projects to be taken up in Phase -II of the Ken-Betwa Link project.

Phase -II(b) of NIH study includes dam break analysis of Daudhan dam, back water studies of Daudhan &

Phase-II(c) covers integrated simulation of dams involved in Ken-Betwa Link, morphological studies etc.

The portions of reports of different phases of Hydrological studies (carried out by NIH, Roorkee) relevant to Phase-I of the Ken-Betwa Link project are placed in Appendix Volume-III.

3.1 General information about regions

Ken basin

The climate of the area is semi-arid to dry sub-humid. Summer is hot and winter is generally mild. About 90% of the annual rainfall is received during the monsoon period, i.e. from June to October. The average maximum and minimum temperatures are 44.2 °C and 6.7 °C respectively. The monthly mean relative humidity data of the basin (for five IMD stations) show that the maximum and minimum values of humidity are 95% and 9% during monsoon and summer seasons respectively. The maximum and minimum wind velocities are 16.1 km/h and 1.0 km/h respectively at Sagar and Nowgong stations. Usually the maximum cloud cover is observed during the months of July or August whereas the minimum cloud cover is observed during December. The monthly average coefficients of sunshine vary from 0.469 and 0.736. There is no pan-evaporimeter installed in the basin. The monthly

average evaporation of two nearby stations (Sagar and Damoh) varies from 6.35 cm (in December) to 40.01 cm (in May).

Betwa basin

The climate of the basin is characterized by hot summer and mild winter. The temperature in the upper reaches sometimes goes beyond 40 °C. The maximum and minimum mean monthly relative humidity are reported to be 83% (August) and 20.5% (April) respectively. The wind velocities in the upper reaches (varying between 6.6 km/h to 18.9 km/h) of the basin are generally higher than that of the lower reaches in the basin (varying between 2.9 km/h to 13.0 km/h). The cloud cover is also reported to be higher in the upper part of the basin compared to the lower part. However, the highest and lowest cloud covers experienced in the entire basin are during the months of August and November respectively.

3.2 Specific information

3.2.1 Drainage basin

Ken basin

The Ken River originates from the Ahirgawan village on the north- west slopes of the Kaimur hills in the Jabalpur district of Madhya Pradesh at an elevation of about 550 m above MSL. The total length of the river from its origin to its confluence with the Yamuna River is 427 km, out of which 292 km lies in Madhya Pradesh, 84 km in Uttar Pradesh and 51 km of its course forms the common boundary between the two states. The river joins the Yamuna River near village Chilla in Uttar Pradesh at an elevation of about 95 m. The river is the last tributary of Yamuna before it joins the Ganga. The river basin lies between 23°12' – 25°54' N latitudes and 78° 30' – 80° 36' E longitudes. The total catchment area of the river is 28058 sq km, out of which 24472 sq km lies in Madhya Pradesh and the remaining 3586 sq km in Uttar Pradesh. The river network in Ken-Betwa system is presented in Fig 3.1. Railway & road network in the basin is shown in Fig 3.2.

The Ken basin covers Sagar, Damoh, Panna, Satna, Chhatarpur, Katni, Narsinghpur and Raisen districts of Madhya Pradesh and Mahoba and Banda districts of Uttar Pradesh. It is bounded by Vindhyan range in the south, Betwa basin on west, free catchment of Yamuna below Ken on east, and the river Yamuna on north. The important tributaries of Ken are Alona, Bearma, Sonar, Mirhasan, Shyamari, Banne, Kutni, Urmil, Kail and Chandrawal.

The longest tributary of Ken River is Sonar which is 199 km in length and lies wholly in Madhya Pradesh in the u/s of the Daudhan dam site. In terms of catchment area also, Sonar is the largest tributary with a catchment

area of 12620 sq km. Out of the others, Alona, Bearma, Mirhasan and Shyamari join Ken River u/s of the proposed Daudhan dam. River Banne on which the Rangawan dam is constructed joins Ken River between the proposed dam site and the existing Bariyarpur PUW, while Kutni, Urmil, Kail and Chandrawal join d/s of Bariyarpur PUW Urmil and Kail rivers have part of their catchments in Uttar Pradesh while river Chandrawal has the most of its catchment area in Uttar Pradesh.

Betwa basin

The Betwa River originates in the Raisen district of Madhya Pradesh near Barkhera village south-west of Bhopal at an elevation of about 576 m above MSL. It flows in a north-easterly direction through Madhya Pradesh and enters into Uttar Pradesh near village Bangawan of Jhansi district. The total length of the river from its origin to its confluence with the Yamuna River is 590 km, out of which 232 km lies in Madhya Pradesh and the rest 358 km in Uttar Pradesh. The river joins the Yamuna near Hamirpur in Uttar Pradesh at an elevation of about 106 m. The Betwa is an interstate river between the two states, viz., Madhya Pradesh and Uttar Pradesh. The river basin lies between 22° 54' to 26° 00' N latitudes, and 77°10' to 80°20'E longitudes. The total catchment area of the basin is 44335 sq km out of which 30238 sq km lies in Madhya Pradesh and the remaining 14097 sq km lies in Uttar Pradesh. The basin is saucer shaped with sandstone hills around the perimeter.

During its course from the source up to the confluence with the Yamuna, the river is joined by a number of tributaries and sub- tributaries; the important among them being the Bina, Jamni, Dhasan and Birma on the right bank and Kaliasote, Halali, Bah, Sagar, Narain and Kethan on the left bank. Out of the 14 principal tributaries 11 lie completely in Madhya Pradesh and 3 lie partly in Madhya Pradesh and partly in Uttar Pradesh. The Halali is the largest tributary of Betwa River having a length of 180.32 km.

Betwa covers the areas of Bundelkhand uplands, the Malwa plateau and the Vindhyan scrap lands in the districts of Tikamgarh, Sagar, Vidisha, Raisen, Bhopal, Guna, Shivpuri and Chhatarpur of Madhya Pradesh and Hamirpur, Jalaun, Jhansi and Banda districts of Uttar Pradesh.

3.2.2 Command area

The Ken-Betwa Link project Phase-I has three commands as described below:

(i) Ken command (Madhya Pradesh)

The Ken command area of Madhya Pradesh comprising 2,41,306 ha CCA is spread over Chhatarpur and Panna districts of Madhya Pradesh.

(ii) Ken command (Uttar Pradesh)

The Ken command area of 2.13 lakh ha is spread over Banda district of Uttar Pradesh. This command is the existing command of Bariarpur RBC.

(iii) Enroute command

The enroute command area comprising 60,294 ha CCA is covered in Chhatarpur and Tikamgarh districts of Madhya Pradesh and Mahoba and Jhansi districts of Uttar Pradesh.

3.2.3 Floods and drainage

Ken Basin

The observed 10-daily discharge data (3 values per month) of two gauging sites namely, Banda and Madla, both d/s of Daudhan are available for 45 and 25 years, respectively, with some missing records. The annual maximum series (25 years of data) for Madla is also available. As per the AMS, the maximum observed flood was 20150 Cumecs in the year 2005. Various G & D sites and structures in the system are shown in Fig 3.3.

Betwa Basin

The observed daily G&D data of only one G&D site in the Upper Betwa basin, i.e., Basoda are available for 30 years (1976 to 2005) with some missing records. The maximum observed discharge at the G&D site was 9289.1 Cumecs on 24th July 1986.

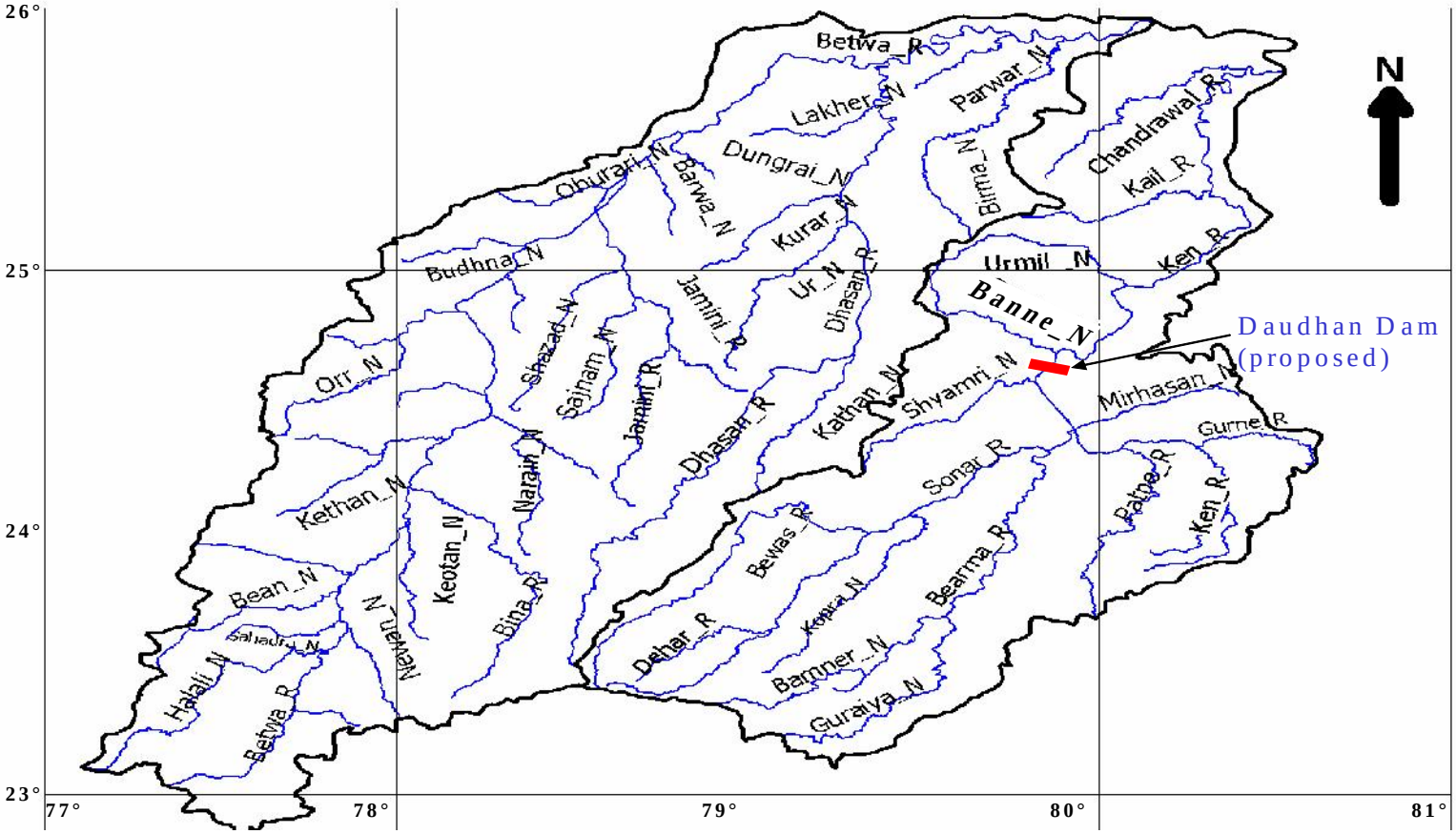


Fig 3.1. River network in Ken-Betwa system

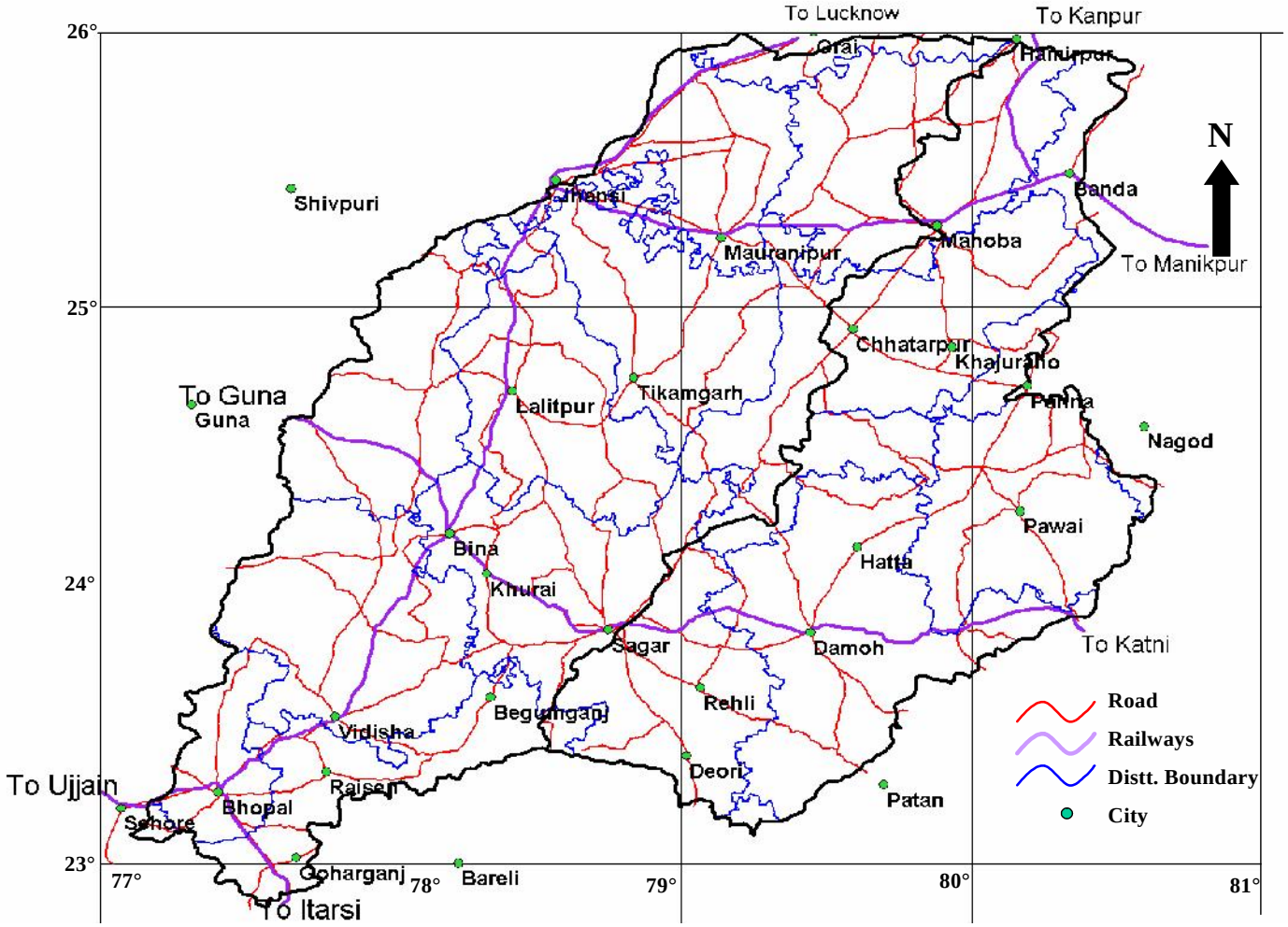


Fig 3.2. Road and rail network in Ken-Betwa system

3.2.4 River geometry

The schematic diagram of Ken-Betwa river system (Fig 3.4) gives an overview of the river geometry.

3.2.5 Ground water recharge

During EIA of Ken-Betwa Link, detailed study of ground water quality, ground water levels, ground water fluctuations have been carried out for 2006-07. The details are furnished in Chapter-VIII “EIA & EMP”. The analysis of water level data in project area indicates a general rise in water level during rainy season. The reservoir and link canal are likely to have a long term increase in water levels of the phreatic zones.

3.2.6 Reservoir area

In Phase-I of Ken-Betwa Link Project, there is only one proposed reservoir viz., Daudhan. Project area of the Daudhan dam is located in the Panna and Chhatarpur districts of Madhya Pradesh. The dam site is situated in the Chhatarpur district near the Daudhan village at 24°36’ 51" N latitude and 79° 50’ 30" E longitude and is about 2.5 km u/s of the old Gangau Weir. The area of the reservoir at FRL is estimated as 9000 ha. The project area is approachable by road from Chhatarpur-Panna state highway. It is about 19 km (WBM road) from this road. The dam site is approachable by a dry weather motorable road of about 5 km from the Irrigation Inspection Bunglow at Gangau. The project site is also approachable by rail up to Satna railway station, which is about 110 km by road towards Chhatarpur. Khajuraho is the nearest airport, which is 31 km away from the dam site, which is also recently connected by new railway line from Mahoba.

About 74% of the reservoir submerged area comes under forests. Parts of these forests are reserved and a part on the north and south bank of Ken River is under Panna National Park. Almost all the forests are dense and mixed jungles comprising deciduous, a few evergreen to semi-evergreen and a few xerophytic to semi- xerophytic types of species.

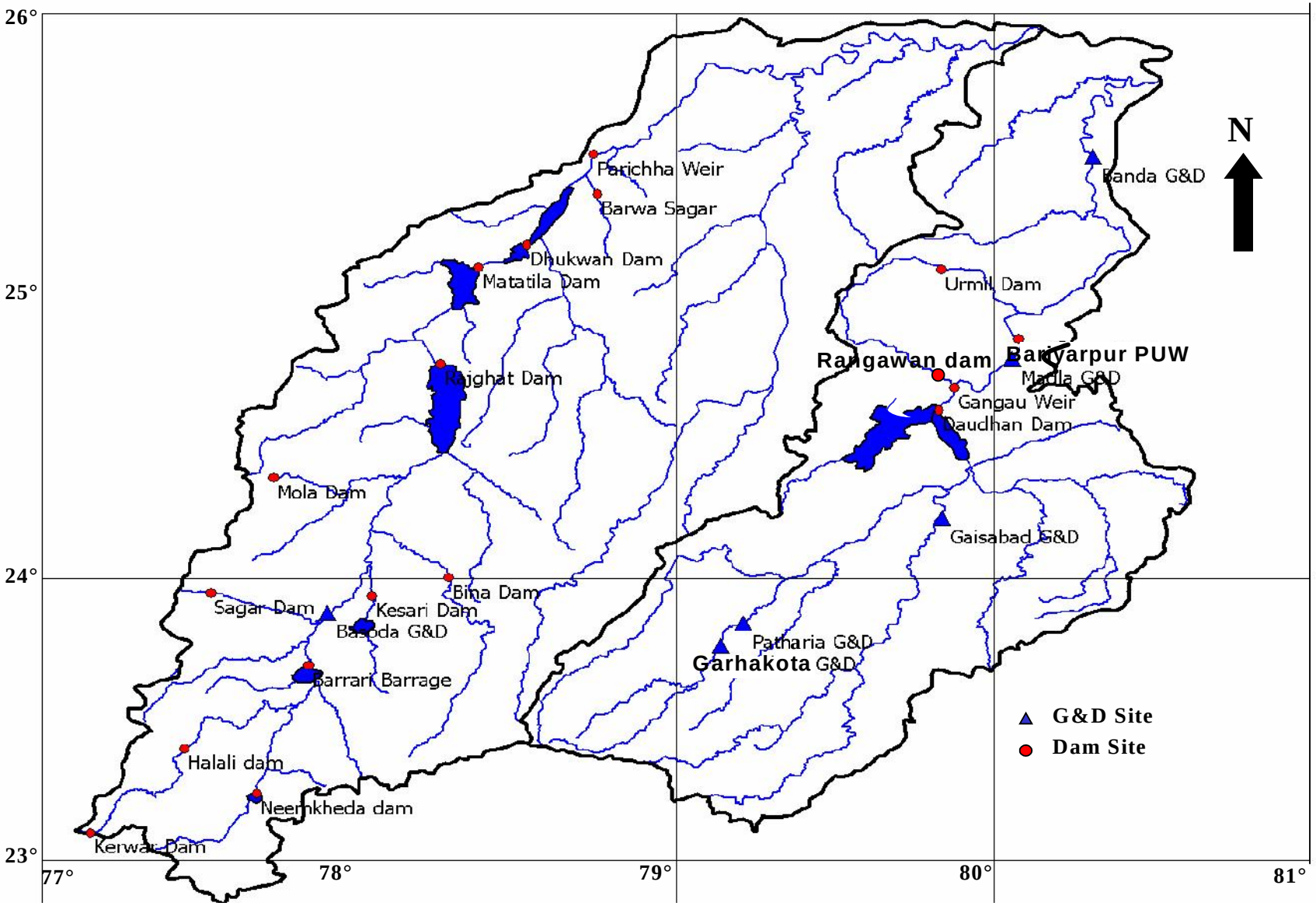


Fig 3.3. Major structures and G&D sites in Ken-Betwa system

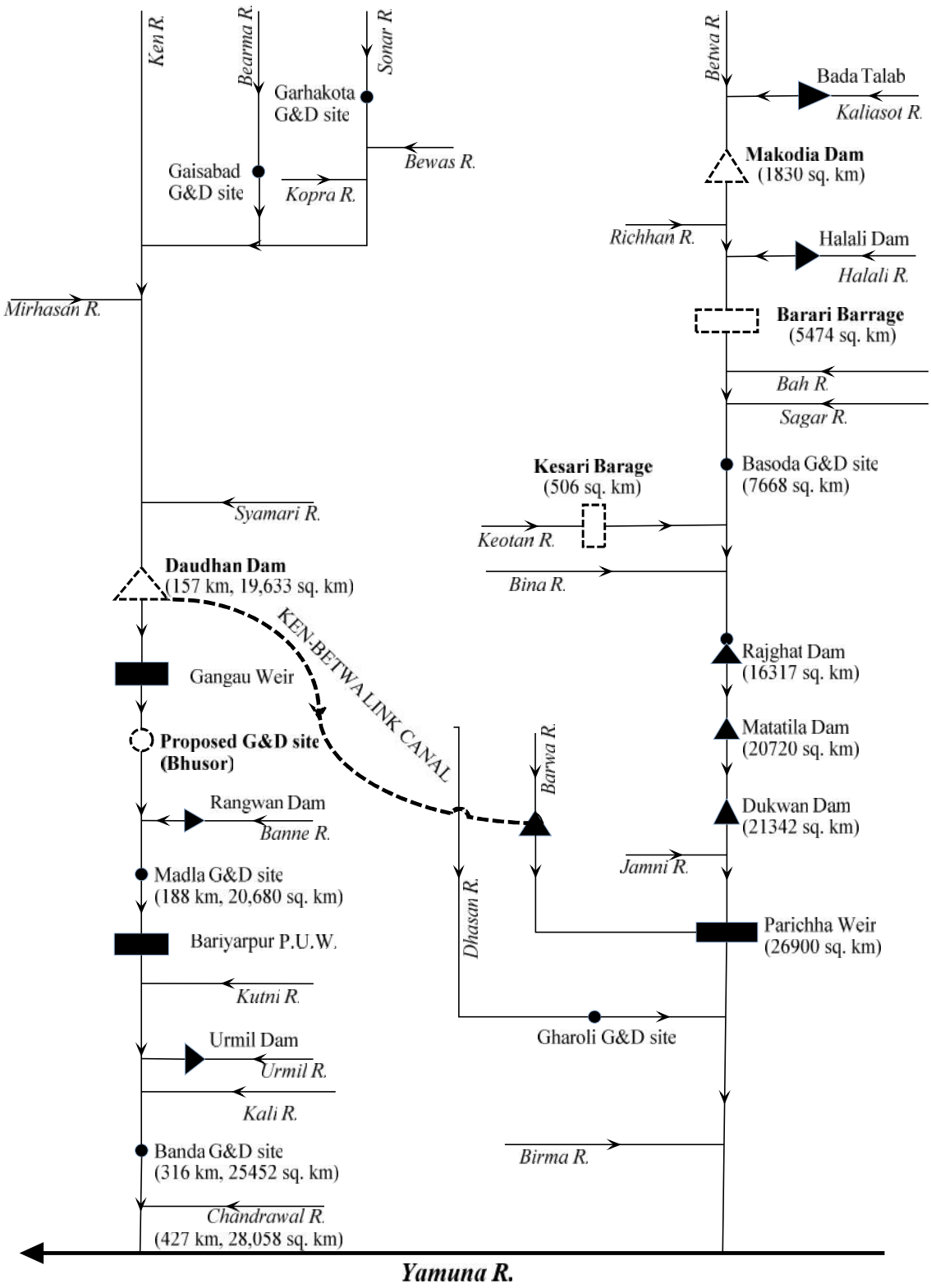


Fig 3.4. Schematic diagram of the Ken-Betwa river system with major structures (existing and proposed) and the link canal

Extensive geological survey made by the Madhya Pradesh State Geology and Mining Department reveals that large quantities of limestone occur in the project area. These areas are highly siliceous and magnesious and do not fetch much economic value. No other valued mineral mines are found in the project area. The Panna diamond mine is nearby the project area but does not fall in the jurisdiction of the proposed project boundary.

Due to creation of the Daudhan dam and reservoir, about 900 families having a total population of approximately 8550 persons will be uprooted from 10 villages, at FRL. A few clusters of population in the periphery of the reservoir will also be affected as lands of these villages may come under submergence. The majority of population in the submergence area is dependent on forest products as the reservoir area is covered mostly by forests. A few of them are either agricultural or industrial workers. About 15 to 20% of the people to be affected in the submergence have agriculture as their occupation. On the other hand, most of the people to be benefited in the command area are dependent on agriculture, either cultivating their own lands or working as labour in agriculture fields.

3.2.7 Other water usage

The water stored in the Daudhan reservoir will mostly be used for irrigation and drinking purposes.

3.2.8 Navigation

Rivers in the Ken-Betwa system are presently not being used for any major navigational purpose. There is no provision for navigation in the proposed Ken-Betwa Link also.

3.3 Data Availability

3.3.1 Rainfall and snowfall

There is no snowfall in Ken basin. Rainfall data availability is described in following paragraphs.

Ken Basin

The precipitation on the basin is in the form of rainfall and the intensity of rainfall varies fairly in time and space as observed from the database. The inventory of raingauge stations & availability of existing database for the basin is given in Table 3.1. The distribution of the existing rain gauges in the Ken basin is shown in Fig 3.5. There are twenty one rain gauge stations in and around Ken basin that are being maintained by IMD.

Table 3.1
Rain gauge stations in Ken basin and their period of availability

RG No.	Station Name	Period of availability	Record length in years
1	Bijawar	1901-2002	101
2	Hatta	1901-2002	101
3	Borina	1927-1994	67
4	Banda	1901-2002	101
5	Rehli	1901-2002	101
6	Majhgawan Hansraj	1927-1992	65
7	Damoh	1901-2002	101
8	Jabera	1901-2002	101
9	Malla	1927-1993	66
10	Hardua Morar	1927-2001	74
11	Deori	1916-2002	86
12	Patan	1913-2002	89
13	Chhatarpur	1901-2002	101
14	Panna	1901-2002	101
15	Ajaigarh	1901-2002	101
16	Nowgong	1901-2002	101
17	Chandia Nalla	1927-1992	65
18	Sagar	1901-2002	101
19	Mahoba	1901-1992	91
20	Naraini	1921-1983	62
21	Murwara/Pawai	1901-1999	98

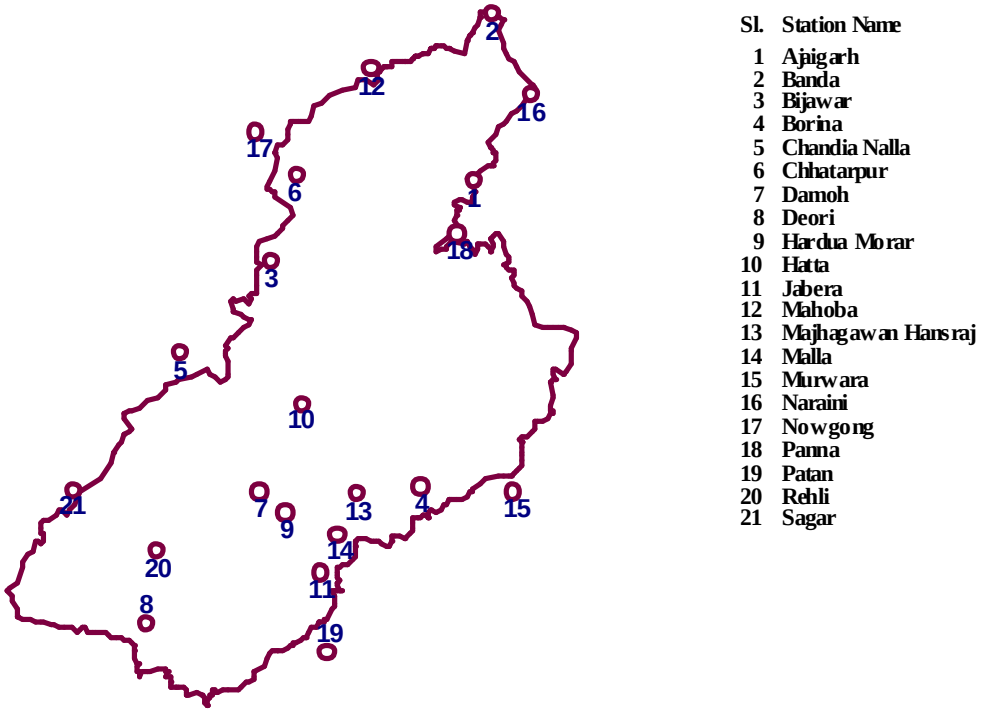


Figure 3.5: Raingauge stations of Ken basin up to Banda gauging site

3.3.1.1 Pan evaporation

There is no pan-evaporimeter installed in the Ken basin. The monthly average evaporation of two nearby stations (Sagar and Damoh) varies from 6.35 cm (in December) to 40.01 cm (in May).

3.3.2 Climatological parameters like temperature, humidity, wind etc.

Climatic parameters for Daudhan are as follows:

Parameter		Daudhan command	
		Max.	Min.
(a)	Air temperature(^{0}c)	44.2	6.7
(b)	Humidity (%)	95.0	9.0
(c)	Wind (km/h)	16.1	1.0

3.3.3 River gauge and discharge

There are four G&D sites in the whole Ken basin. G&D measurements at Patharia site on Sonar tributary of Ken River was stopped in 1982 and the site was shifted to up-stream location Garhakota. The details of all G&D sites in Ken basin is given in Table 3.2.

Table 3.2
Details of gauge and discharge sites in Ken basin

S. No	Name	River	Catchment area (sq km)	Data availability	
				From	To
1	Patharia	Sonar	1634	1974	1982
2	Garhakota	Sonar	1313	1982	2005
3	Gaisabad	Bearma	5758	1974	2005
4	Madla	Ken	20680	1981	2005
5	Banda	Ken	25452	1960	2005

3.3.4 Sediment (suspended and bed load) inflow and grain size composition

The sediment data are collected by CWC at only one G&D site, viz. Banda, in the Ken Basin.

3.3.5 Water quality

As a part of the field study done for socio economic studies, surface water samples were collected from Ken and Betwa river basins and analyzed for various physio-chemical parameters and details are furnished in Chapter-VIII "EIA & EMP". The test results presented in this study indicate that quality of surface water is generally of safe category.

Ground water analysis for EIA studies has been done for the monsoon season 2007. It is found that the quality of ground water is satisfactory in the project area. Thus, it may be generally said that the ground water in the area is good and fresh for use.

3.4 Hydrological data requirement

3.4.1 Alternatives and classifications

This information was not necessary for the present study.

3.4.2 Inputs

3.4.2.1 Type of inputs

Temporal data

Estimation of design flood is required for economic design of any hydraulic structure such as spillways, barrages etc. For estimation of carrying capacity of the diversion channels during construction of a structure, diversion flood is required to be estimated. Guidelines are available for selection of methodology for estimation of design flood. For major structures, the design flood is estimated using hydro-meteorological approach. The diversion flood is estimated mainly by frequency analysis of non-peak period flood. Hence, for estimation of design flood short duration rainfall-runoff data are required. Short duration rainfall data are generally measured at the gauging stations using self recording raingauges. Since the short duration discharge data are estimated from the river stage, hourly gauge data are also required. For estimation of diversion flood the non monsoon peak flow data are required.

To estimate the reservoir inflow, daily discharge series are required. In absence of daily series, ten-daily series can be used. For development of rainfall-yield relationship, daily/ monthly average rainfalls are required. To estimate the average rainfall in the basin, the rainfall of all raingauge stations lying inside or around the basin are required. The inflow to the reservoir is abstracted by water utilization at the u/s. Hence the temporal utilization of water by the u/s projects is also necessary to compute the reservoir inflow.

The periodic water demands and releases from the reservoir, and evaporation rates in the reservoir area are also required for simulation of a reservoir.

Spatial data

For estimation of average rainfall, the locations of raingauges and the delineated basin boundary are required. The basin boundary also gives the area of the basin which can be used for other purposes such as synthetic hydrograph generation, application of conceptual models etc. For reservoir simulation the Elevation-Area-Capacity data are required which can also be used for reservoir routing.

3.4.2.2 Time units for simulation studies

Two types of simulations are mainly carried out: (a) routing of design flood in the reservoir to estimate the dam height, (b) continuous simulation of the reservoir with a series of inflows and demands to estimate the reliability of the reservoir. For reservoir routing, hourly time unit is used. For reservoir simulation, monthly time unit is used.

A view of Bhusor G&D site maintained by NWDA on Ken river

3.4.2.3 Hydrological Inputs

These inputs are explained in details in section 3.4.2.1.

3.4.3 Requirement of the inputs for the project

The relevant information are provided in sections 3.3 and 3.4.2.

3.5 Compilation and processing of basic hydrological data

3.5.1 Hydrological investigation

No G&D site is available on the Ken river nearer to Daudhan dam site other than four G&D sites in entire Ken basin as detailed below:

S.no	Name	River	Catchment area(sq km)
1.	Patheria*	Sonar	1634
2.	Garhakota	Sonar	1313
3.	Gaisabad	Bearma	5758
4.	Madla	Ken	20680
5.	Banda	Ken	25452

* site shifted to Garhakota.

The hydrological studies upto Daudhan dam site have been carried out by using the data of Banda & Madla G&D sites located about 31 km & 150 km respectively d/s of Daudhan dam. However, in order to observe the actual runoff data at the proposed dam site, one G&D site has been established by NWDA at Bhusor, on river Ken d/s of existing Gangau weir near Daudhan dam site and observations have been started w.e.f. 1.10.2006.

3.5.2 Data from other sources

Most of the data used in this study were collected from external Government agencies. Rainfall and evaporation data were collected from IMD, and river G&D and sediment data were collected form CWC. Other data such as location and water utilization of u/s projects were collected from field agencies of the State Govt.

3.5.3 Processing of data

The time units of available and required time series data are often different. Further, the short duration discharges are not measured but are

estimated from the gauge records. This requires preliminary processing of the time series data. Following hydrological variables were processed in this study: (i) rainfall data (ii) G&D data.

3.5.3.1 Quality of data

As mentioned earlier, there are some missing records in daily/ ten-daily discharge and daily rainfall data. However these missing records are not significant in number to adversely affect the data analysis. Further, no discharge data are available at the project locations (the discharge data available are at the gauging sites only). Hence, suitable methodology needs to be applied to estimate the yield data at the project locations.

3.5.3.2 Filling of short data gaps

Rainfall being random process in nature, its missing values has not been filled. However, there were fillings in gaps of yield data. The data gaps in yield during monsoon months have been filled using monthly regression of rainfall and yield and the gaps in the non-monsoon yield have been filled using the average values (regression analysis of non-monsoon rainfall-yield does not give good relationship).

3.5.4 Adjustment of records

For this study, the DMC analysis is used to check the consistency of a rainfall series and adjustment of records which is based on the principle that when each recorded data comes from the same parent population, they are consistent.

A group of stations in neighbourhood of the index station (for which the consistency test is required) is selected. The data of the annual (or monthly mean) rainfall of the index station X and also the average rainfall of the group of base stations covering a long period is arranged in the reverse chronological order, i.e. the latest record as the first entry and the oldest record as the last entry in the list. The accumulated precipitation of the station X and the accumulated values of the average of the group of base stations are calculated starting from the latest record. Individual cumulative rainfall values of the index station are plotted against mean cumulative values for various consecutive time periods. A break in the slope of the resulting plot indicates a change in the precipitation regime of the index station. The precipitation values at the index station prior to the change of regime can be corrected by using the initial slope of the line as follows:

$$P_X(i) = m \times C_A(i) - C_X(i-1) \qquad \ldots(3.1)$$

where

$P_X(i)$ is the corrected rainfall at the index station X during year i;

m is the initial slope of the line;

$C_A(i)$ is the cumulative mean rainfall up to the year i;

$C_X(i-1)$ is the cumulative rainfall at the index station X till the year i-1.

For the study area, the consistency of rainfall series was checked for all the raingauge stations and necessary corrections were made as follows.

First of all, the annual rainfall series of all the stations were computed. The average areal rainfall series, for each station, was computed by taking arithmetic mean of the annual rainfall data of all the stations excluding the data of the station for which the average areal rainfall series was being computed. For each station, the annual rainfall series and average areal rainfall series were arranged in reverse chronological order, and the cumulative annual and average areal rainfall were computed. Graphs were plotted taking cumulative annual average areal rainfall in the X-axis and cumulative annual rainfall of each station. When a change in slope of the line for a station was observed, Eq. (3.1) was used to compute the corrected areal rainfall for the station. The monthly rainfalls were adjusted on the ratio of corrected annual rainfall to the recorded annual rainfall.

For Ken basin the DMC analysis was carried out on monthly basis and it was observed that the rainfall records of Ken basin did not require any correction.

3.5.5 Consistency of data

3.5.5.1 Internal

After necessary adjustment of records of rainfall data, and estimating the average areal rainfall by Thiessen Polygon method, the annual average areal rainfall series was tested for consistency by statistical tests (t and F). The annual average areal rainfall series (1907-2003) was divided into two parts (1907-1953 and 1954-2003) and the tests were performed. The results of these tests indicate that the mean and standard deviation of both the parts are not different statistically and hence, the series is consistent.

Next, t and F tests were performed for the annual yield series of Madla & Banda gauging sites by splitting the series appropriately. The results showed that the yield data are consistent.

The annual rainfall and runoff volumes were plotted for Banda and Madla sites to check any inconsistency (Figs 3.6a and b). It can be observed

from these figures that the data are consistent. Further the runoff factor for Banda and Madla sites during the monsoon period were estimated to be 0.345 and 0.392 respectively which indicates that the rainfall-runoff data are consistent.

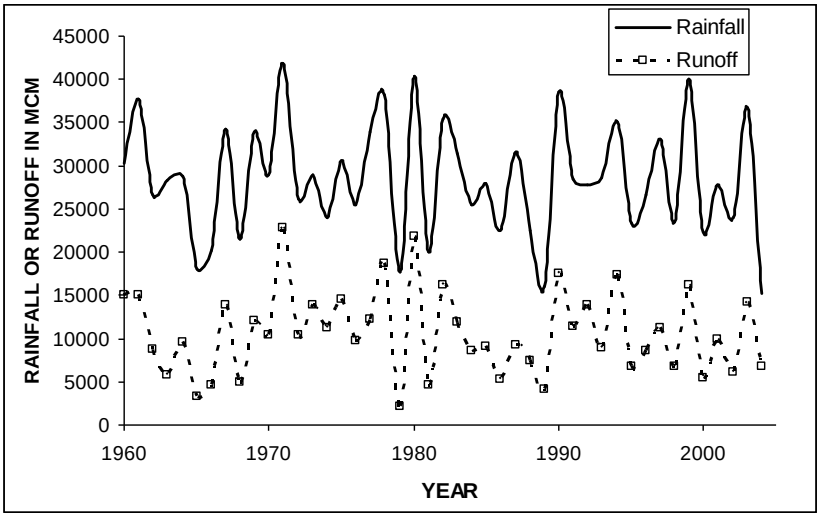


Fig 3.6a: Rainfall and runoff series for Banda (1960-2004)

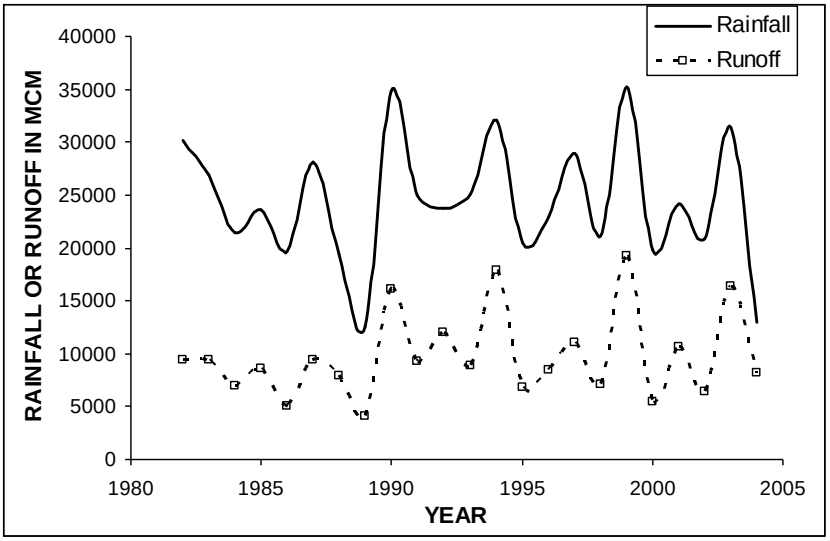


Fig 3.6b: Rainfall and runoff series for Madla (1982-2004)

3.5.5.2 External

No external consistency tests could be conducted due to unavailability of data.

3.5.6 Presentation of data

Rainfall data

In any hydrological analysis the knowledge of the average rainfall over an area is required. However, a rain gauge represents only point sampling of the areal distribution of a storm. Generally three methods are practiced to convert the point rainfall values at various stations into an average value over an area. These are:

(i) Arithmetic average or mean (AM) method,
(ii) Isohyetal method, and
(iii) Thiessen polygon (TP) method.

In the present study, the AM and TP methods have been used to calculate the average areal rainfall over the study area.

In the AM method, the arithmetic average of rainfall observed at all the stations is assumed as representative of the mean areal rainfall. This method was used for double mass curve analysis only. TP method is a weighted average method in which weights to each gauging site is assigned according to the fraction of area it represents in the basin. Since weightings are assigned to the gauges, in case data are not available for few gauges, the estimated average areal rainfall is not affected much. Hence, this method was used for estimation of average areal rainfall for rainfall-runoff analysis and estimation of yields through regression from rainfall.

A computer program was developed for estimation of average areal rainfall of the catchment and sub-catchments using the Thiessen polygon method. For each month, the program forms the combination of rain gauges as per data availability and estimates the Thiessen weights for the stations in the combination.

Discharge/ yield data

The observed 10-daily discharge data (3 values per month) of two gauging sites namely, Banda and Madla, both d/s of Daudhan are available for 45 and 25 years, respectively, with some missing records. These 10-daily data were used to compute the average daily discharge for each month using the following equation:

$$q_m = \left[\frac{Q_{1,m} + Q_{2,m} + Q_{3,m}}{n_m} \right] \quad \text{... (3.2)}$$

where,

q_m is the average daily discharge for month m (cumec);

$Q_{1,m}$, $Q_{2,m}$ and $Q_{3,m}$ are the 1st, 2nd and 3rd ten-daily discharge for the month m (total of daily discharges for consecutive 10 days); and

n_m is the number of days in the month m.

The average daily discharge for the month was then used to compute the monthly yield, $Y_O(m)$ (MCM) as follows:

$$Y_O(m) = \frac{q_m \times 3600 \times 24 \times n_m}{10^6} = 0.0864 \times n_m \times q_m \qquad \text{... (3.3)}$$

Yield assessment refers to estimation of available water at a particular point in the basin with certain degree of dependability. Water availability or/ and yield at different dependabilities at a specific G&D site is generally estimated from the flow duration curve at that site. However, during the course of development of a watershed, water-harvesting structures (projects) come up at various locations. These structures utilize a portion of the available water for various purposes and thereby impact the natural flow of water to the outlet. Depending upon the type and size of a project and its water use, it may also produce some return (delayed) flow. Therefore, the observed discharge series at a G&D site of a developed watershed does not refer to its natural or virgin flow series, and water availability analysis using the observed discharge series alone will lead to erroneous results, if the u/s utilization is significant. The monthly virgin yield is nothing but the sum of the observed yield and the u/s utilization during the month and is estimated as follows:

$$Y_V(m) = Y_O(m) + Y_U(m) \qquad \text{... (3.4)}$$

where, $Y_V(m)$ is the virgin yield for month m;
$Y_O(m)$ is the observed yield for month m; and
$Y_U(m)$ is the utilization of water by u/s projects during the month m (excluding the return flow from the major & medium projects, if any), all in MCM.

Since the monthly utilization series of u/s projects were not available, climatological approach is used to estimate the monthly utilization. In this approach, the cropping pattern, evaporation and rainfall data of the project command area is used to estimate the potential water requirement.

$$WR(m) = \frac{CA}{10^5} \times \sum_{i=1}^{n} \left[\frac{\left(ET(m) \times K_{C(i)}(m) - RF_{eff}(m)\right) \times P_{C(i)}}{IE_i} \right] \qquad \text{... (3.5)}$$

where,

WR(m) is water requirement for month m (MCM);
CA is the project command area (ha);
ET(m) is the normal evapotranspiration (mm) for month m;
$K_{C(i)}$(m) is the crop coefficient of crop i for month m;
$P_{C(i)}$ is the percentage of crop i in the command area;
IE_i is the irrigation efficiency for crop i (%);
n is the total number of crops in the project command area; and
RF_{eff}(m) is the effective rainfall in the month m, estimated using the USDA method.

3.5.7 Data for studies other than simulation

For estimation of design flood hydrograph, UH for the project sites need to be developed. The flood events selected for development of UH for Ken basin is presented in Table 3.3.

Table 3.3
Flood events selected for derivation of UH

Gauging site	Date
Banda	16-09-1987
	21-08-1992
Gaisabad	15-09-1987
	20-08-1992

3.6 Presentation of hydrologic inputs for simulation

3.6.1 Water inflows

Water inflows of Madla G&D site on Ken river were used for simulation study.

3.6.1.1 Storage projects

Daudhan dam across Ken river is the only one storage project, envisaged in Ken-Betwa Link project Phase-I, for which simulation study was carried out.

3.6.2 Extension of data

The rainfall data for the basin is available for a fairy long period whereas, the length of yield data series are short. Extension of yield series (during monsoon months) was carried out using regression analysis of monthly rainfall-yield data.

For developing rainfall-yield relationships on monthly basis for the monsoon months (June to October) both univariate and bivariate regression analyses were carried out using the following equations.

$$Y_m = A + BR_m \quad \text{... (3.6)}$$

$$Y_m = A + B_1 R_{m-1} + B_2 R_m \quad \text{... (3.7)}$$

where,

Y_m is the yield (mm) in the month m;

R_m is the rainfall (mm) during the month m; and

A, B_1 and B_2 are constants.

When the above linear equations are used to relate the monthly yield with the monthly rainfall(s) directly, it is quite natural to get negative values for the constant A, which would accommodate the hydrologic losses during the month. Hence, when the equations are used to estimate the yield from low rainfall months the yield would be negative. To restrict the yields to be positive, the rainfall and yield are transformed to logarithms and regressions are carried out with the log transformed values, which is used in this study.

The results of the regression analyses for monthly yields of the monsoon months (June to October) upto Madla G&D site are presented in Table 3.4.

Table 3.4
Results of regression analysis of monthly yields with rainfall upto Madla G&D site

Regre-ssion	Bivariate					Univariate			
Equa-tion	$y_m = a + b_1 r_{m-1} + b_2 r_m$					$y_m = a + b\ r_m$			
Month	a	b_1	b_2	R^2	SE	a	b	R^2	SE
Up to Madla G&D site									
Jun	-3.720	0.110	1.929	0.599	0.606	-3.806	1.998	0.592	0.596
Jul	-2.472	0.432	1.378	0.788	0.208	-1.925	1.499	0.669	0.254
Aug	-1.605	0.406	1.118	0.794	0.091	-0.239	0.971	0.557	0.130
Sept	-2.427	0.919	0.924	0.808	0.193	-0.108	0.940	0.704	0.233
Oct	-0.151	0.578	0.089	0.536	0.252	1.049	0.159	0.200	0.323

y_m = logarithm of yield during month m;
r_{m-1} and r_m = logarithm of rainfall during month m and its previous month;
a, b, b_1 and b_2 constants;
R^2 = coefficient of determination;
SE = standard error

3.6.3 Data generation

The yield data are available at the G&D sites only. The yield data at the project locations were estimated using proportionality (area and rainfall ratio) formula as below:

$$D_Y(m,y) = \frac{D_A \times D_R(y)}{O_A \times O_R(y)} \times O_Y(m,y) \quad \text{... (3.8)}$$

where,

$D_Y(m,y)$ is the estimated yield at any one project site for month m and year y;

$O_Y(m,y)$ is the virgin yield at the gauging site for month m and year y;

D_A and O_A are the catchment area up to the project site and gauging site respectively; and

$D_R(y)$ and $O_R(y)$ are the average annual rainfall in the project and observation site catchments, respectively, during the year y.

3.6.3.1 Diversion and small pondage

There is no diversion of water in the u/s of Daudhan dam. However, 1074 MCM water will be diverted to Betwa and the enroute command of the link canal from the dam.

3.6.4 Extension of data

This aspect has been discussed in section 3.6.2.

3.6.5 Lake evaporation

The lake evaporations are dependent on the water surface area which is again related to the storage in the lake. The monthly evaporation from the reservoir was computed by simulation of reservoir.

3.6.6 Sedimentation studies

3.6.6.1 Revised area capacity curves

Daudhan dam

The catchment area of Ken River up to the proposed Daudhan dam site is 19633 sq km. It is expected that about 10194 sq km of the area will be intercepted by the projects likely to come in the u/s catchment. These projects may come over a period of next 15 years. Hence, to calculate the areas contributing sediments, the following assumptions have been made:

(a) For the sedimentation period of 50 years, full catchment area of 19633 sq km has been considered for the first 15 years. For the next 35 years, balance catchment area of 19633-10194 = 9439 sq km has been considered.

(b) For the sedimentation period of 100 years, full catchment area of 19633 sq km has been considered for the first 15 years while balance catchment area of 9439 sq km has been considered for the next 85 years.

There is a silt observation site on the main Ken River at Banda which is about 150 km d/s of the proposed Daudhan dam site. At this site, sediment data of 36 years (1962 to 2004 excluding 1975-1981) was available and used to arrive at the silt rate to the Daudhan reservoir. The worked out silt rate is 329.8 $m^3/km^2/yr$.

The sediment distribution was worked out for two periods, viz. 50 years and 100 years, by Empirical Area Reduction method. For this purpose, the FRL of 288 m is adopted and bed level of the reservoir is considered as 216 m. The type of reservoir is considered as gorge type and the standard classification is taken as Type IV. The new zero elevations after 50 and 100 years will 230.9 and 236.4 m respectively.

The minimum draw down level (MDDL) can be fixed anywhere above 236.4 m which is the new zero elevation after 100 years of operation of the reservoir. The revised elevation area capacity curves are shown in Fig 3.7.

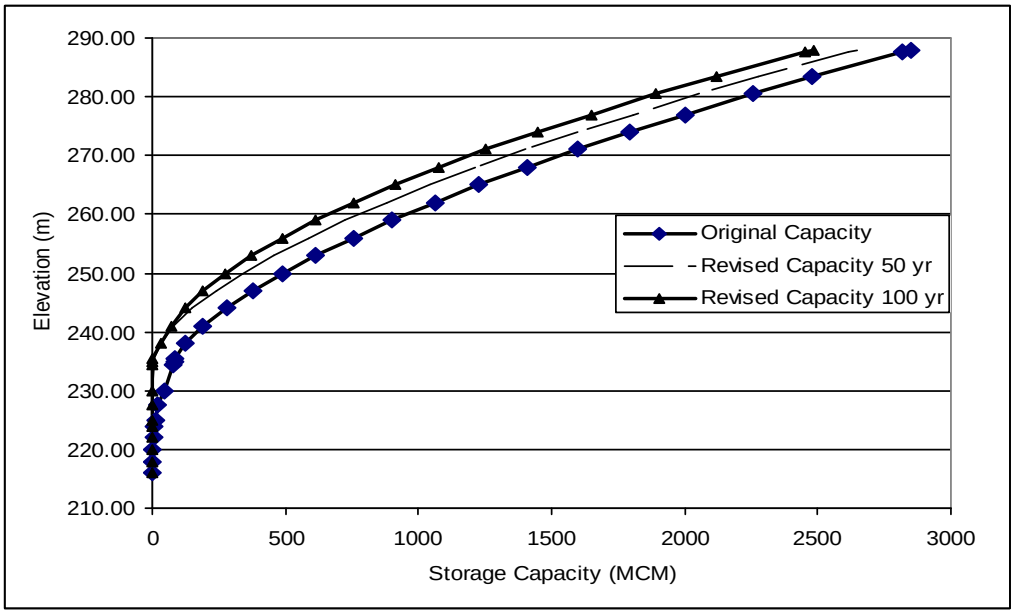


Fig3.7 Elevation vs. Capacity graph for Daudhan – original and after 50-year and 100-year of operation

3.6.6.2 Rate of sedimentation

The total sediment during 50 and 100 years will get distributed up to and above various elevations in Daudhan reservoirs are presented in Table 3.5.

3.6.7 Potential evapotranspiration and rainfall

Normal potential evapotranspiration data of Jabalpur was used for estimation of water utilization of various projects u/s of Daudhan dam. The estimated areal average data for different sub-basins as discussed in section 3.5.6 were used.

Table -3.5
Rate of sedimentation of proposed
Daudhan reservoir

Reservoir level	Sediment deposition in MCM	
	After 50 years	After 100 years
Up to 231 m	49.3	50.3
Above 231 m	156.8	311.4
Up to 236.4 m	85.7	98.0
Above 236.4 m	120.4	263.7
Up to 244 m	127.5	185.7
Above 244 m	78.6	176.0

3.6.8 Flood inputs

With the available short duration rainfall-runoff data the unit hydrograph at Madla gauging site was developed that gave acceptable validation with other observed hydrographs.

3.6.9 Inputs for water quality

Different parameters of water quality are observed regularly at Banda G&D site of CWC. It is observed that quality of water of Ken river is, in general, fit for domestic, industrial and agricultural purposes. However, water samples are being collected every month by NWDA from the Ken river at Bhusor near Daudhan dam site with effect from 1-2-2008 and are being tested at the water quality testing Laboratory of CWC at Agra / Delhi.

3.6.10 Low flow inputs

After analyzing the ten-daily observed discharge at Madla it was found that the ten-daily discharges are zero during the Months of January to May.

The analysis of ten-daily discharge data at Banda shows that the discharge has never been zero. The discharge at this site is minimum during the months of May and June. The minimum ten-daily flow recorded at this site was 3.02 cumecs-days during the first ten-daily period of June 1966

3.6.11 Surface to groundwater recharge

The present ground water level in the phreatic zone, during May 2006 was between 5 m to 10 m below ground water is about 60% of the project area. In the remaining area it varied between 10 m to 20 m. As the quantum of water being transferred is of the order of 1074 MCM annually through the link canal taking off from the reservoir to the Betwa river utilizing 415 MCM in the enroute command and dropping remaining 659 MCM (including transmission losses) into Betwa river, the water levels are not likely to rise to any significant level. Thus, the hazards of water logging and salinization are not anticipated in the region to carry out significant extent. The canal systems under the proposed project are expected to be properly lined. Therefore, there may not be much seepage loss to the ground water.

3.7 Preparation of hydrological inputs for studies other than simulation

3.7.1 Design flood for safety of structures

3.7.1.1 Criteria for selection of design flood for each structure taking into account the importance of each structure

It is not practical, from economic point of view, to design a hydraulic structure for the safety at the maximum possible flood in the catchment where as under designed structures pose serious threat to safety. Small structures such as culverts and storm drainages can be designed for less severe floods as the consequences of higher than the design flood may not be very serious. On the other hand, storage structures such as dams require greater attention to magnitude of floods used in the design since the failure of these structures causes heavy loss of property and life on the down stream. Hence, it is apparent that type, importance of the structure and economic development of the surrounding area dictate design criteria for choosing the flood magnitude. The criteria for estimation of design flood vary from one country to other. In India, the following guidelines (CWC, 1969) are adopted.

Table 3.6
Criteria for selection of design flood estimation method

Sl. No.	Structure	Recommended design flood estimation method
1.	Spillways for major and medium projects with storage more than 60 MCM	(a) PMF determined by unit hydrograph and probable maximum precipitation (b) If the above is not applicable or possible, flood of 1000 years return period
Sl. No.	Structure	Recommended design flood estimation method
2.	Permanent barrages and minor dams with storage less than 60 MCM	(a) SPF determined by unit hydrograph method and standard project storm, which is usually the largest recorded storm in the region (b) If the above is not possible or applicable, flood of 100 years return period
3.	Pickup weirs	Flood of return period 50 to 100 years depending on the importance of the project
4.	Aqueducts (a) Waterway (b) Foundation and freeboard	 Flood of 50 years return period Flood of 100 years return period
5.	Project with very scanty or inadequate data	Empirical formulae

3.7.1.2 Overall approach adopted

Hydro-meteorological approach has been adopted in this study for estimation of the design flood hydrograph of all the projects. For Daudhan dam the unit hydrograph was convoluted with the design hyetograph obtained from the PMP. The PMP and SPS for various projects were obtained from IMD.

3.7.2 Hydro-meteorological approach

In this approach, the unit hydrograph for the basin and the design excess rainfall hyetograph to be estimated first.

Unit hydrographs for different projects were developed using short duration rainfall-runoff data. The SPS and PMP values and time distribution of rainfall for the project catchments were obtained from IMD. As per the time of concentration of the catchments the design storm hyetographs (24 and 48 hours) were prepared for different catchments. The design flood hydrographs obtained for the projects are presented in Figs. 3.8. The peak flood estimated for Daudhan was 57,202 cumec.

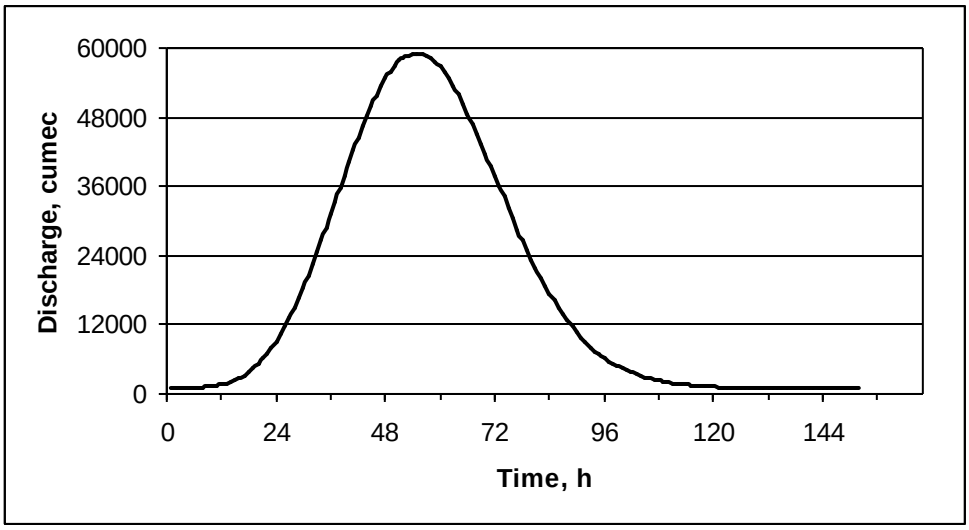


Fig3.8: Design flood hydrograph for Daudhan dam

3.7.3 Frequency approach

At-site flood frequency analysis using AMS of gauge site records is used as a check to the derived PMF value. The AMS model is used to arrive at a return period flood growth curve that is eventually used for deriving a design flood q (T) for a specific return period (T). The return period should be selected as per the guidelines of IS code (Table 3.7).

Table 3.7
Frequency of return period advocated by IS code

S. No.	Structure	Return period of design flood (Yrs)
1.	Major dams with storage more than 6000 ha m (50,000 ac. ft.)	1000
2.	Minor dams with storage less than 6000 ha.m.	100*

S. No.	Structure	Return period of design flood (Yrs)
3.	Barrages and pick up weirs (a) Free board (b) Items other than free board	 500+ 50-100
4.	River Training Works (Calculation of Scour)	50-100@
5.	Water way of bridges	50

Note: * IS 5477 - Method of fixing capacities of reservoirs-Part IV.
+ IS 6966 - Criteria for hydraulic design of barrages and weirs.
@ IS 3408 - Criteria for river training works for barrages and weirs in alluvium.

Table -3.8
Return period flood for Daudhan dam site using Gumbel distribution

S. No.	Return period in years	Return period Flood in cumec
1	500	28734
2	1000	31187
3	5000	36882
4	10000	39334

3.7.3.1 Comparison of design flood estimate

The comparison of design flood estimated by both the approaches is presented in Table 3.9. It is observed that the design flood estimated by hydro-meteorological approach (or UH approach) is significantly higher than those estimated by frequency analysis approach.

Table 3.9
Comparison of design flood estimates for Daudhan

UH Approach	Frequency analysis approach			
	Return period (years)			
	500	1000	5000	10000
57202	28734	31187	36882	39334

3.7.4 Design flood for determination of flood storage & flood control works

For the Daudhan dam, both the FRL and MWL are at EL 288.0 m, hence, there is no separate flood storage in this reservoir above MWL.

3.7.4.1 Flood problems

Studies for probable maximum floods for the proposed Daudhan Dam site was carried out by the UH method based on rainfall in Ken catchment and corresponding flows in the river at gauge discharge site at Banda. The daily flows at Banda and rainfall data upto Banda were used for the analysis.

Modified PULS method had been employed for flood routing of the Daudhan Reservoir. It was assumed that the inflow and outflow at FRL are same and the routing is started from FRL 288 m. The design flood used is 57202 cumec. As there are 33 gates provided over the spillway crest, it was assumed that three of the gates will be inoperative and therefore 30 gates have been considered for computing the MWL. The maximum rise in water level was computed to be 287.88 m. and the corresponding flow passing over the crest was 55099 cumecs. The flood routing had also been carried out with 29 gates open and it was found that the maximum rise in water level would be upto 288.23 m. Therefore, the MWL had been fixed as 288 m. After providing a free board of 3 m above the MWL, the top of the dam has been fixed as 291 m.

As the FRL of the proposed Daudhan reservoir had been fixed at 288 m. which was about 53 m above the present FRL of existing Gangau Weir (2.5 km. d/s of the site), it was therefore assessed that the storage of Daudhan Dam will definitely contribute in mitigating floods in the d/s portion of Ken basin.

The average annual evaporation losses from the reservoir obtained from the simulation analysis was about 104 MCM. This worked out to be 13.46 % of the total storage of the reservoir. The total water requirement on the d/s side of the proposed dam were estimated to be 3006 MCM which will be released regularly below the dam.

3.7.4.2 Degree of protection

The reservoir at Daudhan dam is expected to completely absorb floods of smaller magnitude and the high floods will be moderated with reduction of peak discharge. This will provide flood protection to the d/s of the dam. The reduction of PMF peak is described in details in the section 3.9.2.

3.7.4.3 Design flood for fixing storage & design of structures downstream

This information was not necessary for the present study.

3.7.5 Studies for design of drainage in the command area

3.7.5.1 The problem

Provision of cross drainage work is being contemplated in the project area. These cross drainage works will be so designed that they do not hamper the width and course of the river streams and therefore, minimized the siltation problem which may arise at the crossings. Thus, little impacts on the drainage aspects are anticipated.

3.7.5.2 Surface drainage

The canals irrigating the command area originate from the High altitudes. Necessary provisions are being made in the project area for suitable cross drainage structures with adequate capacities. Suitable diversion arrangements are being made for small streams to the nearby structures. This shall take care of any adverse impacts in the command area.

3.7.6 Design flood for diversion arrangements

The guidelines laid down for arriving at the diversion design flood according to criteria of risk and damage for different types of dams and barrages are as follows (Report of Ministry of Irrigation, 1980):

(i) Diversion capacity for concrete dams and barrages

The capacity of the diversion flood for concrete dams and barrages may be less because flood higher than the designed one could be passed safely over the partly constructed dam. The following criteria would help in deciding the capacity:

a) Maximum non-monsoon flow observed at the dam site.

or

b) 25 years return period flow, calculated on the basis of non-monsoon yearly peaks.

The higher of the two should be taken as the design flood for diversion.

(ii) For large dams

For large dams, it is desirable that 100-year flood should be adopted for diversion works.

For the Madla site the peak of daily flow for non-monsoon months November to May is available for 25 years. On basis of this data, the 25 year return period flow using the GEV model is calculated as 451 m^3/s. As per

clause I(a), the maximum of the non-monsoon flow is 1117.6 m^3/s. As per clause (II), using the AMS, the 100-year return period flood is equal to 30,794 m^3/s. Keeping in view the size of the Daudhan dam, the diversion flood of 1118 m^3/s seems appropriate.

3.7.7 Studies for determination of levels for locating structures on outlets

3.7.7.1 Location of structures

The Ken-Betwa Link Project Phase-I envisages construction of following components:-

1. An earth fill cum concrete dam across Ken river at Daudhan with FRL 288m.
2. An upper level tunnel about 170 m from the left bank of Daudhan dam for taking water to the link canal.
3. A lower level tunnel about 100 m from the left bank of Daudhan dam axis for taking water to the LBC of earlier proposed KMPP.
4. PH-I (2 x 30 MW) to the right of spillway at the toe of Daudhan dam.
5. PH-II (3 x 6 MW) at the outlet of lower level tunnel.
6. A link canal 220.624 km long (including length of upper level tunnel) with off take FSL 257 m to existing Barwasagar with FRL 219.20 m across Barwa nallah, a tributary of Betwa river
7. A 2.1 km long canal for connecting PH-II to Ken LBC at FSL 246.00 m
8. Ken LBC (57.3 km long, modified) proposed under KMPP (to be taken over by Daudhan dam)
9. Major Cross-drainage/Cross-masonry works (55 Nos.).

3.7.7.2 Location of outlets

Outlets provided in Ken-Betwa Link canal to branch canals are given in Table 3.10.

Table 3.10

Details of proposed Branch canals offtaking from main Ken-Betwa Link canal for enroute command of Ken-Betwa Link project

Topo sheet Number	Location of Command	Name of Branch Canal	RD (approx)	FSL of KBL canal	Discharge	FSL of Branch canal
			m	m	m^3/s	m
54 O/12	Lugasi	Lugasi Branch	69460	248.50	2.348	248.40
54 O/8	Now Gaon	Now Gaon Branch 1	76860	248.50	0.952	247.57
	Now Gaon	Now Gaon Branch 2	80227	248.00	2.752	247.19
54 P/5	Kiratpura	Kiratpura Branch	86379	247.50	2.195	246.51
	Kiratpura	Kiratpura Branch	87768	247.00	1.251	246.35
	Gwalta	Gwalta Branch	93227	246.50	1.254	245.65
	Banda	Banda Branch	94418	246.25	1.161	245.51
	Pathada	Pathada Branch	102322	245.75	0.579	244.53
	Didai	Didai Branch	104970	245.50	0.209	244.13
	Pacher	Pacher Branch	109458	244.75	1.195	242.75
	Chhidari	Chhidari Branch	116680	244.25	0.747	242.03
	Purainian	Purainian Branch	121717	243.50	0.971	241.52
54 P/1	Taparian	Taparian Branch	126011	243.00	1.968	241.52
	Lidhaura	Lidhaura Branch	129684	242.50	0.956	240.70
	Bhatgora	Bhatgora Branch	139242	241.50	0.388	239.74
54 O/4	Rajnagar	Rajnagar Branch	147377	239.50	0.164	238.82
	Barana	Barana Branch	155227	239.50	0.228	238.03
	Itali	Itali Branch	160236	238.50	1.068	237.53
	Bamhori	Bamhori Branch	166991	238.00	2.670	236.75
	Bonda	Bonda Branch	170956	237.50	0.594	236.24
54 O/4	Bijrawan	Bijrawan Branch	179756	235.50	0.564	235.36
	Uprara	Uprara Branch	182620	235.5	0.489	235.00
54 O/3	Ratausa	Ratausa Branch	190065	234	1.135	234.34
54 K/15	Dhanahi	Dhanahi branch	193137	233.5	0.773	234.04
	Dhamna	Dhamna Branch	199625	233.5	0.844	233.45
	Rauli	Rauli Branch	201344	233.5	2.397	233.29
	Binuwara	Binuwara Branch 1	206634	224.5	3.185	227.23
	Binuwara	Binuwara Branch 2	209882	224	1.475	226.74
	Kainau	Kainau Branch	216212	223	0.665	223.16
		Total			35.174	

3.7.8 Tail water rating curves

One TRC is proposed at the exit of PH–I to carry the waters to the Ken river after power generation. The grid surveys carried out for dam axis as well as PH-I, have adequately covered the TRC portion also. Data for Tail water rating curve is given in Table 3.11 & Fig 3.9 .

Table 3.11
Tail water rating curve for Daudhan dam (PH-I)

Tail water Level (m)	Discharge (cumecs)	Tail water Level (m)	Discharge (cumecs)
217.00	0.21	232.50	23118.31
217.50	24.70	233.00	25102.75
218.00	74.75	233.50	26556.93
218.50	144.53	234.00	27560.67
219.00	231.49	234.50	28166.39
219.50	228.76	237.00	29809.99
220.00	389.31	237.50	33036.59
220.50	582.16	238.00	35601.56
221.00	804.74	238.50	39172.86
221.50	832.08	239.00	41988.80
222.00	1160.47	239.50	45957.99
222.50	1334.34	240.00	50101.97
223.00	1800.17	240.50	53999.45
223.50	2320.08	241.00	58109.48
224.00	2891.35	241.50	63175.54
224.50	3015.66	242.00	67520.23
225.00	3802.52	242.50	72956.28
225.50	4660.51	243.00	77567.92
226.00	5586.72	243.50	81804.59
226.50	6446.21	244.00	86175.39
227.00	7577.09	244.50	91858.51
227.50	8779.25	245.00	97149.15
228.00	10050.32	245.50	103178.60
228.50	11388.18	246.00	108121.14
229.00	12790.86	246.50	115208.37
229.50	13612.95	247.00	121052.24
230.00	15175.45	247.50	127762.50
230.50	16803.98	248.00	134656.23
231.00	18496.89	248.50	140966.93
231.50	19805.99	249.00	146724.13
232.00	21198.28	249.50	155056.11

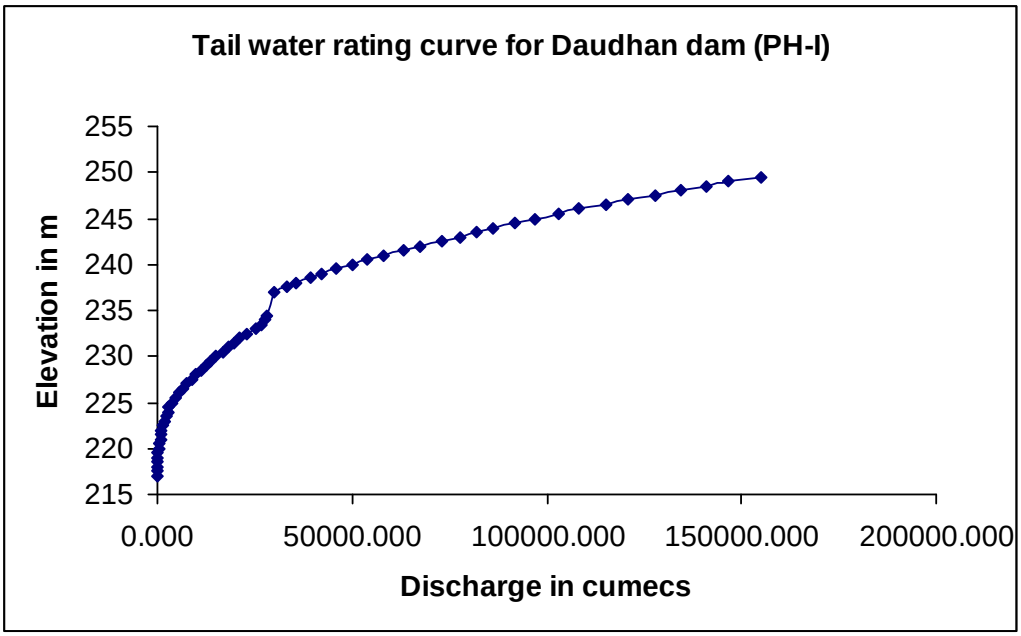


Fig 3.9: Tail water rating curve for Daudhan dam (PH-I)

3.8 Simulation studies

3.8.1 Model studies

A detailed simulation model study was conducted as descried below.

3.8.2 Project performance

Simulation is powerful approach for storage yield analysis. Simulation is essentially a search procedure. It is one of the most widely used techniques to solve a large variety of problems associated with the design and operation of water resources systems. The reason is that this approach can be realistically and conveniently used to examine and evaluate the performance of a set of alternative options available. Furthermore, serial correlations of inflows, seasonality, etc., are easy to account for. Also, it is easy to present the technique and its results to decision makers.

The live storage capacity of the Daudhan reservoir was determined by using the SRA software developed by NIH. This is a simulation program in which operation of the reservoir is simulated by following the rule curves. The input data required for this software include the maximum and dead reservoir storage capacities, the initial storage at the beginning of simulation. Simulation method is also recommended by the IS Code [Fixing the capacities of reservoirs – method, Part 2 Dead storage, IS 5477 (Part 2):1994].

Daudhan Reservoir

For Daudhan reservoir, simulation was carried out for 271 months from June 1981 to Dec 2003. Since the first month of simulation was June, the initial reservoir storage was set at 300 MCM based on the reservoir working table for previous simulation runs. The elevation-area-capacity table as expected after 50 years of operation was used. Two types of demands have been placed on the Daudhan reservoir: the d/s commitments from Uttar Pradesh and Madhya Pradesh and the link diversion. It is important to note that there are high irrigation demands to the tune of 3006 MCM due to shares of Uttar Pradesh and Madhya Pradesh states and the annual link diversion demands are 1074 MCM. The normal monthly depths of evaporation from the reservoir for each month were taken as 0.0699, 0.0889, 0.1714, 0.2921, 0.4, 0.2603, 0.1143, 0.0953, 0.1143, 0.0953, 0.0699, 0.0635 m for January to December respectively.

The gross water availability based on data of Madla are given in Table 3.12.

Table 3.12
Water availability at Daudhan at different dependability

Dependability	Water availability
At 90 %	4979 MCM
At 75 %	6590 MCM
At 50 %	8431 MCM

The time and volume reliability of the reservoir for various purposes of water use/ demands is presented in Table 3.13.

Table 3. 13
Reliabilities of the Daudhan reservoir in meeting demands

Purpose	Time reliability	Volume reliability
Meeting irrigation (KMPP) and other demand	0.980	0.990
Meeting link diversion demands	0.900	0.902

3.8.3 Minimum flow for environmental considerations

The minimum flow required at the river course d/s of the projects are estimated as the 10% of the lean season (November to May) flow at

respective sites. Accordingly the minimum flows at d/s of Daudhan is estimated as 6 MCM/month.

3.9 Effect of project on hydrologic regime

When a controlled reservoir is in operation, it absorbs a part of the high flood water thereby reducing the risk of flooding in the d/s. Due to storage in the reservoir, the floods with smaller peaks may get fully absorbed resulting in no flood in the d/s. In addition to flood moderation, the reservoir would release only the required amount of water to the d/s so that most of the available water is optimally utilized. The exact reduction in flood peak can be estimated routing the flood hydrograph through the reservoir.

3.9.1 Effect on low flows

While simulating the reservoir operation, the minimum environmental flow were treated as demands and given top priority. Since the reservoirs will store water for lean season demands, it can be made to deliver some water to the d/s during the lean season even when there is no inflow to the reservoir. Hence, the river flow condition in the lean flow season in the d/s of the reservoir will be much better than those without the reservoir. This fact can be ascertained from an examination of the reservoir working tables.

3.9.2 Effect on peak floods

During peak inflows, the water level of the reservoir correspondingly increases. In general, the MWL at a reservoir is to be restricted, and to ensure this, spillway gates will have to be judiciously operated. At the same time, it has to be ensured that the peak rate of release does not exceed the safe carrying capacity of the river channel d/s of the reservoir unless absolutely necessary.

The result of reservoir routing for Daudhan is presented in Fig 3.10. It can be observed from the figures that the peak discharge of the design flood hydrograph is moderated from 57202 cumecs to 55099 cumecs (i.e., moderated by 2103 cumecs) with a time delay of three hours for Daudhan. In other words, if the reservoir is operational then floods of relatively lower peak will pass to the d/s. Due to a smaller size of the reservoir compared to the volume of the design flood, significant reduction in peak of the design flood could not be attained. However, many small peaks will be significantly moderated.

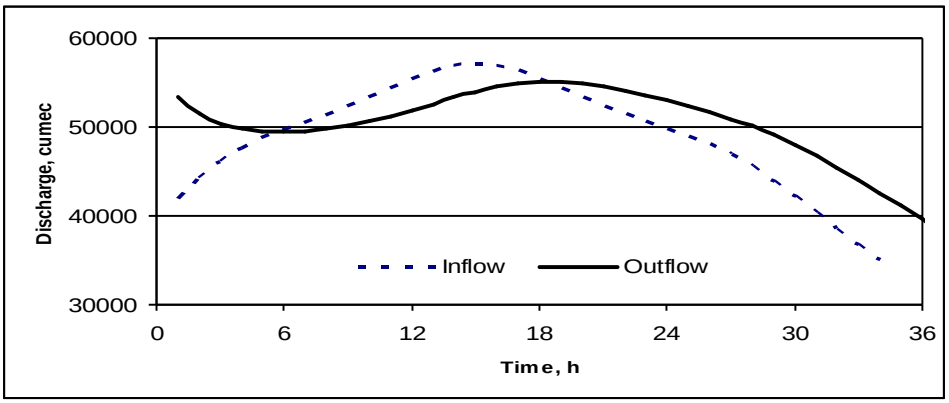


Fig 3.10 Design flood hydrograph routing plot of Daudhan reservoir

3.9.3 Effect on total runoff

Mathematically, the total runoff of a specific catchment does not change when the period is long duration, say yearly. However, a reservoir helps the water demand for lean seasons, and dilutes the peak flows during monsoon. The water that are used in the command area, partly comes back to the stream as a return flow.

3.9.4 Effect on sediment flows

The reservoir affects the sediment load in the in-flowing water by a sedimentation method, where the sediment settles slowly. This also assist in the out flowing a clear water to the d/s. From structural point of view in d/s side, the water is clear without any sediment load.

3.10 Water allocation and interstate aspects

3.10.1 Water

An MOU has been signed between Uttar Pradesh and Madhya Pradesh on water sharing for this project as per which water sharing is given in below in Table 3.14.

Table 3.14
Agreed water sharing of Ken basin upto Daudhan dam

S. No	Particulars	Agreed quantum of water	
		In MCM	In TMC
1	Gross Water available at proposed Dam	6188	218.54
2	Madhya Pradesh (MP) requirement in U/S of dam	2266	80.03
3	Balance Water available	3922	138.48
	Regeneration (+)	442	15.61
	Net Water Balance Available	4364	154.12
4	Total requirement of MP		
	(a) D/s of Ex Daudhan	1375	48.56
	(b) Enroute use	263	9.29
	(c)Domestic enroute utilisation & transmission losses	49	1.73
	Total	1687	59.58
5	D/s of Daudhan including enroute command	1700	60.04
6	Proposed Water Transfer to Betwa Basin	659	23.27
7	Requirement for D/s of dam for ecological needs	318	11.23

3.10.2 Power

It has been proposed to construct two power houses viz.PH-I at the toe of Daudhan dam and PH-II at the end of Lower level tunnel. The installed capacity of the PH-I & II will be 2 x 30 MW and 3 x 6 MW respectively. The average annual generation of power at these power houses would be 219.03 MKwh. A present, there is no agreement between States on sharing of power. As such, agreement on sharing of power will also have to be finalized by both the Govts. of Madhya Pradesh and Uttar Pradesh mutually.

3.10.3 Other aspects

Apart from sharing of benefits, States may also mutually decide sharing of cost of the project, mechanism for regulation of release from Daudhan dam and other things for effective implementation and operation of the project.

CHAPTER-IV
DESIGN ASPECTS

CHAPTER-IV

DESIGN ASPECTS

4.1 Engineering Assessment

As already discussed in the foregoing chapters, the Ken-Betwa Link project Phase-I envisages diversion of water from Ken river to the Betwa river as mandated in the MoU between the state Governments of Madhya Pradesh and Uttar Pradesh. In order to rope in the vast experience of other central organizations in relevant fields and also to complete the DPR preparation of this important project within the scheduled time, the works related with the design aspects of various components of the project have been carried out by different concerned Directorates of CWC, based on the inputs from GSI, CEA, NIH, IIT(Delhi), IIT(Roorkee), CSMRS, etc. Design philosophy for the components, their preliminary design, along with underlying consideration, assumptions & parameters and the basis for selecting the parameters form the subject of the chapter. The salient details of the designs carried out by respective directorates of CWC in respect of various main components are briefly discussed in this chapter.

4.1.1 General

Ken-Betwa Link Project Phase-I mainly envisages construction of Daudhan dam proposed on Ken River, u/s of existing Gangau weir. An upper level link tunnel is planned on the left flank of the reservoir that leads the water into the Ken-Betwa Link canal. A lower level tunnel proposed on the left flank of the reservoir will lead the water into KMPP canal system after generating power. Two powerhouses are proposed.

Hydropower is proposed to be generated from Daudhan storage reservoir at two locations. The first power house is proposed d/s of Daudhan dam and is referred to as Dam-Toe Power House (PH-I), while the second power house is proposed at the exit of the lower level tunnel that carries the water from reservoir to the KMPP canal system and is referred to as Lower Level Tunnel Power House (PH-II). The tail race water from PH-II is led into KMPP canal system. CEA has carried out the power potential studies for the two power houses and proposed the installed capacity for PH-I as 60 MW (2x30MW) and for PH-II as 18 MW (3x6 MW).

An Index map of the entire Ken-Betwa Link Project is given as Plate:1.1 in Drawing Volume – II A.

Thus, the main components under Phase-I stage of the Ken-Betwa Link project comprises of following:

I A) Daudhan dam, B) Bariyarpur barrage and C) Parichha weir

A 1. An 1233 m long earth fill dam across Ken River at Dauhan with FRL 288.00 m

2. A concrete dam of 798 m long (including 536 m long over flow section)
3. An upper level tunnel (1.929 km long including length of transition) about 170 m from the left flank of Daudhan dam for taking water to the link canal.
4. A lower level tunnel (1.1 km long) about 100 m from the left flank of Daudhan dam for taking water to the PH–II and from there to the Ken LBC (proposed in the erstwhile KMPP).
5. PH-I (2x30 MW) to the right of spillway at the toe of Daudhan dam.
6. PH-II (3x6 MW) at the outlet of lower level tunnel.

B. A 850 m long barrage with crest level of 181 m across the Ken river about 1.0 km d/s of existing Bariyarpur pick up weir.

C. A 1.3 km long weir with 702 m long spillway with 184.64 m crest level across Betwa river about 100 m d/s of existing Parichha weir.

II Canal Systems from Daudhan Dam

1. A link canal 218.695 km long (excluding length of Upper level tunnel) with off take FSL of 257.000 m to existing Barwa Sagar reservoir with FRL 219.200 m across Barwa Nallah, a tributary of Betwa river.
2. A 7.1 km long Barwa Nallah (remodelling only) to carry diverted waters from Barwa Sagar to Betwa river at 12.75 km u/s of existing Parichha weir.
3. A 2.2 km long connecting canal from PH-II to Ken LBC with an FSL of 246.000 m.
4. Ken LBC (57.3 km long, modified) proposed under KMPP (which is replaced by Daudhan dam).
5. A bye pass channel from lower level tunnel to meet irrigation requirements of Ken LBC when PH-II is not in operation.
6. Major Cross-drainage/Cross-masonry structures.

A general layout plan of the Daudhan dam and appurtenant works (KBL-7230-P-1002) is appended as Plate 4.1 in Drawing Volume – II A.

4.1.2 Geology, Seismicity and Foundation

(i) Geology

The proposed site of the Daudhan dam site is more or less flat with rolling undulations on both the flanks of the Ken river exhibiting elevations roughly between 216 m (deepest river bed level) and 300 m (right abutment hill). The abutment slopes are gentle and stable. The dam alignment is occupied by hard, compact and massive beds of sandstone(quartz arenite) exposed on the left flank of the Ken river, thinly bedded sequences of

siltstone/sandstone and flagstone with shaly partings in the river section and thinly bedded to laminated black siltstone, shale with porcellanite and chert beds on the right abut hill in succession. A considerable part of dam alignment is occupied by flood plain alluvium forming sandy terraces on either side of the Ken River.

(ii) Seismicity

As already mentioned in the Chapter – II, the studies for site-specific design earthquake parameters for the proposed Daudhan Dam area have been carried out by the Department of Earthquake Engineering, IIT, Roorkee in 2008. As per these seismo-tectonic modelling studies, the site-specific design earthquake parameter is estimated to be of magnitude 6.5. The PGA values for MCE and DBE conditions are estimated to be 0.11 g and 0.06 g respectively. According to the study, the proposed Daudhan dam site in Chhatarpur district of Madhya Pradesh lies in Seismic zone-II as per the seismic zoning map of India given in the IS 1893(Part I)-2002, 'Criteria for earth quake resistant design of structures'. Zone II indicates low seismicity of the area. However, it is recorded in the history of Gangau weir that a severe earthquake shock occurred on 15th January, 1934. Historically, in the region around Daudhan dam site bounded by latitude 21.6^0 to 27.6^0 N and longitude 76.8^0 to 82.9^0 E, around 90 earthquakes having small, moderate to strong intensity have been recorded up to July, 2006. Among these, 21 earthquakes are of magnitude less than 3, while 3 earthquakes are in the range of more than 6 and the rest are in the range in between.

Necessary provision has been made in the design of embankment dam for earthquake. The full study report of IIT, Roorkee is appended as Appendix 2.3, Volume I: Surveys & Investigations.

(iii) Foundation

The foundation investigation of the proposed project site is carried through borehole drilling and required field and laboratory investigations. Out of total 35 drill holes, 19 drill holes were drilled in the concrete dam & Power House portion and remaining in the Embankment dam portion. Based on the interpretation of subsurface data it appears that competent foundation grade sandstone (litho unit A) is available at much higher elevation on the left flank where location of spillway has been fixed on techno-economic considerations. Also the height of the concrete spillway in case of the flank spillway is considerably lesser than that of the centrally located spillway. On the other hand the bedrock available at shallow depth below the over burden in Ken river section is not sufficiently competent (Litho unit B) due to frequent shaley intercalations. Additional remedial measures for improvement of the foundation grade are required, if concrete dam is to be constructed. The topographic levels in the reservoir area varying between EL 251.0 m and 288.0 m indicate height of water column as about 36.0 m. Interpretation of exploratory data from two drill holes on right flank has

revealed that litho units B, C, D continue to form the foundation media in this part of Daudhan dam. The 17 to 20 m explored depth of foundation shows very poor rock condition possibly due to inherent soft nature, higher grades of weathering and structural weakness in the rock mass of above litho units. Adequate investigation of this right abutment is required to be carried out at the pre construction stage for deciding strengthening measures for making impermeable curtain through embankment dam and for ensuring full reservoir competency.

The Geotechnical investigation for foundation strata for earth dam was carried out by CSMRS which includes conducting in situ permeability tests in Auger holes and collection of undisturbed soil samples from the auger holes as well as from the foundation trial pits excavated along the dam axis for foundation characteristics. In all, 5 holes were drilled along the dam axis at reduced distances 650 m, 750 m, 850 m, 900 m and 270 m. A total number of 16 undisturbed soil samples were collected from different depths in these auger holes for conducting various laboratory tests. In addition, 3 pits were excavated in the foundation overburden along the dam axis at reduced distance 0.00 m, 950 m, 1100 m. One undisturbed soil sample was collected from the pit at RD 950 m for conducting various laboratory tests.

Based on the laboratory tests results, it is inferred that the overburden materials in general, possess predominantly silt, clay and fine sand with low to medium plasticity characteristics except few samples which exhibit high plasticity characteristics. The in situ dry density test results indicate that the foundation soil is likely to undergo differential settlement particularly at shallow depths. In view of the above, it is suggested that the soil strata at the levels may be densified by adopting appropriate densification methods. The Triaxial Shear test results indicate good shear strength characteristics of the foundation materials. Based on one dimensional consolidation tests results, the foundation materials are likely to undergo low to medium compressibility. The results of Triaxial Shear tests adopted in the design are given in the following Table 4.1

Table 4.1

Results of Triaxial Shear Tests adopted in the design

Sl. No.	Sample No.	In-situ Dry Density (t/m^3)	Moisture Content (%)	Specific Gravity	Effective Cohesion	Effective Angle of Shearing Resistance	Classification as per BIS.
1.	94/1	1.41	25.00	2.68	0.22	26.9	MI
2.	3	1.74	17.30	2.76	0.30	34.8	CL
3.	6	1.59	12.20	-	0.12	31.9	MI
4.	8	1.71	11.30	2.74	0.36	32.9	CI
5.	9	1.48	20.20	2.66	0.17	27.2	CI
6.	11	2.00	16.60	2.78	0.17	25.3	CI
7.	17	1.46	25.20	2.63	0.22	25.7	CH
8.	13	1.66	17.10	2.69	0.22	24.1	MI

Evaluation of Shear parameters of Foundation soils given in the drawing No. KBL-7230-P-203 is appended as Plate 4.2 in Drawing Volume – II A.

4.1.3 Alternative Studies carried out for Selection of Site and type of Structures

i) Daudhan Dam site

The Government of Madhya Pradesh formulated proposals for KMPP on the Ken river which is also known as Greater Gangau dam and accordingly a detailed project report (1982) had been prepared. As per the report, the project envisaged construction of a dam across the Ken river about 210 m d/s of the existing Gangau weir. The proposed FRL of the Greater Gangau dam was 278.89 m and corresponding live storage was 2062 MCM. However, it was found that by the construction of the Greater Gangau dam, the existing Gangau weir, which has been functioning well since 1915, will be submerged. It was, therefore, felt better to locate the dam u/s of this weir with possibility of utilising the arrangement for generation of hydropower as a pumped storage scheme.

It was, therefore, decided to realign the Ken-Betwa Link with higher off take level at feasibility stage. To ascertain the potential reservoir sites on Ken river, topo sheet studies of Ken basin were carried out in the upper reaches of Greater Gangau dam site. Three reservoir sites are identified viz. Jhalar reservoir (CA 18205 sq km), Ghari Ghat reservoir (CA 18055 sq km) and Daudhan reservoir (CA 19633 sq km) as shown in Fig 4.1. These sites are identified on the d/s side of the confluence of Sonar and Bearma tributaries with Ken with the obvious advantage of having adequate yield for the proposed irrigation in Ken basin as planned, as well as transfer of the requisite quantity of water through the link canal. Several parameters like submergence area, capacity of the reservoir at different elevations, number of villages affected, forest and Culturable areas under submergence etc. were studied and finally Daudhan dam site was found suitable.

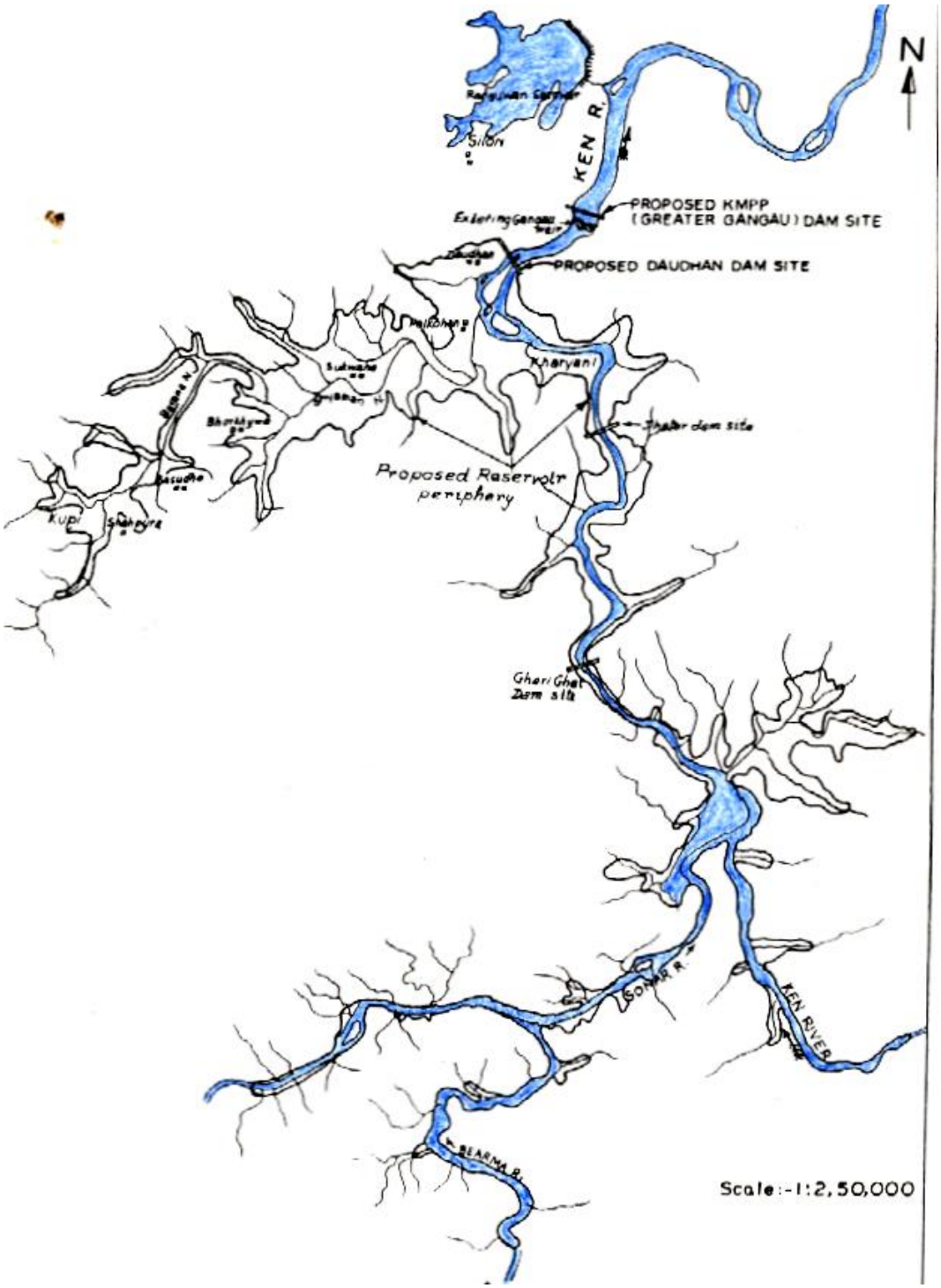


Fig. 4.1 : Map showing locations of alternative dam sites on Ken river

The catchment area of Ken River at Daudhan site is 19633 sq km, which is only 0.16% less than that at Greater Gangau. Therefore, the annual yield at Greater Gangau has been taken as valid at Daudhan site also. The FRL of Daudhan dam site has been proposed as 287.0 m and the corresponding gross storage capacity will be 2775 Mm^3. While keeping the general operational features of the original KMPP proposals more or less the same, the power generation is proposed as under. One Power House will utilize the irrigation releases from

the reservoir at the tail race water level at 234.75 m. This Power House is proposed to function as a pumped storage power plant i.e. the water released will be further picked up by Gangau weir, which can be pumped back to generate additional power during peak period. The other Power House is planned at right bank of Pukhraha Nalla, 2 km away from the dam with a tail water level 259 m from where Ken-Betwa link canal off takes.

It can be seen that this site is also preferable to the Greater Gangau dam site due to following:

(i) it would not submerge the existing Gangau weir,
(ii) it would provide enroute irrigation to higher level command along the canal alignment and
(iii) additional power generation by pumped storage scheme during peak period.

Considering all the above alternatives, the present proposals as enumerated above have been formulated and finalized.

4.1.4 Choice of Final Layout of All Major Components of the Project and Reason

The location of dam site had again been reviewed jointly by the officials of CWC, GSI and NWDA prior to taken up the detailed survey and investigations for preparation of DPR of this link project and decided to keep the location of dam axis same as finalized at the time of preparation of feasibility study report of the project. However, during joint visit of officers of CWC, GSI and NWDA to the proposed Daudhan dam site during the month of June, 2006, the Chief Engineer, Design (NW&S), CWC, Director, GSI, Bhopal and other officials of CWC & GSI after having detailed discussions emphasized to explore the possibility of keeping the spillway at the centre of the river gorge instead of left bank of the river as proposed earlier in the FR of this project.

Accordingly, as per the suggestions of GSI, few exploratory drill holes in the river gorge for specified depth were drilled to find out the preconstruction geological conditions for locating the spillway at the centre of the river gorge. After carrying out the mapping of the area & logging of the drill cores, GSI vide its preconstruction geological note dated 24.7.2007 recommended on the basis of geological conditions of the area to keep the location of spillway in the left flank itself as proposed at feasibility stage of the project. The general layout plan of Daudhan Concrete & Earth dam is given in KBL-7230-P-101 is appended as Plate 4.3 in Drawing Volume – II A.

4.1.5 Design Flood and Sediment Studies

a) Design Flood

The design flood for Daudhan dam has been estimated using two approaches viz., (i) unit hydrograph, and (ii) frequency analysis. The design flood estimated by unit hydrograph method is found to be 57202 cumecs with

time to peak at 49 hours, and the time base of the hydrograph as 123 hours. The coordinates of Flood Hydrograph at Daudhan dam site is given at Annexure-4.1

b) Reservoir Sedimentation

The type of Daudhan reservoir is considered as gorge type. For computation of rate of silt load expected at Daudhan reservoir, the silt observations carried out at Banda G & D site located on Ken river on d/s of the proposed dam site are considered as shown below.

Total sediment transport (average of 36 years)
= 8356972 tonnes/year (at Banda)
Catchment area of Ken up to Banda G/D site
= 25452 sq km.
Considering 15% bed load, the total sediment
= 1.15*8356972 tonnes/year
Sediment transport per year
=9610518 tones/year
Average density of silt
= 1.145 t/m^3
Silt inflow=total sediment/silt density
=9610518/1.145=8393465 m^3/year
Silt rate=silt inflow/catchment area
=8393465/25452 =329.8 m^3/sq km.

This sediment rate of 329.8 m^3/sq km/year has been considered appropriate for design purpose. Out of the total catchment area of 19633 sq km at Daudhan, an area of 9439 sq km is assumed to be intercepted by other projects in the next 15 years. Accordingly, the expected sediment deposit into Daudhan reservoir after 50 years and 100 years is computed as below.

(a) After 50 years

Rate of silt deposition = 329.8 m^3/sq km/year

(i) For first 15 years the silt deposition from the catchment area of 19633 sq km = 329.8*19633*15 = 97.12 MCM.
(ii) For the next 35 years the silt deposition from the catchment area of 9439 sq km = 329.8*9439*35 = 108.95 MCM.
(iii) Total sediment deposition = 97.12 + 108.95 = 206.1 MCM.

(b) After 100 years

Rate of silt deposition = 329.8 m^3/sq km/year

(i) For first 15 years, the silt deposition = 97.12 MCM (as estimated above).
(ii) For the next 85 years the silt deposition from the catchment area of 9439 sq km = 329.8*9439*85 = 264.6 MCM.

(iii) Total sediment deposition = 97.12 + 264.6 = 361.73 MCM.

The total sediment deposition in the reservoir during 50 and 100 years are estimated to be 206.1 MCM and 361.73 MCM respectively as shown above. The sediment distribution is worked out for the two periods, viz., 50 years and 100 years, by Empirical Area Reduction method. For this purpose, the FRL of 288.00 m is adopted and bed level of the reservoir is considered as 216.00 m. The new zero elevations after 50 years and 100 years have been found to be as 230.9 m and 236.4 m respectively. The total sediment during 50 and 100 years will get distributed up to and above various elevations as given in the Table 4.2 below.

Table 4.2

The total sediment estimated at Daudhan.

Reservoir level	Sediment deposition in MCM	
	After 50 years	After 100 years
Up to 231 m	49.3	50.3
Above 231 m	156.8	311.4
Up to 236.4 m	85.7	98.0
Above 236.4 m	120.4	263.7
Up to 244 m	127.5	185.7
Above 244 m	78.6	176.0

The original and revised (after 50 and 100 years) area-capacity volumes are given at Annexure-4.2

4.1.6 Free Board

The basic requirement of free board for the earth dam is that the dam should not be overtopped under design wind conditions. The procedure adopted is based on recommendations of IS 10635-1993 (Reaffirmed 1998) “Guidelines for free board requirements in Embankment dams”. For normal freeboard the wind velocity at the dam site over land has been taken as 39 m/s. The computed free board comes out to be 5.05 m for and accordingly the top of dam has been provided as 293.0 m against FRL of 288.0 m. The total height of dam will be 77 m above river bed level of 216.0m.

The design computations of freeboard for the Daudhan earth dam have been presented in Drawing No. KBL-7230-P- 201 which is appended as Plate 4.4 in Drawing Volume – II A.

4.1.7 River Diversion Arrangement

NIH, Roorkee has analysed the flood characteristics and suggested 1 in 25 year non monsoon flood and 1 in 100 year monsoon flood at the dam site for diversion. In addition, as per the guidelines laid down in the ‘Report of Ministry of Irrigation, 1980 for arriving at the diversion design flood according to criteria of risk and damage for different types of dams and barrages’ the diversion floods for construction shall be follows.

(i) Diversion capacity for concrete dams and barrages

The capacity of the diversion flood for concrete dams and barrages may be less because flood higher than the designed one could be passed safely over the partly constructed dam. The following criteria would help in deciding the capacity.

a) Maximum non-monsoon flow observed at the dam site.

or

b) 25 years return period flow, calculated on the basis of non-monsoon yearly peaks.

The higher of the two should be taken as the design flood for diversion.

(ii) For large dams

For large dams, it is desirable that 100 year return flood should be adopted for diversion works.

For the study area, the peak of daily flow data for non-monsoon months i.e., from November to May is available for 25 years. Based on this data, as per clause 1(a) mentioned above, the 25 year return period flow using the GEV (PWM) model is calculated as 451 m^3/s. As per clause I(b), the maximum of the non-monsoon flow is 1117.6 m^3/s. As per clause (II), using the AMS, the 100-year return period flood is computed as 30,794 m^3/s by NIH, Roorkee.

Since the earth dam is located in the river section and concrete gravity dam on the left flank, diversion flood of 1 in 100 years return period which works out to 30,794 m^3/s has been considered in the design of diversion arrangements.

The diversion arrangements for Daudhan Dam shall consist of

a. U/s Coffer dam part of main Earth dam
b. D/s cofferdam
c. Diversion Channel through concrete gravity dam

The u/s cofferdam is 29 m high earth dam with top of dam as 245 m, which will be part of the main earth dam. The diversion flood MWL shall not be more than 243 m. For seepage control through dam body u/s impervious soil layer of 1.5 m thick at top and 3 m thick at bottom has been provided whereas, for seepage through foundation a cut off trench at u/s end has been provided. In addition, one row of curtain grouting at 3 m centre to centre to a depth of h/3 (h is difference of bottom of COT and MWL of coffer dam i.e. 243 m) will be carried out. The down stream coffer dam of about 12 to 18 m height, with 2 H: to 1 V slope both u/s & d/s, will also be provided away from the d/s toe of earth dam to protect all structures including Power House. The

exact height shall be decided at the time of preconstruction stage depending upon the existing Gangu weir d/s of the dam.

Daudhan dam being a composite dam and the earthen dam is situated in the deepest level of the river, it has been planned to divert the flood of 30,794 cumecs during the construction period. As quantity of flow is very high it is not possible to pass it through the diversion tunnels, a diversion channel in the area of Spillway has been proposed. Approximate width of channel be 100 m at EL 223.00 m and 300 m at EL 239.0 m. The maximum of diversion flood will pass at EL 243.00 m.

In the proposed plan, the work of construction of diversion channel will be executed prior to construction of the coffer dam. After completion of construction of coffer dam up to level of 245.00 m , the construction of spillway blocks in the area of the diversion channel be taken up. The diversion flood during construction of spillway blocks can be managed by channelizing the required flood as per relevant IS codes.

4.1.8 Construction Materials

(i) Daudhan dam

As already discussed in Chapter-II of the report, it is proposed to utilise the soil from the Daudhan reservoir area for construction of Earth dam and accordingly the soil samples have been collected.

For construction material of Earth dam 44 representative soil samples were collected from 4 different borrow areas for conducting various standard laboratory tests in order to ascertain their suitability as construction materials. Daudhan borrow area in general, possess predominantly silt and clay sizes as the other borrow area samples viz. Gangu, Palkohan and Kharyani possess, in general, predominantly silt, clay and fine sand sizes. The tri-axial shear tests results indicate good shear strength characteristics of the borrow area materials. Based on the one dimensional consolidation test results, the borrow area samples in general, possess low to medium compressibility characteristics. The result of laboratory permeability test indicates that these materials are impermeable. The results of the Triaxial shear tests adopted in the design are furnished in the following Table 4.3.

Table 4.3

Results of Tri-axial Shear Tests adopted in the design

Location	SL.No.	Sample No.	Maximum Dry Density (t/m^3)	OMC (%)	Specific Gravity	Effective Cohesion	Effective Angle of Shearing Resistance (In degree)	Classification as per BIS.
DAUDHAN BORROW AREA	1.	2007/174	1.69	18.8	2.70	0.22	22.6	CI
	2.	2007/177	1.74	15.8	2.74	0.28	25.1	CI
	3.	2007/187	1.92	11.4	2.71	0.12	30.6	CL
	4.	2007/190	1.80	15.8	2.74	0.22	23.8	CL
	5.	2007/193	1.83	14.8	2.72	0.16	21.3	CL
PALKOHAN BORROW AREA	6.	2007/198	1.81	15.0	2.67	0.14	29.2	CL
	7.	2007/201	1.79	15.0	2.72	0.13	26.4	CL
	8.	2007/207	1.74	15.6	2.66	0.17	25.8	CL-CI
KHARYANI BORROW AREA	9	2007/209	1.81	17.0	2.66	0.18	22.0	CI
	10	2007/215	1.85	13.9	2.68	0.14	29.2	CL
	11	2007/217	1.84	15.9	2.65	0.20	23.2	CI
	12	2007/220	1.85	13.9	2.66	0.15	27.1	CL

All the tested borrow area soil samples in general exhibit plasticity characteristics and are suitable for construction of earthen dam. Based on the Standard Proctor compaction tests, it may be inferred that the borrow area soil samples are capable of achieving good compaction densities. The results of triaxial shear tests conducted on soil samples (remoulded at 98% of Standard Proctor maximum dry density) indicate that the tested soil samples possess fairly good shear strength characteristics. Based on one-dimensional consolidation test results, the borrow area soil samples tested in general possess low to medium (slightly higher side) compressibility characteristics. The results of falling head laboratory permeability tests conducted on 7 soil samples indicate that the borrow area soil samples exhibit impervious characteristics. The consensus arrived based on the four special dispersivity identification tests indicate that the tested soil samples can be categorised as Non-dispersive.

(ii) Ken Betwa Link Canal

Soil samples were collected at a distance of around 5 km except at locations where sampling was difficult due the presence of rocky strata or some other valid reasons like large depth. At fill sections of canal, representative soil samples in gunny bags were collected around canal alignment for laboratory evaluation for their suitability as construction material. Similarly, wherever significant cutting sections of canal were involved, undisturbed soil samples in core cutters (100 mm dia) were collected for laboratory determination of their Index and engineering characteristics at in situ density.

4.1.9 Details of the Model Studies for Important Structures

No model studies work carried at this stage which may be taken up at preconstruction stage of the project, if necessary.

4.2 Daudhan Dam

4.2.1 Daudhan Earth dam – Design criteria & Stability Analysis

A homogenous earth dam 1233 m long with a height of 77 m above river bed level is proposed. The u/s part of the main dam will be used as a cofferdam thereby fully utilizing the available construction material. Daudhan dam of Ken-Betwa Link Project is a 77 m high dam with top at EL 293.00 m and having river bed EL of 216.0 m. The left side of the dam is wrapped around non-overflow blocks of 120m length. The right flank is resting on hill slope. Diversion arrangement consists of 29 m high u/s cofferdam which is a part of the earth dam. D/s cofferdam will not be a part of earth dam. Its height and other details will be finalized at the time of preparation of construction drawings. The layout of the dam and appurtenant structures as available in Drawing No. KBL-7230-P- 101 is appended as Plate 4.3 in Drawing Volume – II A. U/s cofferdam section and details are given in drawing No. KBL – 7230 –P-208 is appended as Plate 4.5 in Drawing Volume –II A.

Earth Dam Section

The geometry of the earth dam has been provided taking into account the structural safety, Seismic aspects, seepage control etc. Detailed investigation for construction material is to be undertaken before actual construction is taken up. The dam section consists of zoned section. The u/s face has slope varying from 2.5H:1V to 3.25H:1V while d/s face has slope varying from 2.5H:1V to 3.5H:1V. The u/s face is protected by a hand placed riprap of 0.6 m thickness laid over 0.2 m thick crushed stone/aggregate and 0.2 m thick sand filter. There are four berms each 6 m wide on u/s face at EL 275.0 m, EL 260.0 m, EL 245.0 m and EL 230.0 m. The d/s face has four berms, two 6 m wide at EL 275.0 m & EL 260.0 m one 15 m wide at EL 245.0 m and one 7 m wide at EL 230.0 m. The material of the embankment dam is mainly CI & CL. Therefore 0.6 m thick sand drains at 5 m interval have been provided in the u/s draw down portion to relieve pore pressure in the event of draw down. Rock toe of maximum height of 14 m is provided in the d/s portion from ground level to EL 230.0 m. The top width of dam is 8.0 m. The typical section and details of earth dam has been presented in Drawing No KBL-7230-P-207 is appended as Plate 4.6 in Drawing Volume – II A.

Evaluation of Design Parameters.

For estimation of shear strength parameters of borrow area of embankment materials, 75% dependable values of borrow area results were

adopted. These are presented in Drawing No. KBL-7230-P-202 is appended as Plate 4.7 in Drawing volume-II A. For estimation of shear strength properties of overburden material in foundation, 100% dependable values were adopted. As already mentioned, the evaluation of shear parameters of foundation overburden are available in Drawing No. KBL-7230-P-203 is appended as Plate 4.2 in Drawing volume-II A.

The properties are summarized below in Table 4.4.

Table 4.4
The shear properties of over burden soil at Daudhan dam site

Sl. No.	Material	Saturated Unit Weight in t/m^3	Cohesion ' C' in t/m^2	Angle of shearing 'Φ'
1.	Embankment Material	2.13	1.6	24^0
2.	Foundation	2.03	1.7	24^0
3.	Rock fill	2.13	0	40^0

Stability Analysis

The stability analysis has been carried out by a software made in-house based on Swedish slip circle or Fellinious method. The minimum factors of safety obtained for various loading conditions is indicated in the following table and also available in the drawings No. KBL-7230-P-204 to 206 are appended as Plates No. 4.8, 4.9 and 4.10 respectively in Drawing Volume-II A. The factors of safety considered are furnished in the Table 4.5.

Table 4.5
Minimum Factor of Safety

Sl. No.	LOADING CONDITION	UPSTREAM	DOWNSTREAM	
			With TWL	Without TWL
1.	Steady Seepage without EQ	1.627	1.479	1.690
2.	Steady Seepage with EQ	1.224	1.112	1.347
3.	Sudden Drawdown	1.307	0.000	1.292

Zoning of Dam Section

The dam section comprises of 5 kinds of material viz. embankment material, sand drains, filter (Sand layer & crushed stone layer), compacted rock fill in rock toe and hand placed riprap. At the time of construction, material excavated from the gravity dam for making diversion channel, if found suitable, could also be used for the cofferdam construction. This will make the construction faster for coffer dam. The embankment material

should be compacted to an average density of 100% of standard proctor density subjected to minimum density equal to 98% of proctor density. Zoning of the dam section would have to be finalized after availability of the strength parameters and gradation of the materials from required excavation at the pre-construction stage.

Drawing showing details of earth dam u/s & d/s wraparound details of Daudhan earth dam drawing No. KBL-7230-P-214 and appended as Plate 4.11 in Drawing Volume – II A.

Protection of Slopes of Dam Section.

The u/s face is protected by a hand placed riprap of 0.6 m thickness laid over 0.2 m thick crushed stone/aggregate and 0.2 m thick sand filter. This riprap shall consists of angular rock fragments with 80% fragments heavier than 50 Kg. In the remaining 20% not more than 50% fragments shall be smaller than 75mm in the minimum dimension. However, this will be finalized after detailed survey prior to construction stage. Turfing has been provided on the down stream face. Further for the collection of the rainfall water and seepage water surface drainage and a toe drain has been provided. The details are available in drawings No. KBL-7230-P-213 is appended as Plate 4.12 in Drawing Volume – II A.

Filter

The filter shall be compacted to an average relative density of 75% with a minimum acceptable relative density of 70%. Filter material shall satisfy the following criteria:

$$\frac{D_{15} \text{ of Filter material}}{D_{15} \text{ of base material}} < 0.5$$

$$\frac{D_{15} \text{ of filter material}}{D_{85} \text{ of base material}} < 0.5$$

Where D_{15} and D_{85} are 15% and 85% finer material by weight. Further the grain size curve of the filter material will be parallel to that of the base material. Maximum particle size of the filter material shall not be more than 75 mm and it should not contain more that 5% of the material finer than 0.074 mm (200 mm Sieve).

Seismic Design Considerations

For seismic design Earthquake coefficient, α_h as 0.6g and α_v as 0.4g has been adopted for Pseudo-static analysis of the section. However these coefficients shall be recalculated based on site specific response spectra. Adequate factor of safety has been provided against slip failure of slopes during earthquake combined with steady seepage. A wide abutment core-

contact will ensure the safety against opening of joint during the earthquake.

Earthquake coefficients adopted, have been got approved by the National Committee of Seismic Design Parameters(NCSDP). The letter of approval of the Committee is furnished at Annexure-4.3.

Foundation Treatment

The foundation treatment has been decided based on the geological interpretation carried out from the data of drill holes and other investigations. To control the under seepage, grout curtain in three rows staggered at 3 m c/c up to a depth half the hydraulic head measured above the base of the cut-off trench up to FRL have been provided. The minimum depth of curtain grouting shall be 16 m. In addition, peripheral grouting shall be carried out at FRL. At the time of pre construction/construction the depth of curtain shall be decided in consultation with Geologist. The post-grouting permeability should be less than 5 lugeons. The foundation treatment of right abutment is based on limited investigation carried out at DPR stage. The detailed investigation is to be carried out at pre construction stage for suggesting treatment to control seepage through right abutment. Based on the investigation foundation treatment shall to be provided.

The foundation treatment details are presented in Drawing No KBL-7230-P-209 is appended as Plate 4.13 in Drawing Volume – II A.

Drawing showing plan and L-section of Daudhan earth dam (Drawing No KBL-7230-P-210), and earth dam section at various RD's (Drawing No KBL-7230-P-211 and 212) are appended as Plates No 4.14, 4.15 and 4.16 respectively in Drawing Volume – II A.

4.2.2 Daudhan Concrete dam/ Non over Flow Section / stability analysis/ Spillway section

Daudhan dam consists 30.0 m long NOF blocks on the left side, 232.0 m long on the right side (112 m long for Power and 120 m long NOF blocks for Earthen dam) with a 536.0 m long spillway on the left flank (27 bays of 16.0 m width with 26 piers of 4.0 m width) to pass a peak flood of 57,202 cumecs (PMF).

(i) Non over Flow Section

The stability analysis for NON OVERFLOW SECTION has been done at the deepest foundation level i.e., 232.0 m as per IS-6512-1984 for all the following seven load combinations i.e.:

1. A (construction condition),
2. B (Normal Operating Condition),
3. C (Flood Discharge Condition),
4. D (Combination A with earthquake),
5. E (Combination B with earthquake but no ice).
6. F (Combination C but with extreme uplift drains inoperative) and

7. G (combination E but with extreme uplift drains inoperative).

The stresses obtained are compressive in all above mentioned conditions and the factor of safety against sliding are more than 1 as per IS.6512-1984. The following data have been adopted for the design of Non Overflow (NOF) sections.

a) MWL	288.00 m
b) FRL	288.00 m
c) Maximum TWL	241.00 m
d) Minimum TWL	233.00 m
e) Silt Level in m.	236.40 m
f) Top width of dam	8.0 m
g) U/S slope (H:1)	0.100
h) Horizontal seismic coefficients	0.06 g
i) Vertical seismic coefficients	0.04 g
j) D/S slope	0.85
k) Cohesion	500 t/sq m
l) Angle of internal friction	55 degrees
m) Width of drainage gallery	2.0 m
n) Height of drainage gallery	2.5 m

The proposed Daudhan dam site falls in zone II indicating low seismicity of the area. The values of horizontal and vertical seismic coefficients adopted are 0.06 g & 0.04 g respectively, which have been approved by NCSDP. The cohesion and angle of internal friction of the rock has been taken as 500 t/sq m and 55^0 respectively as furnished by the field investigation engineers. In case of any appreciable change in these values, the stability analysis has to be revised. The drawing showing maximum non-overflow section, zoning of material (NOF section) and water stop details are enclosed as KBL-7230-P-103, KBL-7230-P-104 and KBL-7230-P-107 are appended as Plates No. 4.17, 4.18 and 4.19 respectively in Drawing Volume – II A.

(ii) Spillway

The overflow section has been designed to pass peak flood of 57,202 cumecs (PMF) keeping crest level at 270.00 m and MWL 288.00 m through the length of the spillway section (over flow section). Vertical u/s face has been provided from EL 260.00 m to 268.40 m and below EL 260.00 m a slope of 1 in 10 in u/s face has been provided up to foundation level The crest shape, discharge coefficients and d/s water surface and water nappe profiles have been worked out as per relevant IS codes.

The stability analysis for OVERFLOW section has also been done at the deepest foundation level i.e. 223.0 m as per IS-6512-1984 for all the seven

load combination as mentioned above for non over flow section. The data used for design is as given below.

a)	Radial gate trunion elevation level	277.00 m
b)	Bridge weight	15 t/m
c)	Top width	8.0 m
d)	Width of block	20 m
e)	Elevation of T.P.	256.33 m
f)	Top Bridge level	293.00 m
g)	Cm	0.735
h)	Top of crest	270.00 m

The stresses obtained are compressive except in “G” condition which is within permissible limit and the factor of safety against sliding are more than 1 as per IS:6512-1984. The drawing showing maximum overflow section, zoning of material (OF section) and Water stop details are enclosed as KBL-7230-P-102, KBL-7230-P-105 and KBL-7230-p-106 are appended as Plate 4.20, 4.21 and 4.22 respectively, in Drawing Volume-II A.

(iii) Gates

Radial gates shall be provided on Spillway of Daudhan Dam. There will be Irrigation Sluice Gates and various Intake Gates. The description of various gates are as follows.

A) Spillway Radial Gates

27 Nos. Spillway Radial Gates of size 16 m X 18.5 m will be provided to control the flow of spillway. These gates shall be operated by d/s twin cylinder Hydraulic Hoists. The Hoist cylinders shall be pivoted on the Hoist Support structure mounted on the pier. The power pack shall be installed on the top of the pier. Each gate shall have individual Power Pack. However, provision shall be made to operate the adjacent hoists in case of emergency.

The gate shall consist of curved skin plate stiffened by vertical stiffeners. The vertical stiffeners shall be supported by four Horizontal girders. The load from horizontal girders shall be transmitted to trunion by three radial arms on each side of gate. The load from trunion shall be further transferred to concrete by independent anchorage system. Thrust block/Tie Beam shall be provided to transfer the lateral load of radial arms. Suitable bracings shall be provided for Horizontal girder and arms. The sill level of gate shall be 269.50 m and trunion shall be installed at 277.0 m. The radius of gate leaf shall be kept as 21.5 m. Bottom seal of gate shall be provided as wedge type. The side seals shall be of Z type and will move on curved seal seat. The gate shall be designed as per IS: 4623.

Drawing of General Installation Daudhan Dam spillway radial gates are KBL-7320-P-1501 & KBL-7231-P-1502 and are appended as Plate 4.23 & 4.24 respectively in Drawing Volume –II A.

B) Spillway Stoplogs

Three sets of stoplog's shall be provided to carry out the maintenance of spillway Radial Gate. Each set of stoplog's shall consist of ten units of 16000 mm X 1900 mm. Bottom Unit shall be non interchangeable type. All other units shall be interchangeable. The stoplog's shall be operated under balanced water head condition except top most unit which shall be lifted under unbalanced water head condition for one gate unit height water head.

D/s skin plate and d/s sealing's shall be provided. Wedge type bottom seal and solid bulb type side seals shall be provided to make the gate watertight. The Stoplog's shall be operated by gantry crane moving on the bridge. The Stoplog's shall be connected to gantry crane through Lifting Beam and Ramshorn Hook. Drawing of stoplog's for Daudhan Dam spillway is KBL-7230-P-1503 is appended as Plate 4.25 in Drawing Volume – II A.

C) Gantry Crane

The Spillway Stoplog's shall be operated by moving Gantry Crane. The tentative capacity of gantry crane shall be 60 T. The Gantry Crane shall have hoist machinery mounted on trolley. The trolley shall of moving type. The crane structure along with trolley shall be capable of moving in longitudinal direction with the help of LT travel mechanism. Suitable counter weight shall be provided to make the crane stable for different stability conditions. The crane shall be designed as per IS: 3177 and IS: 807. 10 T Auxiliary hoist shall be provided to operate the irrigation sluice Stoplog's.

(iv) Energy Dissipation Arrangement

Energy dissipation arrangement envisaged is that of ski-jump bucket type. IS-7365-1985 stipulates that ski-jump bucket is used when the tail water depth is insufficient for the formation of hydraulic jump and when the bed of the river channel on d/s consists of sound rock. The jet coming down the spillway is thrown sufficiently away from the toe of the dam. Considering hard rock at d/s of the bucket, no specific scouring arrangement is being proposed. However, based on site condition and model studies sufficient precaution would be taken in design at preconstruction stage.

(v) Constraints Felt during Concrete Dam Design

Following constraints have been felt during concrete dam design:

1. Studies are based on limited geotechnical data/information and hence detailed geological appraisal needs to be carried out at pre-construction stage.
2. Model studies should be carried out to ascertain the efficiency of energy dissipation arrangement and layout and profile of approach and spill channel at the pre-construction stage.
3. Pre-designed plunge pool with side protection may be provided after carrying out adequate model studies.

4.2.3. Openings through Daudhan Dam

In all four openings are provided in the concrete section of the Daudhan dam of which 2 openings act as intake for the dam toe PH-I and II openings act as river sluices to release water to meet d/s requirement when the PH-I is not in operation. While the design aspects, relating to Powerhouse intake are discussed under the head Powerhouse, the same relating to river sluices are discussed below. A provision has been kept to pass continuous flow of water for the d/s requirement. It has been planned to release a water of 40 cumecs through sluice when the water level in reservoir reduces to below EL 252.00 m. However the sluices can be operated when the water is at crest. Accordingly two number of sluices size 1.6 m x 2.4 m have been proposed at EL 237.2m in block no 27. Gates for river sluice will be operated through Operation Chamber provided at EL 242.60 m. There will be direct approach to this gallery from the Elevator shaft and staircase provided in block No. 30

(i) Dam Sluice Gate

Two numbers sluice shall be provided in Dam to reduce the flow in the main river course. Provision of service, emergency and bulkhead gates shall be provided. Service and Emergency gates shall be slide type. These gates shall be operated under unbalance water head condition by Hydraulic Hoists. The hoist chamber shall be sealed by providing bonnet cover. Solid bulb rubber seals shall be provided on the d/s side to make the gate water tight. Suitable air vent shall be provided at the d/s of service gate and emergency gate. Model study for the gate is proposed to be carried out at the time of execution to assess hydro-dynamic forces and air requirement. Steel liners shall also be provided to avoid erosion of concrete in the vicinity of gates.

Drawing of irrigation sluice gate of Daudhan Dam KBL-7230-P-1504 & 1505 are appended in Drawing Volume – II A as Plate 4.26 & 4.27 respectively. One Fixed Wheel Bulkhead Gate shall also be provided to carry out the maintenance of emergency gates. Spring loading guide shall be provided to guide the movement of bulkhead gates. Emergency and Service gates shall be designed to operate water level corresponding to the spillway crest. The Bulkhead gate shall be operated under balanced water head conditions by means of auxiliary hoist of spillway gantry crane. The drawing

showing sluice arrangements and Training & divide wall details are given in the Drawing Volume as KBL-7230-P-108 and KBL-7230-P-109 are appended as Plate 4.28 and 4.29 respectively in Drawing Volume – II A.

4.3 Canals from Daudhan Dam

In all two canal systems are proposed from Daudhan dam project viz.,

A) Ken-Betwa Link canal to divert water from Ken river to Betwa river (including en route irrigation) and

B) Ken LBC to provide irrigation to the Ken command (contemplated in the erstwhile KMPP, now taken over by Daudhan dam).

4.3.1 Description of Canal Systems including Ridge/Contour/Lift Canal Capacity and Considerations for Fixing Alignments etc.

A) Ken – Betwa link canal

The Ken-Betwa Link canal which envisages diversion of water to Betwa river apart from providing en route irrigation starts with a tunnel. The flow control is achieved through a regulating gate at the tunnel entry. A settling basin arrangement is proposed from which the actual canal takes off. To facilitate flow of water into Ken-Betwa Link canal, an Upper level tunnel of 1.929 km length is proposed at the Daudhan reservoir. Various design aspects of the Upper level tunnel are discussed in the following Para's.

(i) Upper level tunnel

a) Intake

The upper level link tunnel is an irrigation tunnel to divert water from the Daudhan reservoir into the Ken-Betwa Link canal. The discharge through the tunnel will vary depending upon the water demand throughout the year. The Intake of Upper Level Tunnel is located on the left bank u/s of Daudhan dam and 90 m further u/s of Lower level tunnel intake in the reservoir spread area. An independent inclined intake structure, sloping at around 10º has been provided.

The intake structure mainly comprises of concrete piers, rib beams, metallic trash racks, bell-mouth entry, emergency and service (regulating) gates and a maintenance platform at the top. The concrete piers and rib beams have been provided with suitable cut water and ease water shapes for stream lining the water flow. The intake is designed for a maximum discharge of 76.226 cumecs. The 1928.91 m long tunnel is 6 m diameter, D-shaped and is laid at a longitudinal slope of 1:800. The invert level at the start of the tunnel is EL 256.0 m and at the end of the exit portal is EL 253.601 m. The operating platform for mechanical trash rack cleaning is provided at EL 293.00 m, above MWL/FRL for ease of maintenance in all seasons. The trash

racks have been provided up to EL 270.229 m. The trash rack grooves extend beyond EL 270.229 m up to the top platform.

A metallic trash rack structure is provided to prevent entry of trash, debris and other floating matter into the tunnel. Being a large storage reservoir, the sediments are expected to significantly settle down in the reservoir itself. The invert level at intake is well above the expected reservoir sedimentation level after 100 years. The c/c spacing between the trash bars is provided as 80 mm. The total number of trash rack panels for the intake structure works out to 18. Bell mouth transition has been provided at intake entrance for smooth flow of water. Beyond the bell mouth entry, provision has been made for two gates, emergency gate and service (regulating) gate. Provision for air vent has been made d/s of the regulating gate. After the gates, a transition of 6.60 m length from square to D-shape has been provided. The service gate proposed will be regulating type to supply the required water demand. High velocities in the gate area and hydraulic jump formation are expected depending upon the extent of gate opening. To protect the concrete tunnel lining from abrasion, steel lining is proposed d/s of service gate for a distance of 25 m which is to be firmed up based on model studies. After the exit portal, a transition of 6.6 m length from D-shape tunnel to 6 m x 6 m square concrete box section has been provided which will lead the water further into the Ken-Betwa Link canal after crossing Pukhra Nallah. Hydraulic model studies are to be carried out at detailed design stage for firming up the hydraulic details of intake.

b) Rock Support System

The excavation of the upper level link tunnel is proposed to be carried out by conventional drill and blast method from the intake end and exit portal side. Hence no provision for adit is made. GSI has carried out the geological investigations and furnished their report on the likely rock strata to be encountered along the alignment of the tunnel. The tunnelling media expected along the tunnel include massive sandstone, gravely-pebbly conglomerate and interbedded sequence of sandstone and slatey shale and foliated quartzite. For more geological details, concerned chapter may be referred. The rock mass has been classified adopting the Geo mechanic classification system (CSIR method) criteria which is as follows.

Very good rock	-RMR	81-100
Good rock	-RMR	61- 80
Fair rock	-RMR	41 - 60
Poor rock	-RMR	21 – 40
Very poor rock/Squeezing conditions	-RMR	≤ 20

The rock support system has been designed for the above classes of rock mass and basically consists of shotcrete, rock bolts and steel ribs as shown in the drawing. During excavation, 75 mm dia, 4000 mm long drainage

holes is to be provided as required in seepage zones. The tunnel is proposed to be lined with M-25 grade concrete lining, 400 mm thick. A typical scheme of contact and consolidation grouting has been proposed. Eight drawings pertaining to Upper Level Link Tunnel are appended as Plates No. 4.30 to 4.37 in Drawing Volume – II A as shown below.

	Details of drawing	Drawing No	Plate
1)	Intake Structure - Plan and Sectional details	KBL-7230-P-1151 (Sheet 1/3)	4.30
2)	Intake Transition Details	KBL-7230-P-1152 (Sheet 2/3)	4.31
3)	Trash Rack Metal Structure Details	KBL-7230-P-1153 (Sheet 3/3)	4.32
4)	Longitudinal Section	KBL-7230-P-1154	4.33
5)	Typical Excavation & Rock Support Details(Drill and Blast Method)	KBL-7230-P-1155	4.34
6)	Typical Concrete Lining & Grouting Details	KBL-7230-P-1156	4.35
7)	Exit Portal Details	KBL-7230-P-1157	4.36
8)	Details of Transition after Exit Portal	KBL-7230-P-1158	4.37

c) Intake Gates

One number Service Gate and one number Emergency gate of size 6 m x 6 m shall be provided in Upper Level Tunnel Intake. The gates shall be Fixed Wheel Vertical Lift type. The gates shall be fabricated in different parts and bolted together. Service gate shall have d/s skin plate and d/s sealing while the Emergency gate shall have u/s skin plate and u/s sealing. The gates structure shall consist of skin plate stiffened by vertical stiffeners and horizontal girders. The horizontal girders shall be supported by End vertical girders provided on each side of gate. The water thrust shall be transmitted to the concrete from horizontal girder by wheels and track embedded in the concrete. The wheels shall be mounted on self lubricating bush bearing. Sill level and top of opening shall be EL 256.00 m and EL 262.05 m respectively. The gates shall be designed to withstand water load corresponding to FRL i.e. 288.00 m. These gates shall be operated by independent rope drum hoist mounted on common support structure. The support structure shall be installed at EL 293.00 m. Each Hoist Machinery shall consist of rope drum, gears and pinions, electric motor and electro–magnetic brakes. Drawing showing details of intake, service and emergency gate KBL-7230-P-1510 and KBL-7230-P-1510 1511 are appended as Plates No 4.38 and 4.39 respectively in Drawing Volume – II A.

ii) Link canal

The Ken-Betwa Link canal is predominantly contour canal except in small reaches where it is aligned as a ridge canal. The Ken-Betwa Link canal which takes of from the desilting basin located after the exit portal of the Upper Level tunnel, traverses a total length of 218.695 km and out falls into Barwa Sagar reservoir. It crosses several streams, minor/major Rivers and several roads. The alignment of canal starting with FSL of 256.931 m (at RD

500 m) from Daudhan Dam to outfall in Barwa Sagar (RD 218695 m) at FSL of 221.000 m has been divided into four reaches. Each reach has different slope and cross section elements. The alignment has been marked on the strip survey contour sheet for every 2.5 km along with the corresponding longitudinal section. Total 88 No of sheets have been prepared. Following data has been provided as Longitudinal Section table with every Drawing.

1	R.D (metre)
2	NSL
3	Canal Bed Level
4	Bed Slope (nH:1V)
5	Distributary FSL
6	Distributary Discharge
7	Design Discharge (Cumec)
8	FSL
9	F S D
10	Bed Width
11	Head Loss (Bed Slope)
12	Head Loss (CD Structure)
13	Manning's Rugosity Coefficient
14	Side Slope (nH:1V)
15	Flow Velocity (at FSD)
16	Free Board
17	Canal Top Level
18	Canal Top Width
19	Depth of Cutting
20	Depth of Filling

Similar details as listed above have been given in all the Longitudinal Section maps of various canals pertaining to the Ken-Betwa Link project.

All the 88 sheets containing the Longitudinal Section and strip contour maps of Ken-Betwa Link canal are given as KBL-7320-D-2501 to 2588 which are appended as Plates No. 4.40 to 4.127 respectively in Drawing Volume –II A & II B. The alignment consists of straight lines and circular curves as per Clause 6.4 of IS 5968: 'Guidelines for planning and layout of canal system'. The range of radius are given in Table 4.6 below.

Table 4.6
Radii of curves for canals

Discharge(m^3/s)	Radius, Min(m)
280 and above	900
Less than 280 to 200	750
Less than 200 to 140	600
Less than 140 to 70	450

Discharge(m^3/s)	Radius, Min(m)
Less than 70 to 40	300
Less than 40 to 10	200
Less than 10 to 3	150
Less than 3 to 0.3	100
Less than 0.3	50

Accordingly all the curves in the Ken-Betwa Link canal have been proposed with radius of 300 m.

a) Cross Section and Lining

The design of canal cross sections have been done as per provisions of IS 10430: 'Criteria for design of lined canals and guidelines for selection of type of lining'. The details are given in Drg. No KBL-7320-D-2589 is appended as Plate 4.128 in Drawing Volume – II B.

b) Capacity of Ken-Betwa Link Canal

Proposed Ken-Betwa Link Canal has been designed for Capacity varying from 76.226 cumecs at head reach to 59.32 cumecs at end. The subtractions have been done for minimum discharge in each distributaries of a reach and transmission losses are not taken into account for greater flexibility of the system.

c) Shape

The shape of the canal has been selected as trapezoidal with rounded corners as per provisions of IS 3873: 'Laying cement concrete/stone slab lining on canals - Code of practice' for ease in laying of lining. The bed width reduces from head to tail with no change in the water depth so that intended flow velocity is generated with ease in construction.

d) Manning's n

As per CL 4.1.2.1 of IS 10430: 'Criteria for design of lined canals and guidelines for selection of type of lining' the value of N may be taken as shown in Table 4.7 given below.

Table 4.7 Value of ' n ' to be considered in lined canals

Sl No.	Surface Characteristics	Value of n
i)	Concrete with surface as indicated below:	
a)	Formed, no finish/PCC tiles or slabs	0.018-0.020
b)	Trowel float finish	0.015-0.018
c)	Gunited finish	0.018-0.022

Sl No.	Surface Characteristics	Value of n
ii)	Brick/tile lining	0.018-0.020
iii)	U.C.R./Random rubble masonry with pointing	0.024-0.026
iv)	Asphalt	
a)	Smooth	0.013-0.015
b)	Rough	0.016-0.018
v)	Concrete bed trowel/float finish and slopes	
a)	Hammer dressed stone masonry	0.019-0.021
b)	Coursed rubble masonry	0.018-0.020
c)	Random rubble masonry	0.020-0.025
d)	Masonry plastered	0.015-0.017
e)	Stone pitched lining	0.020-0.030
vi)	Gravel bed with side slope characteristics :	
a)	Formed concrete	0.02-0.022
b)	Random rubble in mortar	0.017-0.023
c)	Dry rubble (rip-rap)	0.023-0.033

However the Manning's 'n' is taken as 0.018 to compensate for increased resistance due to curves and for taking into account increased resistance due to deterioration of lining with time.

e) Free board

As per Clause 8.2 of IS 10430: 'Criteria for design of lined canals and guidelines for selection of type of lining' the value of free board may be taken as per Table 4.8 given below.

Table 4.8 Values of Free board required for lined canals

Canal Discharge	Free Board
More than 10 cumecs	0.75 m
Between 3 to 10 cumecs	0.60 m
1 to 3 cumecs	0.50 m
Less than 1 cumec	0.30 m
Less than 0.1 cumec (Water Course)	0.15 m

However the free board is taken as 920 mm from RD 0 to RD 216.250 km (reach 1 to 3) and 750 mm from RD 216.250 km to end (reach 4). This is

provided as per free board provision in major canal systems of India and their performance and to make possible the en route irrigation of area lying between link canal and LBC of KMPP proposed earlier by Madhya Pradesh, Water Resources Department, which is currently proposed to be served by LBC by lift.

f) Side Slope

As per Clause 8.1.1 of IS 10430: 'Criteria for design of lined canals and guidelines for selection of type of lining' the side slope shown in Table 4.9 below.

Table 4.9 Recommended side slopes for the lined canals

Sl No.	Type of Soil	Side Slopes (Horizontal : Vertical)	
		In cutting	In embankment
i)	Very light loose sand to average sandy soil	2 : 1 to 3 : 1	2 : 1 to 3 : 1
ii)	Sandy loam	1.5 : 1 to 2 : 1	2 : 1
iii)	Sandy gravel/Murum	1.5 : 1	1.5 : 1 to 2 : 1
iv)	Black cotton	1.5 : 1 to 2.5 : 1	2 : 1 to 3.5 : 1
v)	Clayey soils	1.5 : 1 to 2 : 1: 1	1.5 : 1 to 2.5
vi)	Rock	0.25 : 1 to 0.5 : 1	0.25 : 1 to 0.5 : 1
Note — The above slopes are recommended for depth of cutting/height of embankment up to 6 m. For depth/height in excess of the above, special studies for the stability of slopes are recommended.			

However, the slope adopted is 1.5 H : 1 V for cutting as well as for filling. The cross sectional details of the link canal are given in Drg. No. KBL-7320-D-2590 which is appended as Plate 4.129 in Drawing Volume – II B.

g) Bed Slope

Bed slope of the link canal has been kept from 1 in 9,000 to 1 in 12,000 for different reaches.

4.3.2 Study of integrated network of canal system and its operation to utilise the water potential of streams crossed by main canal system by provision of storage/tail tank etc.

Detailed study of integrated network of canal system will be taken up at pre construction stage.

4.3.3 Description of soil profile along the canal alignment based on pit/auger holes.

Soil samples were collected at a distance of around 5 km except at locations where sampling was difficult due the presence of rocky strata or some other valid reasons like large depth. At fill sections of canal, representative soil samples in gunny bags were collected around canal alignment for laboratory evaluation for their suitability as construction material. Similarly, wherever significant cutting sections of canal were involved, undisturbed soil samples in core cutters (100 mm dia) were collected for laboratory determination of their Index and engineering characteristics at in situ density. In all 40 samples, both disturbed and undisturbed samples were collected from different pits except complete filling locations where only disturbed samples were collected. These pits wherever possible, were excavated to various depths along/around the canal by the project authorities for sampling by CSMRS field parties. There is a large variation of soil along/around the canal length, varying from SM (Silty sand), SC (Clayey sand) to CL/CI (Clays of low to intermediate plasticity mostly). Soil is capable of attaining high densities on Proctor compaction. Good In situ densities are also observed for the samples. Very low values of strength parameters for few samples along the canal alignment at RDs-18.150, 82.751, 108.451 & 211.800 km was observed. These canal reaches may be further investigated at smaller interval of distance to determine the extent of such soils before construction. Free swell Index values were found from moderate to high in case of some samples. Shrinkage limit was also found to be around 11-12 % in such samples. Swelling pressure is expected in these samples and should be taken into consideration after evaluation in design. Canal sections having soil in semi-pervious range need appropriate measures for seepage control. Densities along with corresponding strength parameters should form the basis of canal design. The canal is generally in full or partial cutting whereas complete filling exits at other locations. Suitable soil available from cutting sections preferably with some plasticity can be used in fill portions of canal.

It is suggested to conduct further soil investigations at lower intervals of distance (Smaller RDs) during construction stage.

4.3.4 Evaluation of the Design Parameters Based on the Samples Collected Along the Canal Alignment, borrow area and Suggested Treatment for Problematic Reaches.

A) Evaluation of Design parameters

The Ken-Betwa Link canal has been designed in such a way that it carries out its intended design function of conveying the discharge from Daudhan Dam to Barwa Sagar and fulfills the enroute irrigation and drinking water demand with safety, economy and efficiency. For this purpose the

following design-criteria based on the relevant provisions of IS codes, and established design practices is proposed.

1. Non-silting non-scouring velocities should be generated for efficient sediment transport.
2. The system should be flexible to cater to any combination of requirement of irrigation of enroute command and water transfer
3. The Transmission losses should be minimum.
4. The canal should not overtop its lined section in any reach.
5. Designed discharge should be available all the distributaries at designed water level.
6. Deep cutting or high embankments are to be avoided and cutting and filling should be balanced as far as possible.
7. Head loss due to various structure and section resistance should be minimum and compatible with design etc.,

In addition of above, following sub-criteria based on the relevant provisions of IS codes and established design practices have also been adopted.

1) The designed Alignment should involve balanced cutting and filling.
2) Deep cutting or high embankments are to be avoided as far as possible.
3) The canal should not overtop its lined section in any reach.
4) More than intended head loss should not take place.
5) The design should be for better overall economy.
6) The water loss due to seepage and evaporation should be minimum.
7) The bed slope should be such that non-silting non-scouring velocities are generated.
8) The design should take into account efficient sediment transport etc.,

4.3.5 Details of Lining

The lining adopted is concrete lining of thickness 100 mm as per provisions of IS 3873: 'Laying cement concrete/stone slab lining on canals - Code of practice'. It is also proposed to deploy a HDPE geo membrane as per provisions of IS 9698: 'Lining of Canals with Polythene films-code of Practice' behind the lining to further reduce losses. The lining is proposed to be unreinforced. The pressure release arrangements as per provisions of IS 4558: 1995 'Code of practice for under-drainage of lined canals' are provided to release water pressure behind lining due to rise in ground water level and canal empty condition. In the absence of data on the ground water level variation, it is proposed to provide 30% of the canal lined section with

pressure release arrangement. The details of under drainage are illustrated in Drawing No. KBL-7320-D- 2591, which is appended as Plate 4.130 in Drawing Volume – II B. The details of Mechanical placement of the lining of Ken-Betwa Link project are given Drg. No KBL-7320-D-2592 which is appended as Plate 4.131 in Drawing Volume – II B. The lining shall however be reinforced at the junction of lining with any CD structure on u/s and d/s for a distance of 50 m.

4.3.6 Transmission Losses Assumed for Lined/Unlined Channel (Cumecs/million sq m)

Transmission losses for the entire length of the KBL canal are worked out as 68 MCM at 0.6 cumecs/million sq m of wetted perimeter as per provision in IS Code 4745-1964. The details are given at Annexure 4.4.

4.3.7 Cut off statement showing the details of the discharge required from tail to the head considering the irrigation requirement and transmission losses in taking of channel of distributaries out falling from Ken-Betwa Link Canal

Details about the discharge required from tail to the head considering the irrigation requirement and transmission losses in taking of channel of distributaries out falling from Ken-Betwa Link Canal will be finalised during pre construction stage.

4.3.8 Design Calculation for Adequacy of Canal Selections Adopted

The water balance studies of Ken and Betwa basins carried out by NWDA show that 1020 MCM of surplus water will be available in the Ken basin upto Daudhan dam, which can be diverted to Betwa basin. The reservoir operation studies carried out for Daudhan dam show that the link canal from Daudhan dam will carry a maximum monthly flow of 185 MCM in the month of August and September. As per present proposal, surplus water transfer from Ken to Betwa basin is confined to 8 months (243 days) from July to February. The design discharge of Ken-Betwa link canal will be 76 cumecs from RD 0 km to RD 107 km, 72 cumecs from RD 107 km to RD 171 km, 68.42 cumecs from RD 171 km to RD 216.250 km and 59.32 cumecs from RD 216.250 km onwards. The section changes because of the withdrawal of water in the enroute command. The length of the Ken-Betwa Link canal will be 231.45 km with FSL at head 259 m. A freeboard of 0.75 m has been provided in the link canal. The side slope of the canal and bed slope will be 1.5H : 1V and 1:10,000 respectively. The link canal will be lined completely with plain cement concrete. Design of Link Canal Cross Sections in various reaches are given at Annexure 4.5.1 to 4.5.4.

The design of canal sections has been checked for passing 25% additional design discharge. It is seen that it is possible to pass this additional discharge with about 0.40 m encroachment in the 0.75 m free board available in the canal.

The details of the canal sections are given in the Table 4.10.

Table 4.10 Reach wise Details of canal sections

Canal reach	Design discharge	Bed width	Full supply depth	Bed slope	Velocity
	cumec	m	m		m/s
From RD 0 to 107 km	76.23	13.2	3.44	1 in 9,000	1.09
From RD 107 to 171 km	72.04	13.1	3.44	1 in 10,000	1.03
From RD 171 km to 216.25 km	68.42	13.0	3.44	1 in 11,300	0.97
From RD 216.25 km to Terminal point	59.32	10.75	3.44	1 in 12,000	0.92

4.3.9 Design Discharge Data (irrigation requirement, transmission losses, evaporation losses etc) for each Distributaries Supported by Detailed Calculation for a Representative Distributary.

The KBL Canal is designed to provide enroute irrigation and drinking water to command area in its reach. Information on the distributaries network is furnished in every L- section of 2.5 km of the length of the link canal, for the distributaries falling in that reach. Details of distributaries out falling from KBL Canal are given in Annexure 4.6.

The shape of the distributaries section adopted is cup shaped as per codal provisions and established design practices. The respective depths of various triangular portions are shown in the Table. The section has been designed for maximum flow and bed slope of 1 in 10000 in the absence of detailed data. The details of cross sections of distributaries Drg No KBL-7320-D-2599 and appended as Plate 4.132 in Drawing Volume –II B.

4.4 Canal structures across Ken-Betwa Link Canal

(i) Cross regulators

21 cross head regulators will be provided at various locations of Ken-Betwa Link Canal as shown in Annexure 4.5 referred above, for providing design discharge to distributary at required water level.

The Cross Regulators are provided for the following functions:

1. To ensure pond level in front of head regulators so that the desired quantity of water may be diverted to the distributary.

2. To enable maintenance of a particular stretch of the canal.
3. To facilitate operation of canal escapes.
4. Efforts shall be made to combine bridges with the canal cross regulators to effect economy.

Head regulator has not been proposed for the distributaries in view of the small discharge to be diverted. Instead the water is diverted to distributary through MS pipe of appropriate diameter. To regulate the flow, a valve is proposed to be provided.

Following design criteria has been adopted for design of canal cross regulators:

1. The cross regulator should cause minimum head loss for water flow through the canal. To fulfil this criteria sufficient waterway of the cross regulator shall be provided.

2. The head regulator should be able to dissipate energy satisfactorily in the partial flow. To fulfil this criteria, stilling basin shall be provided.

3. The cross regulator should be able to withstand the uplift pressure. To fulfil this criteria, thickness of floor as well as pressure release valves shall be provided.

4. The cross regulator should be able to prevent piping. To fulfil this criteria sufficient length of floor is provided and cut-off wall is provided. A conservative approach is taken for a later possibility that the canal lining gets damaged at the junction of cross regulator and there is no water on the d/s side of the cross regulator.

5. U/s and D/s protection in the cross regulator makes it strong enough to with stand the various hydraulic forces due to water flowing over and below it. To fulfil this criteria, sufficient reinforcement shall be provided. The flexible protection is not provided as the canal is fully lined. However, the canal section is reinforced on the u/s and d/s for a distance of 50 m.

The typical cross section of the cross regulator is given as Drawing No. KBL-7230-P-2600 which is appended as Plate 4.133 in Drawing Volume – II B. The design of cross regulator is given at Annexure 4.7.

Gates for cross regulators

The cross head regulators shall be at various locations of Link Canal. There will be 21 Cross Regulators each with five Service gates of Fixed Wheel Type Vertical Lift Gate. Size of service gates shall be 3.500 m x 4.500 m. The service gates shall be provided with d/s skin plate and d/s sealing's. Wedge

type seal shall be provided for bottom sealing and music note solid bulb seals shall be provided for side sealing's. The seal shall remain in contact with stainless steel seal seats to make the gate watertight. The gate structure shall consist of skin plate stiffened by vertical stiffeners and horizontal girders. The horizontal girders shall be supported by end vertical girders on each side. The water thrust will be transferred to concrete structures from the end vertical girder through wheels and wheel track. The wheels shall be mounted on self lubricating antifriction bearings. The wheel shall be made up of corrosion resistant steel. The BHN of wheel track shall be 50 BHN higher than the wheel material. 20 mm guide and two numbers guide shoes shall be provided on each side to guide the gate in grooves. The gates shall be operated by rope drum hoist of suitable capacity. The Rope Drum Hoist shall consist of hoist machinery mounted on hoist support structure. Each hoist machinery will be equipped with two rope-drums, gears, pinions, couplings, shafts, worm reducer, motor and brakes. The hoist bridge shall be supported on trestles. One set of stoplog's having two units shall be provided to carry out the maintenance of service gates. The stoplog's shall be provided with d/s skin plate and d/s sealing's. The stoplog's shall be operated in balanced water head conditions. However, the top most unit can be lifted under unbalanced water head for one unit height water head. The stoplog's shall be operated with monorail crane. The stoplog units shall be stored in stoplog groove above MWL. The stoplog units shall have bronze pad sliding on stainless steel track. 20 mm guide shall also be provided to guide the stoplog units. Drawing showing details of cross regulator service gates of 3500 mm x 4500 mm - general installation sheet 1 of 2 (Drawing No. KBL-7230-P-1515) and stoplog of 1750 mm x 4500 mm - general installation sheet 2 of 2 (Drawing No. KBL-7230-P-1516) are appended as Plate 4.134 and 4.135 respectively in Drawing Volume – II B.

(ii) Structures at both ends of Ken-Betwa Link Canal

It is proposed that energy dissipation cum settling basin may be provided in the beginning of canal for flowing purpose.

1. To dissipate the excess kinetic energy for water when canal is running with high water level in Daudhan Dam.
2. To settle silt in the water as bed slope is very low.
3. To act as canal escape.

The details of settling basin are furnished in Drg No KBL-7320-D- 2593 which is appended as Plate 4.136 in Drawing Volume – II B. The details of exit regulator which is proposed at the outfall into Barwa Sagar are given as Drg. No KBL-7320-D- 2594 which is appended as Plate. 4.137 in Drawing Volume – II B. The design particulars of the exit regulator are given at Annexure 4.8

(iii) CD works structures

The Ken-Betwa Link canal is predominantly contour canal except in small reaches where it is aligned as a ridge canal. It crosses several streams, minor/major rivers and several roads. The type of CD works depend upon the catchment area of the streams and its bed level with reference to the bed level of the canal it crosses. In general, if bed level of canal is well above the HFL of a drain, an aqueduct is the obvious choice. Super passage is proposed when the bed level of the stream is much higher than the FSL of the canal at the crossing. Syphon aqueduct has been provided if the HFL of the drain is higher than the canal bed. Canal syphon has been provided if the FSL of the canal is sufficiently above the bed level of the drainage trough, so that the canal can flow under syphonic action under the trough. Following CD/CM works are proposed across the Ken-Betwa Link canal.

1. Major Bridges	7 Nos
2. Minor Bridges	42 Nos
3. Aqueduct	10 Nos
4. Syphon Aqueduct	12 Nos
5. Canal Syphon	1 Nos
6. Canal Falls	4 Nos.
7. Escapes	4 Nos.
8. Railway bridge	1 No.

Wherever practical, syphon aqueduct is preferred over canal syphon for lower head loss. Only one canal syphon is proposed at river Dhasan crossing. A list of cross drainage works comprising 10 aqueducts and 12 syphon aqueducts is furnished at Annexure 4.9. Canal falls are provided at RD 202.150 km (3.6 m), RD 205.531 km(2.0 m), RD 210.080 km (3.0 m) and at RD 216.581 km (2.0 m) keeping in view the topographical constraints. Canal escapes are proposed at Starting point (RD 0.500 km), U/S of Dhasan (RD 107.201 km), at Bhatgora CR (RD 139.242 km)and at the End point (RD 218.675 km). The design of canal siphon across Dhasan is furnished at Annexure 4.10.

A minor bridge shall be combined with every Aqueduct, Syphon Aqueduct and Cross Regulator to ensure at least one passing over in every 2.5 km. Forty two Bridges Minors (Independent) are proposed across the length of the link canal. One railway bridge is also proposed on the Mauranipur – Jhansi railway line at RD 187.228 km. The list of CM works i.e., Road bridges and railway bridge across the link canal is furnished as Annexure 4.11.

The design of bridges is adopted as per provisions of IRC standard designs for Bridges. The typical drawings of i) Major bridges (Drg. No. KBL-7320-D- 2595), ii) Aqueduct (Drg no. KBL-7320-D- 2596) iii) Syphon Aqueduct (Drg no. KBL-7320-D- 2596-A), iv) Canal syphon across Dhasan river (Drg no. KBL-7320-D- 2597) and v) Canal falls (Drg No KBL-7320-D- 2598) are given at Plates No. 4.138, 4.139, 4.140, 4.141 and 4.142 respectively in Drawing volume- II B.

(iv) Canal Outfall at Barwa Sagar

The existing outlet i.e. waste weir on the extreme right side of Barwa Sagar shall be used to drop link canal water at EL 220.620 m into Betwa river through Barwa river. At the end of canal, the structure proposed is an exit regulator to Barwa Sagar and an end Cross regulator. Both are proposed with automatic control with manual override for ease in operation. This arrangement is proposed for following purpose

1. The water outfalls to Barwa Sagar safely and efficiently. Barwa Sagar bed may not be scoured excessively due to incoming water.
2. For the case when water is not required in Barwa Sagar / when it has become full, the water should be conveyed to Parichha Weir bye passing the Barwa Sagar.

(v) Barwa Sagar Outfall Gates

Three Numbers automatic radial gates are proposed to transfer the water of Ken-Betwa Link canal to Barwa Sagar. The water level of Barwa Sagar shall be kept at EL 220.280 m. When the water of Barwa Sagar rises above EL 220.280 m, the radial gates shall close automatically. To achieve this, radial gates shall be provided with counter weight at d/s side. When the water level of Barwa Sagar exceeds from pre-decided level, the counter weight shall float in the water. The buoyancy of water will reduce the force on gate due to counter weight and the gate shall close due to self weight. Model study of the gate arrangement shall be carried out at design stage to verify the working of gate. The gate structure shall have curved skin plate, stiffened by vertical stiffeners. The vertical stiffeners shall be supported by horizontal girders. The load from horizontal girders shall be transferred to trunion through parallel arms. Combined anchorage system will transfer the water load from trunion to concrete in bonding. Hydraulic cylinder may also be provided to avoid hunting of gate and operation of gate. The gate trunion shall be fitted with self aligned self lubricating bush bearings of standard make. The trunion shall be mounted above tail water level. One set of stoplog's shall also be provided to carry out maintenance of automatic Radial Gates. The stoplog's shall be operated by Gantry Crane.

(vi) Gates of Cross Regulator at end of Ken-Betwa Link

Automatic radial gates shall be provided to regulate the flow of link Canals. When the water level in Link Canal rises due to closure of Barwa Sagar Outfall Gates, the End Cross Regulator Gates will be lifted automatically. This will help in avoiding the spilling over of link canal. These gates shall be radial type. The radius of gate and level of trunion shall be carefully chosen. The gate leaf will be provided with horizontal flap to give extra uplift force when water level in u/s side increases. Rope Drum Hoist shall also be provided to lift the gate at any other condition. The gate structure shall have curved skin plate, stiffened by vertical stiffeners. The vertical stiffeners shall be supported by horizontal girders. The load from horizontal girders shall be transferred to trunion through parallel arms. Combined anchorage system will transfer the water load from trunion to concrete in bonding.

4.5 Ken LBC (including connecting canal)

In the KMPP proposed earlier by the state Govt. of Madhya Pradesh envisaged one LBC to provide irrigation facilities in the Ken Command. Since the Daudhan dam project (a major component of the Ken-Betwa Link project) replaces the earlier proposed KMPP, the Ken command area proposed to be irrigated by KMPP will now be taken over by the Daudhan dam through the same canal as proposed in the KMPP (Ken LBC). However, the length of the Ken LBC will now be 57.3 km instead of 67.3 km (as proposed earlier) and a connecting canal of 2.1 km length will join tail race channel of PH-II to the Ken LBC. L-section of link canal to KMPP is shown in Plate No. 4.143 in Drawing Volume-II B. The other salient design details are kept unaltered. The full supply depth of the Ken LBC at the head is 3.81 m and bed width is 11.585 m. The designed velocity is 1.357 m/s. The bed slope is 1 in 6000. The condensed L- section of the Ken LBC as proposed in the KMPP is given in 4 sheets and appended as Plates No. 4.144, 4.145, 4.146 and 4.147 in Drawing Volume – II B.

The details of connecting canal now proposed, are discussed in the following Para's.

Connecting Canal to Ken LBC has been proposed from exit of PH-II to convey the water from the Daudhan Dam to Ken LBC Command. The design details of PH – II and intake (Lower Lever Tunnel) are discussed under the Power House component.

The alignment of the connecting canal has been marked on the strip survey contour sheet. Various data as described in Para 4.1.4, have been provided as Longitudinal Section table with every Drawing. For details refer drawings sheet No KBL-7320-D- 2680 which is appended as Plate. 4.143 in Drawing Volume – II B. The KMPP connecting Canal connects the tail race of PH -II at FSL 245.690 m to Ken LBC (proposed earlier under KMPP) at FSL of

245.340 m. at RD 6.00 km. The connecting canal is designed only for 2.2 km length. No Distributary or CD works are envisaged in this reach.

a) Cross Section and Lining

The design of cross section has been done as per provisions of IS 10430: Criteria for design of lined canals and guidelines for selection of type of lining. The cross section has been designed on Manning's formula. The sectional details are given in Drg No KBL-7320-D-2681 which is appended as Plate 4.148 in Drawing volume- II B.

b) Capacity

Capacity has been taken as 65.194 cumecs from head reach starting from tail race of PH-II to its outfall in KMPP. The subtractions are done for minimum discharge in each distributary of a reach and transmission losses are not taken into account for greater flexibility of the system.

c) Shape

The shape has been selected as trapezoidal with rounded corners as per provisions of IS 3873: Laying cement concrete/stone slab lining on canals - Code of practice for ease in laying of lining. The bed width reduces from head to tail with no change in the water depth so that intended flow velocity is generated with ease in construction.

Other details viz., side slopes, bed slopes, free board etc., for the connecting canal are considered suitably as discussed for Ken-Betwa Link canal.

d) Lining

The lining adopted is concrete lining of thickness 100 mm as per provisions of IS 3873: Laying cement concrete/stone slab lining on canals - Code of practice. It is also proposed to deploy a HDPE geo membrane as per provisions of IS 9698: Lining of Canals with Polythene films-code of Practice behind the lining to further reduce losses. The lining is proposed to be unlined. The pressure release arrangements as per provisions of IS 4558 : 1995 Code of practice for under-drainage of lined canals are provided to release water pressure behind lining due to rise in ground water level and canal empty condition. In the absence of definitive data on the ground water level variation, it is proposed to provide 30% of the canal lined section with pressure release arrangement. The lining shall however be reinforced at the junction of lining with structure on u/s and d/s for a distance of 50 m.

e) Structure at the beginning and end of Canal

In the starting and end of canal, arrangements have been proposed to safely inlet the water into canal and to outlet into Ken LBC.

f) CD Structures

No CD Structures are involved in the connecting canal.

4.6 Power House

Hydropower is proposed to be generated from Daudhan storage reservoir at two locations. The first Power House is proposed d/s of Daudhan dam and is referred to as Dam-Toe PH-I, while the second Power House is proposed at the exit of the lower level tunnel that carries the water from reservoir to the KMPP canal system and is referred to as Lower Level Tunnel PH-II. The tailrace water from PH-II is led into KMPP canal system. CEA has carried out the power potential studies for the two Power Houses and proposed the installed capacity for PH-I as 60 MW (2x30MW) and for PH-II as 18 MW (3x6 MW).

The overall conceptual planning of the project has been carried out by NWDA taking into consideration the agreement entered into by the two States, results of hydrological and other studies, surveys and investigations. The proposal of two tunnels i.e. upper and lower level tunnels and their elevations have accordingly been finalized by NWDA. NWDA has proposed generation of power by utilizing the water being released for irrigation through the dam and through the lower level tunnel and the head available in the reservoir. However no power is envisaged by NWDA on the Upper Level Link Tunnel.

4.6.1 Alternative studies

Alternative studies limited to finalizing the location of the intake structures and alignment of upper and lower level tunnels as well as the location of the two Power Houses is carried out as discussed in the following Para's.

(i) PH-I

Various alternatives have been considered for the location of PH-I keeping in view the point that the tailrace water from PH-1 has to be led into the river, d/s of the dam. The proposal of locating PH-I on the left side of the spillway, d/s of the dam is resulting in too much of excavation of the left bank slopes and requires a long tail race channel. The underground option at the same location is ruled out due to non-availability of adequate rock cover in the area. After evaluating the technical and economic aspects of various alternatives, PH-I is finally proposed to be located on surface at the toe of the dam between spillway and the river.

(ii) PH-II

Various alternatives have been considered for the location of PH-II keeping in view the point that the tailrace water of PH-II has to be led into

the KMPP LBC. In the first alternative (Alt-1), the intake for the head race tunnel is proposed around 180 m u/s of the dam axis along the left bank and the tunnel is aligned ensuring adequate vertical and lateral rock cover. The surge shaft is suitably located ensuring adequate lateral rock cover. From the surge shaft, a pressure shaft leads the water into a surface power house. In the second alternative (Alt-2), attempt is made to shift the above intake location further away from the dam and is placed at around 300 m from the dam axis. The HRT length reduces by around 50 m and pressure shaft length by around 100 m for the same tailrace channel length. A bend in tailrace channel is also avoided. The third alternative (Alt-3) considers locating the power house at the toe of the dam on the left side of spillway. This alternative leads to increased excavation of the left bank slopes d/s of the dam and a very long TRC/tunnel. After evaluating the technical and economic aspects of various alternatives, the second alternative (Alt-2) is preferred and adopted for PH-II.

(iii) Upper Level Tunnel

Various alternatives have been considered for aligning the upper level link tunnel keeping in view that the water has to be led into the proposed Ken-Betwa Link canal. Two alternatives, Alt-1 and Alt-2 have been considered with different intake locations as shown in the Plate No. 4.149 Alternative Studies in Drawing Volume-II B. The hydraulics of flow, extent of excavation involved, adequate rock cover availability and geological inputs are some of the main factors considered for comparative study. After evaluating the technical and economic aspects, Alt-2 is finally preferred and adopted. The general Layout Plan of PH-I, PH-II & Upper Level Tunnel is shown in Plate No.4.150 Drawing Volume-II B.

4.6.2 Dam-toe PH-I

The Dam-Toe PH-I is proposed near the toe of the dam around 85 m d/s from the dam axis. The power house is located on the right of the spillway and on the left of Ken river. The water from PH-I is led back into the river through the tail race channel. In the event of sudden shutdown of the power house or during planned maintenance, the water can be released d/s through under sluices/spillway. The FRL/MWL of Daudhan reservoir is EL 288.0 m. The discharge through each unit of the powerhouse is 82.0 cumecs and the total discharge is 164.0 cumecs. The gross maximum and minimum head is 54 m and 18 m respectively. The installed capacity proposed for this power house is 60 MW comprising of 2 units of 30 MW each.

4.6.2.1 Intake

Two independent intake structures have been provided for the two units of PH-I in blocks 32 and 33 of non-overflow portion of Daudhan dam. The intake structure proposed on the u/s face of the dam body is of semi-circular type. The c/c distance between the two intake structures is 20 m. The

intake structure mainly comprises of concrete piers, rib beams, metallic trash racks, bell-mouth entry, emergency and service gates and a maintenance platform at the top. The concrete piers and rib beams have been provided with suitable cut water and ease water shapes for stream lining the water flow.

The MDDL for power generation in Daudhan Reservoir for PH-I would be EL 252.0 m. The operating platform for trash rack cleaning is provided at EL 293.0 m, above MWL/FRL for ease of maintenance in all seasons. The trash racks have been provided up to EL 252.00 m. Above this, concrete panel wall has been provided in the opening between the concrete piers. However the trash rack grooves extend beyond EL 252.0 m up to the top of the dam.

a) Trash rack structure

A metallic trash rack structure is provided to prevent entry of trash, debris and other floating matter into the penstock. Being a large storage reservoir, the sediments are expected to significantly settle down in the reservoir itself. The invert level at intake is well above the expected reservoir sedimentation level after 100 years. The c/c spacing between the trash bars is provided as 100 mm conforming to BIS codes for the proposed Kaplan turbine units. The height of each trash rack panel is kept as 3.28 m. The radius of semicircular trash rack is 6.6 m. The total number of trash rack panels for each intake structure works out to 30.

Each intake is designed for a discharge of 82.0 cumecs. The centre line of penstock has been kept at EL 243.0 m ensuring that minimum water submergence required with respect to MDDL to prevent vortex formation is available. Bell mouth transition has been provided at intake entrance for smooth entry of water. Beyond the bell mouth entry, provision has been made for two gates, emergency and service. Provision for air vent has been made d/s of the service gate. After the gates, a transition of 5.0 m length from rectangular to circular shape has been provided. Hydraulic model studies are to be carried out at detailed design stage for firming up the hydraulic details of intake. The plan and sectional details of intake structure as given in drg. No. KBL-7230-P-1003 (Sheet 1/3) is at Plate 4.151 in Drawing Volume – II B. Similarly the intake transition details and Trash metal structure details (Drg. No. KBL-7230-P-1004 (Sheet 2/3) and KBL-7230-P-1005 (Sheet 3/3)) are appended as Plates No. 4.152 and 4.153 respectively in Drawing Volume – II B.

b) Intake Gates

Fixed Wheel Vertical Lift Gate of size 3.800 m x 4.500 m shall be provided at the intake of Dam Toe PH–I. The gate shall have wedge type bottom seal and hollow bulb side and top seals. The seals shall be provided at the d/s side of the service gate. These gates shall be operated by hydraulic hoist mounted at top of the pier at EL 293.00 M. The hydraulic power pack

shall be installed in the chamber provided in the dam body. Sill level of gate shall be 240.75 m and shall be designed to withstand a static head of 47.25 m corresponding to FRL i.e. 288.00 m. The gates shall be closed in unbalanced water head conditions and shall be lifted in balanced water head condition to be achieved by crack opening of gate. The gates shall be capable for fully open or fully closed positions. No regulation shall be provided.

Air vent shall be provided at the d/s of service gate to meet out the air requirement. Drawing of intake service gate and stoplog's Dam toe PH–I sheet 1 of 2 is KBL -7230-P-1506 and appended as Plate 4.154 in Drawing Volume – II B. Two units of Stoplog's shall be provided to carry out the maintenance of Service gate. The Stoplog's shall have u/s skin plate and u/s sealings. The Stoplog's shall be operated by Intake gantry crane and lifting beam. Drawing intake service gate and stoplog's Dam Toe PH-I Sheet 2 of 2 is KBL-7230-P-1507 is appended as Plate 4.155 in Drawing Volume – II B.

c) Gantry Crane

20T Gantry Crane shall be provided to operate the Dam Toe PH-I Intake Stoplog's. The Gantry Crane shall have hoist machinery mounted on trolley. The trolley shall of moving type. The crane structure along with trolley shall be capable of moving in longitudinal direction with the help of LT travel mechanism. The crane shall be designed as per IS: 3177 and IS: 807. The gantry shall be installed at road level i.e. 293.00 m. These gates shall be operated by independent rope drum hoist mounted on common support structure. The support structure shall be installed at EL 293.00 m. Each Hoist Machinery shall consist of rope drum, gears and pinions, electric motor and electro –magnetic brakes.

4.6.2.2 Power Channel

Since the intake to the PH-I is directly from the Daudhan dam, no provision for power channel needed to be considered.

4.6.2.3 Tunnels/Pressure Shafts

No tunnel is proposed for the PH – I. However one Lower level tunnel is proposed for the PH – II, the details of which are dealt under PH – II details.

4.6.2.3 Balancing Reservoir

No balancing reservoir is proposed for PH – I

4.6.2.4 Fore Bay

No fore bay is proposed for PH – I.

4.6.2.6 Penstocks and Surge Shaft

i) Embedded Steel Penstock

The centre line of penstock is at EL 243.0 m. The penstock is aligned horizontal from the intake. The steel liner of penstock starts from the end of transition. The horizontal penstock as it leaves the d/s sloping face of the dam body is bent down at an angle of 55º to align almost parallel to the d/s sloping face. After the bottom vertical bend of 55º, the penstock runs horizontal. The centre line of the bottom horizontal penstock is EL 222.0 m which is also the centre line of spiral casing.

Optimization studies for working out the economic diameter of penstock have been conducted. The internal diameter of penstock provided is 4.5 m which gives a velocity of 5.2 m/s. The total length of the embedded steel penstock along the centre line of the penstock from the start of steel liner (after transition) upto D-line of the Power House is 84.345 m. At D-line of the Power House, the diameter of the penstock is reduced by a reducer piece from 4.5 m to 4.0 m. The c/c distance between the two penstocks is 20 m. The entire length of penstock is embedded in concrete. The penstock between the d/s sloping dam face and D-line of the Power House is embedded in concrete up to EL 233.50 m (service bay level) for ease of movement around Power House. Provision for a manhole has been kept inside the Power House, u/s of the Main Inlet Valve for maintenance of penstock. Penstock Steel Liner details as illustrated in drawing Nos. KBL-7230-P-1006 and KBL-7230-P-1007 are given as Plates 4.156 and 4.157 respectively in Drawing Volume – II B.

The steel proposed for the steel liner of the penstock is IS 2002 – Grade 2 with yield strength of 2650 kg/cm^2 and ultimate tensile strength of 4200 kg/cm^2. The steel liner is designed for full internal pressure including water hammer pressure. The steel liner has been checked for the likely external water pressure and grout pressure. Minimum handling thickness for 4.5 m diameter penstock works out as 12.5 mm. The steel liner thickness provided varies from 16 mm to 20 mm along the length of the penstock.

The length of an erection piece would be 5.0 m formed by welding of two 2.5 m long ferrules in the workshop. All non destructive tests viz. radiography, ultrasonic and hydrostatic testing shall be carried out. All the erection pieces shall be painted from inside.

b) Surge shaft

No surge shaft is provided for the intake to PH-I.

4.6.2.7 Surface Power House (PH-I)

PH–I is proposed as surface powerhouse referred to as Dam-Toe PH-I between the spillway and river portion with its long axis aligned almost

parallel to the dam axis. It is located at the toe of the dam in front of non-overflow dam blocks no. 32 and 33. Geological investigations have revealed that the Power House is located in massive sandstone. For more geological details, concerned chapter may be referred.

The FRL/MWL of Daudhan reservoir is EL 288.0 m. The minimum draw down level for power generation for PH-I would be EL 252.0 m. The maximum TWL is indicated as EL 234.0 m. The expected HFL at the Power House site is EL 240.890 m. The power potential study has been carried out by CEA. The design discharge proposed through each unit of the Power House is 82.0 cumecs and the total discharge is 164.00 cumecs. The gross maximum and minimum head is 54 m and 18 m respectively. The installed capacity proposed by CEA for this Power House is 60 MW comprising of 2 units of 30 MW each.

The Power House structure consists of machine hall, service bay, unloading bay, control rooms and transformer deck area. The structure comprises of RCC columns and beams designed to bear the loads coming from various electro-mechanical equipments. The weight of generator rotor is conveyed as 105 t. The capacity of EOT Crane for Power House is 125/30 t. The crane beam has been designed accordingly. A steel truss forms the roof of the Power House

The Electro-Mechanical design and drawings for the Power House have been carried out by CEA. The D-line of the Power House is at a distance of 85 m for the dam axis. The dimensions of the Power House excluding control room and including unloading bay is 88.5 m (long) x 22 m (wide) x 53 m (high). The c/c spacing between the units is 20 m. Vertical shaft Kaplan turbines have been proposed by CEA. The centre line of spiral casing is EL 222.0 m. The Main Inlet Valve proposed is of butterfly type having 4.0 m diameter. Two draft tubes with separate gates have been provided.

Draft tube gates

The draft tube gates shall be provided at the d/s of power unit. Each power unit of PH-I shall have one draft tube gate of size 5.0 m x 4.4 m. The draft tube gate shall be lowered to isolate the power unit from d/s side and the maintenance of power unit will be carried out without affecting other units. To achieve this, the draft tube gates shall have sealing and track on power unit side. Spring loaded guide shall be provided to avoid pressuring of power unit. However, additional safety feature in electrical circuit shall also be made. The power unit will not start until the draft tube gate is at lifted position.

The skin plate of gate shall be stiffened by vertical stiffeners and horizontal girders. The load from horizontal girders shall be transferred to end vertical stiffeners provided on each side. Bronze pad shall be fitted to end vertical girders. The load will be transferred to concrete through bronze pad

and stainless steel track. The gate shall be closed in balanced water head condition. Lifting of gate shall be done in balanced water head condition which shall be achieved by filling valve. The filling valve shall be linked to lifting arrangement of gates. The initial movement of lifting arrangement shall open the filling valve. The gate shall be lifted after achieving the balance head on both sides of gate. The gate shall be linked to gantry crane through lifting beam. Drawing of draft tube gate for PH–I(KBL-7230-P-1513) is appended as Plate 4.158 in Drawing Volume – II B.

The following drawings in respect of PH–I are appended in Drawing Volume – II B at Plates shown below.

	Details	Drg. No.	Plate
1.	Cross section of Dam toe PH-I	KBL – 7230 – P – 1008	4.159
2.	M.I.V. Floor Layout Plan	KBL – 7230 – P – 1009	4.160
3.	Turbine Floor Lay out plan	KBL – 7230 – P – 1010	4.161
4.	Generator floor Lay out plan	KBL – 7230 – P – 1011	4.162
5.	Machine hall and Service bay Layout plan	KBL –7230– P – 1012	4.163
6.	Control Room Lay out Plan at El 238	KBL – 7230 – P – 1013	4.164
7.	Control Room Lay out Plan at El 243	KBL – 7230 – P – 1014	4.165
8.	Power House L- section through Centre line of the Unit	KBL–7230 – P – 1015	4.166

Tail Race Channel

A 32 m wide and 405.0 m long TRC will carry the turbine discharge back to the river. As per CEA, the maximum TWL with two units operating is 234.000 m. The crest level at the start of TRC is kept at 232.060 m. The tail race pool(TRP) floor is sloping upwards at 1:5. The TRC is a RCC structure with a slope of 1 in 800 towards the river. The top of the retaining walls is proposed at EL 243.0 m (transformer deck level) which is above the reported HFL of 240.89 m. From safety considerations, one meter high railing is proposed on the top of the retaining wall. The details of TRC from PH-I are shown in Drg. No. KBL – 7230 – P – 1016 and is appended as Plate 4.167 in Drawing Volume – II B.

4.6.3 Lower Level Tunnel (PH-II)

4.6.3.1 Intake for PH-II

The lower level tunnel PH–II is proposed at the end of the pressure shaft tunnel as a surface Power House. The water after power generation will finally be released into Ken LBC. The discharge through each unit of the Power House is 20.33 cumecs and the total discharge is 61.0 cumecs. The gross maximum and minimum head is 42 m and 14 m respectively. The installed capacity proposed for this Power House is 18 MW comprising of 3 units of 6 MW each.

The Intake of PH-II is located on the left bank, around 300 m u/s of Daudhan dam in the reservoir spread area. An independent inclined intake structure, sloping at around 10º has been provided. The intake structure mainly comprises of concrete piers, rib beams, metallic trash racks, bell-mouth entry, emergency and service gates and a maintenance platform at the top. The concrete piers and rib beams have been provided with suitable cut water and ease water shapes for stream lining the water flow.

The MDDL for power generation in Daudhan Reservoir for PH-II would be EL 260.0 m. The operating platform for mechanical trash rack cleaning is provided at EL 293.0 m, above MWL/FRL for ease of maintenance in all seasons. The trash racks have been provided up to EL 254.525 m. The trash rack grooves extend beyond EL 254.525 m up to the top platform.

a) Trash rack structure

A metallic trash rack structure is provided to prevent entry of trash, debris and other floating matter into the tunnel. Being a large storage reservoir, the sediments are expected to significantly settle down in the reservoir itself. The invert level at intake is well above the expected reservoir sedimentation level after 100 years. The c/c spacing between the trash bars is provided as 80 mm conforming to BIS codes for the proposed Kaplan turbine units. The height of each trash rack panel is kept as 2.624 m. The total number of trash rack panels for the intake structure works out to 10.

The intake is designed for a discharge of 65.194 cumecs. The centre line of intake tunnel has been kept at EL 247.35 m ensuring that minimum water submergence required with respect to MDDL to prevent vortex formation is available. Bell mouth transition has been provided at intake entrance for smooth flow of water. Beyond the bell mouth entry, provision has been made for two gates, emergency and service. Provision for air vent has been made d/s of the service gate. After the gates, a transition of 6.0 m length from rectangular to modified horseshoe shape has been provided. Hydraulic model studies are to be carried out at detailed design stage for firming up the hydraulic details of intake. The plan and sectional details of intake structure as given in Drg. No. KBL-7230-P-1101 (Sheet 1/3) is at

Plate 4.168 in Drawing Volume – III. Similarly the intake transition details and Trash metal structure details (Drg. No. KBL-7230-P-1102 (Sheet 2/3) and KBL-7230-P-1103 (sheet 3/3) are appended as Plates 4.169 and 4.170 respectively in Drawing Volume – II B.

b) Intake Gates

One number Service Gate and one number Emergency gate of size 4.600 m x 5.500 m shall be provided in Lower Tunnel PH-II Intake. The gates shall be Fixed Wheel Vertical Lift type. The gates shall be fabricated in different parts and bolted together. Service gate shall have d/s skin plate and d/s sealing while the Emergency gate shall have u/s skin plate and u/s sealing. The gates structure shall consist of skin plate stiffened by vertical stiffeners and horizontal girders. The horizontal girders shall be supported by End vertical girders provided on each side of gate. The water thrust shall be transmitted to the concrete from horizontal girder by wheels and track embedded in the concrete. The wheels shall be mounted on self lubricating bush bearing. Sill level and top of opening shall be EL 244.60 m and EL 250.10 m respectively. The gates shall be designed to withstand water load corresponding to FRL i.e. 288.00 m.

Two drawings of intake service and emergency gate for PH-II viz., KBL -7230-P-1508 (Sheet 1 of 2) and KBL -7230-P-1509 (Sheet 2 of 2) are appended as Plates No. 4.171 and 4.172 respectively in Drawing Volume – II B.

4.6.3.2 Power Channel

Since the intake to the PH-II is directly from the surge shaft located at the exit of Lower Level Tunnel, no provision for power channel needed to be considered.

4.6.3.3 Tunnels/Pressure Shafts

Optimization studies for working out the economic diameter of HRT have been conducted. Modified horse-shoe shaped, 5.5 m finished diameter, concrete-lined, HRT is provided which gives a velocity of 2.65 m/s. The length of HRT is 1008 m and is laid at a slope of 1: 175. The excavation of the tunnel is proposed to be carried out by conventional drill and blast method from two ends, i.e. the intake end and pressure shaft end. Hence no provision for adit is made. The L - section of the HRT (Lower level tunnel) for PH – II (Drg. No. KBL -7230-P-1104) is given as Plate. 4.173 in Drawing Volume – II B.

GSI has carried out the geological investigations and furnished their report on the likely rock strata to be encountered along the alignment of HRT. The tunnelling media expected include massive sandstone, gravely-pebbly conglomerate and interbedded sequence of sandstone and slaty shale. For

more geological details, concerned chapter may be referred. The rock mass has been classified adopting the Geomechanic classification system (CSIR method) criteria which is as follows.

Very good rock	-RMR	81-100
Good rock	-RMR	61- 80
Fair rock	-RMR	41 - 60
Poor rock	-RMR	21 – 40
Very poor rock/Squeezing conditions	-RMR	≤ 20

The rock support system has been designed for the above classes of rock mass which basically consists of shotcrete, rock bolts and steel ribs as shown in the drawing. During excavation, 75 mm dia, 4000 mm long drainage holes are to be provided as required in seepage zones. The HRT is proposed to be lined with M-25 grade concrete lining, 350 mm thick. A typical scheme of contact and consolidation grouting has been proposed. The details of typical Excavation and rock support system and the details of concrete lining and grouting details as shown in Drg. No. KBL -7230-P-1105 and KBL -7230-P-1106 are given as Plates No. 4. 174 and 4.175 respectively in Drawing Volume – II B.

4.6.3.4 Balancing Reservoir

No balancing reservoir is proposed for PH – II

4.6.3.5 Fore Bay

No fore bay is proposed for PH – II.

4.6.3.6 Penstocks and Surge Shaft

i) Penstocks

Optimization studies for working out the economic diameter of pressure shaft have been conducted. The internal diameter of penstock provided is 2.4 m which gives a velocity of 4.5 m/s. Three 2.4 m finished diameter, steel-lined pressure shafts are emanating from the bottom of the surge shaft. The pressure shaft is laid horizontal from the surge shaft up to the Power House with centre line EL 240.0 m. The length of the central steel-lined pressure shaft from surge shaft (after transition) to exit portal is 113.55 m. The length of other two pressure shafts from surge shaft (after transition) up to the exit portal including the horizontal bend is 119.661 m. Thereafter it is exposed for a length of 15 m and embedded in concrete for a length of 25 m. In the exposed reach of 15 m, it is proposed to provide a T-junction in the penstock fitted with a Howell Bunger Valve for bypassing the water to the tailrace d/s whenever the powerhouse is closed. The steel proposed for the steel liner of the penstock is IS 2002 – Grade 2 with yield strength of 2650 kg/cm^2 and ultimate tensile strength of 4200 kg/cm^2. The steel liner is

designed for internal pressure including water hammer pressure and checked for external pressure. No rock participation has been considered in resisting internal pressure. Minimum handling thickness for 2.4 m diameter pressure shaft works out as 8 mm. The steel liner thickness proposed for the pressure shaft up to exit portal is 12 mm and thereafter up to D-line of the Power House is 14 mm. The length of an erection piece would be 5.0 m formed by welding of two 2.5 m long ferrules in the workshop. All non destructive tests viz. radiography, ultrasonic and hydrostatic testing shall be carried out. All the erection pieces shall be painted from inside. The Pressure Shaft Penstock steel liner details as given in Drg. No. KBL -7230-P-1108 is appended as Plate 4.176 in the Drawing Volume – II B.

ii) Surge shaft

A 60 m high, restricted orifice type surge shaft of 18 m finished diameter, open to sky has been proposed at the end of HRT to take care of the surges arising from the various operating conditions of the power plant. Three pressure shafts are emanating from the surge shaft bottom leading to the individual units. For isolating the pressure shaft/penstock for maintenance, separate gates have been proposed for each pressure shaft at surge shaft bottom. The minimum sectional area of surge shaft required for hydraulic stability as per Thoma criteria has been worked out as stipulated in the code. Accordingly, 18 m finished diameter of surge shaft is provided. An orifice of 3.5 m diameter has been provided in the orifice slab of the surge shaft satisfying Calame and Gaden criteria as given in the code. The thickness of orifice slab is 2.0 m. Steel liner, 16 mm thick has been proposed around the orifice in the orifice slab.

Transient analysis has been carried out using a computer programme for various operation conditions of the Power House. The maximum upsurge corresponding to simultaneous full load rejection of all the units works out as EL 295.0 m. The maximum down surge corresponding to simultaneous full load rejection followed by acceptance of two units works out as EL 255 m.

The rock support system for the surge shaft shall basically comprise of shotcrete, rock bolts and steel ribs depending on the rock mass encountered. During excavation, 75 mm diameter, 4000 mm long drainage holes are to be provided as required in seepage zones. 1000 mm thick reinforced concrete lining is provided for surge shaft. Consolidation grouting of the rock mass will be carried out to improve the rock conditions around the surge shaft. To ensure proper contact between concrete lining and surrounding rock, contact grouting at a pressure of 2 Kg/cm^2 is proposed. Being open to sky, the surge shaft is proposed to be covered by a steel frame structure with barbed wire and fencing all around. The details of Restricted orifice type surge shaft provided at the exit of the Lower level tunnel, as given in Drg. No. KBL -7230-P-1107 is appended as Plate. 4.177 in Drawing Volume – II B.

iii) Surge Shaft Gates:

Three Number Penstocks are proposed to carry water from HRT to generating units. Three numbers of fixed wheel type vertical lift gate of size 2400 mm x 3000 mm shall be provided in surge shaft. These gates shall be provided to carry out the maintenance of pressure shaft and power unit. The pressure shaft shall be isolated without affecting other power units.

The gates shall be operated by individual rope drum hoist mounted on hoist platform. The gate shall be capable of closing in unbalanced water head condition by its own weight. Suitable size ballast may be provided to make the gate self closing. The gate shall be lifted under balanced water head condition which shall be achieved by filling valve provided in the gate. The filling valve shall be opened by initial movement of hoist. The closing speed of gate shall be so selected to close the gate in 15 seconds in case of emergency situation in penstock or Power House. The speed of gate shall be reduced at the end of closing cycle to avoid hitting of gate at sill.

The gates shall have d/s skin plate stiffened by vertical stiffeners and horizontal girders. The girders shall be supported by end vertical girders. Each end vertical girders shall be supported by two wheels. The wheels shall be mounted on anti-friction bearing to minimise requirement of closing force. Taflon cladded solid bulb rubber seals shall be provided for side and top sealing. The bottom seal shall be wedge type. The lip angle of gate shall be optimized to minimise closing force.

Drawing of surge shaft gate Drg. No. KBL-7230-P-1512 is appended as Plate 4.178 in Drawing Volume – II B.

4.6.3.7 Surface Power House (PH-II)

PH-II is proposed as a surface powerhouse after the exit of the pressure shaft tunnel. The D-line of the Power House is at a distance of 40 m from the exit portal. The FRL/MWL of Daudhan reservoir is EL 288.0 m. The MDDL for power generation would be EL 260.0 m. The maximum TWL for the Power House is conveyed as EL 246.0 m. The power potential study has been carried out by CEA. The discharge through each unit of the Power House is 20.33 cumecs and the total discharge is 61.0 cumecs. The gross maximum and minimum head is 42 and 14 m respectively. The installed capacity proposed by CEA for this Power House is 18 MW comprising of 3 units of 6 MW each. The Power House structure consists of machine hall, service bay, control rooms and transformer deck area. The structure comprises of RCC columns and beams designed to bear the loads coming from various electro-mechanical equipments. The weight of generator rotor is conveyed as 20 t. The capacity of EOT Crane for Power House is 30/10t. The crane beam has been designed accordingly. A steel truss forms the roof of the Power House.

The Electro-Mechanical design and drawings for the Power House has been carried out by CEA. Vertical shaft Kaplan turbines have been proposed by CEA. The dimensions of the Power House inclusive of control rooms is 82.5 m (long) x 29 m (wide) x 37.8 m (high). The c/c spacing between the units is 16 m. The center line of spiral casing is EL 240.0 m. The Main Inlet Valve proposed is butterfly type, 2.4 m in diameter. Three draft tubes with separate gates have been provided. In the event of sudden shutdown of the units or during planned maintenance, the water can be released d/s through a bypass valve arrangement proposed just u/s of the Power House.

Draft Tube gates

The draft tube gates shall be provided at the d/s of power unit. Each power unit of PH-II shall have one draft tube gate of size 5000 mm X 4000 mm. The draft tube gate shall be lowered to isolate the power unit from d/s side and the maintenance of power unit will be carried out without affecting other units. To achieve this, the draft tube gates shall have sealing and track on power unit side. Spring-loaded guide shall be provided to avoid pressuring of power unit. However, additional safety feature in electrical circuit shall also be made. The power unit will not start until the draft tube gate is at lifted position. Drawing of draft tube gate for PH–I (KBL-7230-P-1514) is appended as Plate 4.179 in Drawing Volume – II B.

The following drawings in respect of PH–II are appended in Drawing Volume – II B at Plates shown below.

	Details	Drg. No.	Plate.
1.	Cross section of Dam toe PH-II	KBL – 7230 – P – 1109	4.180
2.	M.I.V. Floor Layout Plan	KBL – 7230 – P – 1110	4.181
3.	Turbine Floor Lay out plan	KBL – 7230 – P – 1111	4.182
4.	Generator floor Lay out plan	KBL – 7230 – P – 1112	4.183
5.	Service bay and auxiliary bay Lay out plan at El 250.20m	KBL – 7230 – P – 1113	4.184
6.	Power House L- section through Centre line of the Unit	KBL – 7230 – P – 1114	4.185

Tail Race Channel

A 40 m wide and 255.0 m long TRC is proposed to connect to KMPP canal system. As per CEA, the maximum TWL is EL 246.0 m. The crest level at the start of TRC is kept at EL 244.9 m. The TRP floor is sloping upwards at 1:5 slope. The TRC is a RCC structure with a slope of 1 in 800 towards the river. The top of the retaining walls of TRC is proposed at EL 250.20 m. From safety considerations, one meter high railing is proposed on the top of the retaining wall. The details of TRC from PH-II are shown in Drg. No. KBL – 7230 – P – 1115 and is appended as Plate 4.186 in Drawing Volume – II B.

4.7 Infrastructure Studies

Almost entire area of the project is well connected with road and rail net work. No constraints on transportation of heavy equipment up to project site are envisaged as the area is well connected by NH-76 which can bear class-a loading. The weights of generating units, power transformers and other components etc to be transported by road or from the nearest railhead to project site shall be within the transport limits of 70 tonnes. For transportation of heavy machinery to the dam site some of the road bridges and culverts need to be strengthened at the time of preconstruction stage.

4.8 Industrial and urban use

The domestic and industrial requirement of the project area is proposed to be met from the proposed canal system. However necessary storage and distribution system are to be developed by the local authorities.

4.9 Instrumentation

The requirement of special instruments for the construction of dam, Power House and canals are described in other chapters.

4.10 Navigation and Tourism development

There is no provision for development of navigation aspect in the project. As far as the Development of Tourism is concerned this project has got full potential, particularly because of it close proximity of Daudhan dam with Khajuraho and that of tail end of Ken-Betwa Link canal with Orchha temple near Jhansi. Provision for development of tourist huts, picnic spot has been made on the periphery of Daudhan reservoir & Barwa Sagar.

4.11 Operation and maintenance

The proposed organizational set up at the construction stage can be made available for operation and maintenance of the project. The entire operation and maintenance will be looked after by one Chief Engineer along with sufficient organizational set up. A suitable operation and maintenance programme has to be developed for meeting the various objects of the project.

4.12 Other studies

The other studies which are not covered in the DPR stage will be planned at the preconstruction stage. No other study was required do be done at DPR stage. However, if any study are suggested by Design organization of CWC at a later stage, the same may be carried out at appropriate stage.

A view of the Barwa Sagar project during monsoon, 2008

A View of spill way of Barwa sagar during the floods,2008

CHAPTER-V
RESERVOIR & POWER

CHAPTER- V

RESERVOIR & POWER

5.0 General

Spatial & temporal variability of precipitation in India makes it imminent that water storages play a leading role in the Planning & Development of water resources. The main function of a reservoir formed behind structures like dams & barrages is to regulate natural stream flow by storing water during the high flow season and to release the stored water in the dry season to meet various demands. Depending on the magnitude of natural inflows, demands at a particular time and keeping in view techno-economic aspects, attempt is made to fix the size of the reservoir.

The Ken-Betwa Link project Phase-1 envisages creation of one major reservoir on Ken river at Daudhan, 2.5 km u/s of the existing Gangau weir, The total area under submergence of Daudhan reservoir at FRL comes to 90 sq km. The storage thus created at Daudhan is proposed to be utilised for meeting irrigation requirements of d/s commands in Madhya Pradesh & Uttar Pradesh and for diversion of 1074 MCM (including transmission losses of 68 MCM) of water from Ken river to Betwa river through a canal off taking from the Upper Level Tunnel. Details of Daudhan reservoir are described in the subsequent Para 5.0.1 to 5.1.7.

5.0.1 Daudhan Reservoir

5.0.2 Fixation of Storage and Reservoir Levels Approach – Criteria

The gross availability of water at 75% dependable annual yield has been worked out as 6590 MCM by the NIH, Roorkee in Hydrological studies for Ken-Betwa Link project (Phase-I). Water balance for Ken basin upto Daudhan dam site at 75% dependability has been worked out as 1468 MCM after considering d/s commitment, u/s domestic, irrigation and industrial water requirements and regeneration thereof. Details of water balance studies at Daudhan dam site are furnished in Annexure 5.1.

The required storage to meet the given demands depends on three factors: the variability of stream flows, the size of demands and the reliability of meeting the demands. The procedure for estimating the storage capacity needed to meet given demands or the possible yield from a given project design and data constitute the SY analysis to compute the storage capacity for various purposes, such as irrigation, municipal and industrial water supply, and hydropower generation. The techniques based on the critical period concepts are the earliest techniques of SY analysis. The critical period is defined as the period in which an initially full reservoir, passing through

various stages (without spilling), empties. One such method, known as the Mass Curve Method is the first rational method to compute the required storage capacity of a reservoir.

Simulation method is another approach for SY analysis. It is basically a search procedure and is one of the most widely used techniques to solve a large variety of problems associated with the design and operation of water resources systems. This approach can be realistically and conveniently be used to examine and evaluate the performance of a set of alternative options available.

The reservoir simulation study has been carried out for estimating the live capacity of reservoirs that would provide the required yield at specified reliability. The flow data for a period of 22 years from 1981 to 2003 of Madla G&D site maintained by CWC, which is about 23 km d/s of Daudhan dam, has been used for the analysis. The analysis has been done using a Simulation Programme developed by NIH, Roorkee. This programme also takes into account the three different releases from Daudhan i.e. from Lower level tunnel, Upper level tunnel and directly from dam body through PH-I for d/s release. The result of this analysis is enclosed in the Annexure 5.2, which gives detailed output for gross capacity of 2650.4 MCM. The analysis shows that for 75% dependability performance, the gross capacity of 2650.4 MCM gives the water utilization of 4080 MCM.

5.1.1 Dead storage level (DSL)

The Daudhan Dam shall be used for meeting irrigation requirement as envisaged under KMPP project, diversion of sizeable water of Ken to Betwa river including provision for irrigation to enroute command area and also to generate 219.03 MU of average electrical energy through two powerhouses.

The dead storage capacity of the Daudhan reservoir, has been fixed on the basis of the guidelines given in “Fixing the capacities of reservoirs – method, Part 2 Dead storage, IS 5477 (Part 2): 1994”.

The new zero level of the Daudhan reservoir has been worked out as 236.4 m on the basis of sedimentation studies. The corresponding capacity at this level as per the original area - capacity curve comes to 100.77 MCM. However, DSL of the reservoir has been proposed as 240 m (corresponding capacity of 169.27 MCM) and sluices are proposed to be provided at this level. The details of sedimentation studies are furnished in Annexure 5.3.1 & 5.3.2.

5.1.2 Low water level /Minimum Draw-Down level(MDDL)

The MDDL of Daudhan reservoir can be fixed anywhere above 236.4 m which is the new zero elevation after 100 years of operation of the reservoir, based on sedimentation studies carried out by NIH, Roorkee.

At feasibility stage, there was only one tunnel, i.e., upper level tunnel and PH-II was proposed at the exit of that tunnel. As a result, MDDL was fixed at a level of 269 m which was major cause in reduction of live storage. At DPR stage, one additional tunnel, at a lower level has been introduced to meet irrigation requirement of the command area envisaged under KMPP and location of PH-II has been shifted to the exit of lower level tunnel. This has helped in lowering MDDL and in turn increasing live storage and power generation from the PH-II from 12 MW to 18 MW. The schematic diagram of Upper Level and Lower Level tunnels are given in Fig 5.1 & 5.2.

Fig.5.1

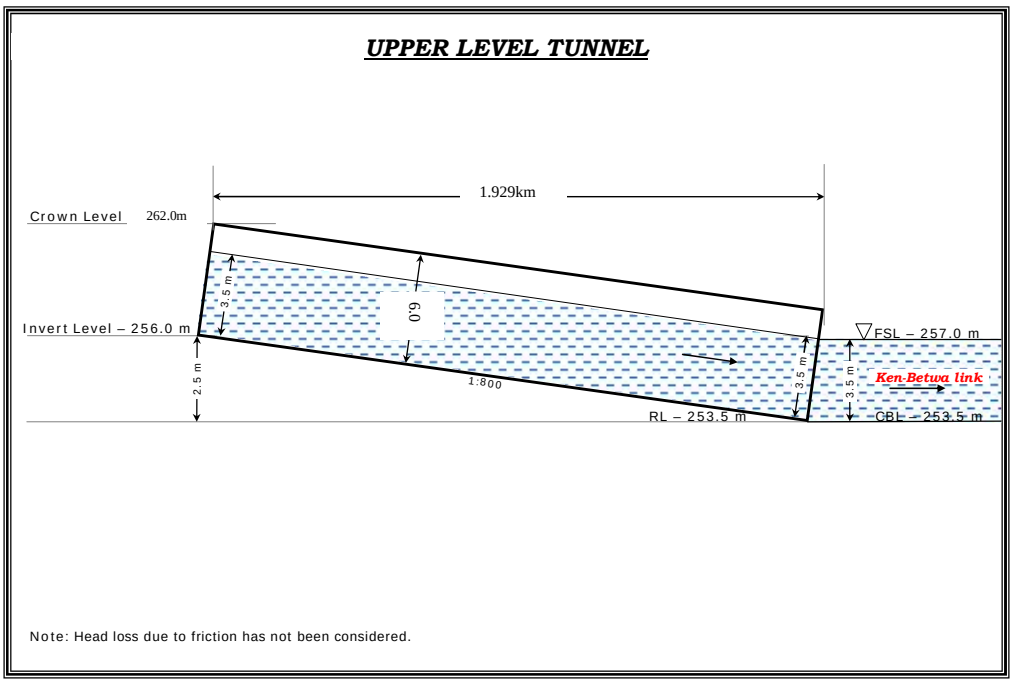
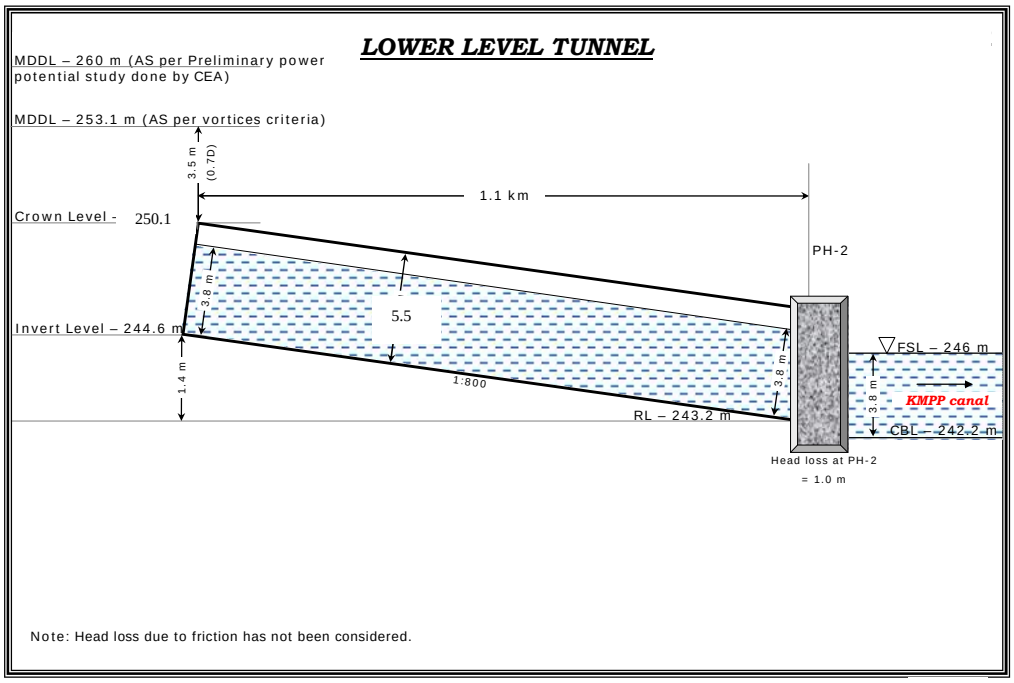


Fig.5.2



Various scenarios of MDDL for irrigation and provision of two tunnels at different levels etc. have been studied in detail. MDDL for lower level tunnel has been kept at 253.1m considering about 5.5m dia. tunnel and 0.7D for vortex criteria and 1m head loss in 1 in 800 tunnel slope so that the canal proposed by Madhya Pradesh, Water Resources Department for K,P can be fed at FSL 246.340 m after generating power. However, CEA has fixed MDDL for Lower Level Tunnel at 260m on the basis of their power potential study.

5.1.3 Full reservoir level (FRL)

At feasibility stage, divertible quantity of Ken water to Betwa was 1020 MCM whereas it has been modified to 1074 MCM at DPR stage in order to meet increased enroute demand of irrigation and drinking water. So, in order to meet the enhanced demand of the link canal, FRL of Daudhan reservoir has been fixed as 288.0 m and invert level of upper level tunnel at the inlet has been kept as 256.0 m.

The operation of the Daudhan reservoir was simulated by assuming various values of the maximum storage. It was found that if the FRL is kept at 288 m (corresponding storage of 2650.4 MCM), the time and volume reliabilities in meeting d/s irrigation demands are 79.3% and 91.9% and these values for the link are 95.6% and 97.3%. The annual irrigation reliability is 75.0% when deficit up to 10% is ignored.

5.1.4 Maximum water level(MWL)

MWL of Daudhan reservoir has been kept as 288.0 m (same as FRL). Keeping this in view, spillway gates have been designed to pass design flood of 57202 cumecs.

The MWL as worked out from flood routing study is 287.88 m with one gate as inoperative and 288.23 m with two gates inoperative. The MWL has, therefore, been fixed as 288 m.

Reservoir routing (routing of a flood wave through a reservoir) is an important part of the reservoir analysis whose major applications are for fixing MWL during reservoir design, design of spillway and outlet works and dam-break flood wave analysis.

For the Daudhan reservoir, flood routing was carried out using the Modified Puls method. The proposed spillway of Daudhan dam had earlier 14 gates. In order to limit the MWL to 288 m, more than 14 gates would be required. Computations were performed for two cases: when 30 gates are operational and when 29 gates are operational. It was assumed that the reservoir is at 288.0 m when the flood impinges.

Results of reservoir routing for the first case (when 30 gates are operational) show that the MWL attained was 287.88 m (maximum storage 2640 MCM) and the peak of the outflow hydrograph was at 57394 cumecs. For the second case, when 29 gates are operational, the MWL attained was 288.23 m (storage 2676 MCM) and the peak of the outflow hydrograph was at 57125 cumecs. Finally, the MWL at Daudhan has been fixed as 288.0 m. The details of Reservoir Routing for Daudhan dam are furnished in Annexure 5.4.1 & 5.4.2. It was felt that providing these gates would may make the spillway quite expensive. Further if limited submergence of a few cm beyond 288.0 m is permitted in event of the design flood (which may occur very rarely), spillway could be substantial smaller size thereby saving precious resources. Therefore number of gates were fixed as 27 Nos by CWC. The water level in the reservoir will have to be kept below 287 m initially before the design flood impinges the reservoir. Thus, various levels fixed in respect of Daudhan Reservoir are given in Table 5.1.

Table -5.1
LEVELS FIXED AS PER REVISED SIMULATION STUDY

CONTROLLING LEVELS	ELEVATION (m)
• FRL of Daudhan reservoir	288.0 m
• MWL of Daudhan reservoir	288.0 m
• FSL of link canal	257.0 m
Minimum levels for irrigation	

CONTROLLING LEVELS	ELEVATION (m)
• Ken-Betwa Link through upper level tunnel	256.0 m
• Ken LBC through Lower level tunnel	246.0 m
• D/s requirement through PH-I	246.0 m
UPPER LEVEL TUNNEL	
• Invert level at inlet	256.0 m
• Crown level at inlet	262.0 m
• Invert level at outlet	253.5 m
LOWER LEVEL TUNNEL	
• Invert level at inlet	244.6 m
• Crown level at inlet	250.1 m
• Invert level at outlet	243.2 m
• MDDL for PH-II Considering Vortices Criteria & 5.5m dia. of tunnel	253.1 m
• MDDL for PH-II Proposed by CEA after carrying out preliminary power potential study	260.0m
PH-I (AT TOE OF DAM)	
• Invert Level of pen stock at inlet	240.0 m
• MDDL for PH-I Considering Vortices Criteria & 6m dia of tunnel	252.0 m

5.1.5 Maximum backwater at FR level and MWL and its impact,Maximum distance of such points from the axis of the structure

The FR and MWL level of Daudhan dam has been fixed at 288 m as per simulation studies. The maximum back water level(BWL) at FRL/MWL is El. 287.500 m and the effect extends upto a distance of 70 km from the axis of the dam (at the periphery of the reservoir) within which no structures of significant importance have been identified.

5.1.6 Fetch

The fetch of the reservoir was determined to fix the free board and the top of the dam. The fetch computations were done as per IS: 10635-1993, “Guidelines for Free board requirements in Embankment Dams”. The maximum & effective fetch length of 8.36 km & 4.436 km respectively has been worked out. The following factors are taken into consideration while computing the free board requirement.

(a) Wave characteristics, particularly the wave height and wave length.
(b) U/s slope of the river and roughness of the pitching.

(c) Height of wind setup above the still water level

The detailed computations for free board required for FRL and MWL conditions have been done and the free board requirement has been worked out as 5.0 m without any wave deflector. A parapet wall of 0.9 m high is also provided.

5.1.7 Direction of wind - Velocity of wind - wave height - Free board-Top of dam

The direction of wind in Daudhan reservoir area is mostly from west to east. The Sagar IMD station is located near to the Daudhan dam site. The maximum wind velocity of 11 km/h is experienced in the month of June and the minimum wind velocity of 5.0 km/h is experienced in the month of December. The average velocity of wind is 8.5 km/h. However, a normal wind velocity of 39 m/s has been considered. The computed free board works out to 5.0 m. The top of the earthen portion the Daudhan dam has been fixed at 293.0 m.

5.2 Sedimentation data and studies

The catchment area of Ken River up to the proposed Daudhan dam site is about 19633 sq km. It is expected that about 10194 sq km of the area will be intercepted by the projects likely to come in the u/s catchment. These projects may come over a period of next 15 years. Hence, to calculate the catchment areas contributing sediments, the following assumptions have been made:

(a) For the sedimentation period of 50 years, full catchment area of 19633 sq km has been considered for the first 15 years. For the next 35 years, balance catchment area of 19633-10194 = 9439 sq km has been considered.

(b) For the sedimentation period of 100 years, full catchment area of 19633 sq km has been considered for the first 15 years while balance catchment area of 9439 sq km has been considered for the next 85 years.

There is a silt observation site on the main Ken river at Banda which is about 150 km d/s of the proposed Daudhan dam site. Sediment data of 36 years (1962-2004 excluding 1975-1981) was available for this site. The same has been used for sedimentation studies of Daudhan dam reservoir.

5.2.1 Rate of sedimentation

The sediment rates for some of the nearby projects, namely Tawa, Barna, Sondur, Gandhisagar, Mahanadi reservoir and Hasdeo in Madhya Pradesh and Matatila in Uttar Pradesh have been given in CBIP publication no.

137 on Major dams in India, 1979. It is found that the designed sediment rates of these projects are in the range from 130 to 706 m^3/sq km/year. Hence the silt rate for the Daudhan dam as worked out in Para 5.2.5, viz. 329.8 m^3/sq km/year has been considered to be appropriate for design purpose. The details of sediment rate in various nearby reservoirs are furnished in Table 5.2.

Table-5.2
Sediment rate in various nearby reservoirs

Name of dam	Catchment Area (sq km)	Dead Storage (MCM)	Sediment Rate (m^3/sq km/year)
Matatila (UP)	20718	269.3	130
Gandhisagar(MP)	23140	835.0	361
Sondur (MP)	512	19.0	371
Mahanadi Res.(MP)	3670	143.0	390
Tawa (MP)	5983	260.0	435
Hasdeo (MP)	6737	370.0	549
Barna (MP)	1176	83.0	706

Sediment Distribution

The sediment distribution is worked out for two periods, viz. 50 years and 100 years by Empirical Area Reduction method. For this purpose, the FRL 288 m is adopted and bed level of the reservoir is considered as 216 m. The original Elevation-Area-Capacity table for Daudhan dam is given in Table 5.3.

Table-5.3
Original Elevation-Area-Capacity table for Daudhan dam

Sl.No.	Contour (m)	Contour area (ha)	Cap = $[A_1+A_2 + (A_1*A_2)^{0.5}]^* h/3$	Capacity (MCM)
1	288.00	9000	35.30	2853.01
2	287.60	8650	337.07	2817.71
3	283.50	7800	226.46	2480.64
4	280.50	7300	250.67	2254.18
5	277.00	7025	206.99	2003.51
6	274.00	6775	201.00	1796.52
7	271.00	6625	189.68	1595.52
8	268.00	6025	177.26	1405.84
9	265.00	5800	167.96	1228.48
10	262.00	5400	158.24	1060.51
11	259.00	5150	148.46	902.28
12	256.00	4750	137.98	753.82
13	253.00	4450	125.93	615.84
14	250.00	3950	111.68	489.92
15	247.00	3500	100.47	378.24
16	244.00	3200	86.07	277.77

Sl.No.	Contour (m)	Contour area (ha)	Cap = $[A_1+A_2+(A_1*A_2)^{0.5}]^* h/3$	Capacity (MCM)
17	241.00	2550	67.30	191.70
18	238.00	1950	36.92	124.40
19	235.50	1050	5.08	87.48
20	235.00	981	4.64	82.40
21	234.50	875	35.36	77.77
22	230.00	700	27.15	42.40
23	225.00	400	13.25	15.25
24	220.00	150	2.00	2.00
25	216.00	0	0.00	0.00

The type of reservoir is considered as gorge type and the standard classification is taken as Type IV. The new zero elevation will be as follows:

New zero elevations:	
For 50 years	230.9 m
For 100 years	236.4 m

The MDDL can be fixed anywhere above 236.4 m which is the new zero elevation after 100 years of operation of the reservoir. The total sediment during 50 and 100 years will get distributed up to and above various elevations as given in the Table-5.4.

Table-5.4
Distribution of total sediment at various elevations of Daudhan dam

Reservoir level	Sediment deposition in MCM	
	After 50 years	After 100 years
Upto 231 m	49.3	50.3
Above 231 m	156.8	311.4
Upto 236.4 m	85.7	98.0
Above 236.4 m	120.4	263.7
Upto 244 m	127.5	185.7
Above 244 m	78.6	7176.0

The original elevation vs. capacity graph along with those after 50-year and 100-year of operation have been plotted and shown in Fig 5.3 below.

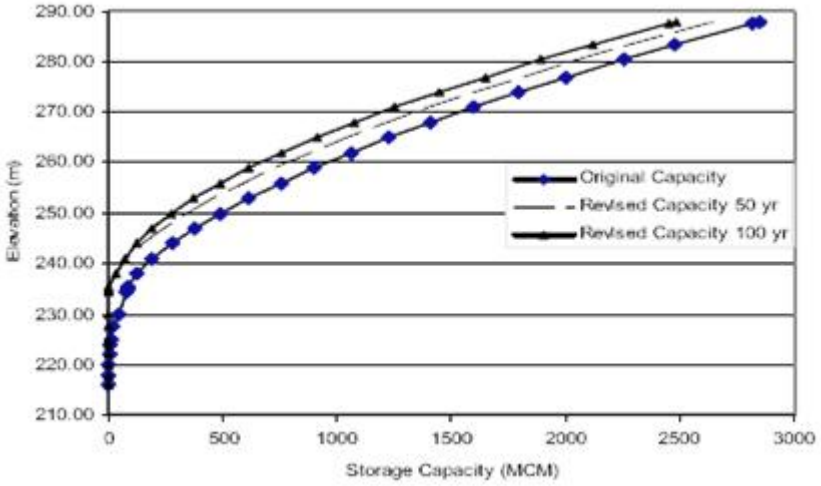


Fig 5.3

Original and revised (after 50 and 100 years) Elevation-Area-Capacity table for Daudhan dam is given in Table-5.5 below.

Table-5.5
Original and revised (after 50 and 100 years) Elevation Capacity table for Daudhan dam.

Elevation	Original Capacity	Revised Capacity after 50 yr	Revised Capacity after 100 yr
(m)	(MCM)	(MCM)	(MCM)
216.00	0.00	0.00	0.00
220.00	2.00	0.00	0.00
225.00	15.25	0.00	0.00
230.00	42.40	0.00	0.00
234.50	77.77	4.34	0.00
235.00	82.40	5.62	0.00
235.50	87.48	7.39	0.00
238.00	124.40	28.74	7.76
241.00	191.70	79.20	38.55
244.00	277.77	150.27	92.10
247.00	378.24	237.41	163.67
250.00	489.92	337.30	249.80
253.00	615.84	452.86	353.23
256.00	753.82	581.77	471.56
259.00	902.28	722.39	603.02
262.00	1060.51	873.92	746.72
265.00	1228.48	1036.23	902.43
268.00	1405.84	1208.93	1069.66
271.00	1595.52	1394.84	1251.18
274.00	1796.52	1592.91	1445.82
277.00	2003.51	1797.73	1648.11
280.50	2254.18	2046.74	1895.17

Elevation	Original Capacity	Revised Capacity after 50 yr	Revised Capacity after 100 yr
283.50	2480.64	2272.41	2119.93
287.60	2817.71	2609.18	2456.35
288.00	2853.01	2644.48	2491.65

Reference: Table 7.5 of "Hydrologic studies of Ken-Betwa link project" by NIH, Roorkee.

5.2.2 Sedimentation fraction

The Petrographic analysis on the silt samples collected from the Daudhan dam site has been carried out by IIT, New Delhi. The report of the analysis is appended as Appendix 2.15 in Volume-II.

5.2.3 Quantity of sediment

(a) During 50 years
Rate of silt deposition = 329.8 m^3/sq km/year

(i) For first 15 years the silt deposition from the catchment area of 19633 sq km = 329.8*19633*15 = 97.12 MCM.

(ii) For the next 35 years the silt deposition from the catchment area of 9439 sq km = 329.8*9439*35 = 108.95 MCM.

(iii) Total sediment deposition = 97.12 + 108.95 = 206.1 MCM.

(b) During 100 years
Rate of silt deposition = 329.8 m^3/sq km/year

(i) For first 15 years, the silt deposition = 97.12 MCM (as estimated above).

(ii) For the next 85 years the silt deposition from the catchment area of 9439 sq km = 329.8*9439*85 = 264.6 MCM.

(iii) Total sediment deposition = 97.12 + 264.6 = 361.72 MCM.

5.2.4 Types and shape of Reservoir

The Daudhan reservoir is considered as gorge type and the standard classification is taken as Type IV.

5.2.5 Sediment studies

Total sediment transport (average of 36 years)=8356972 t/year
Catchment area of Ken up to Banda G/D site = 25452 sq km.
Considering 15% bed load,

The total sediment = 1.15*8356972 t/year
Transport per year = 9610518 t/year
Average density of silt = 1.145 t/m^3
Silt inflow=total sediment / silt density=9610518/1.145
=8393465 m^3/year
Silt rate=silt inflow/catchment area
=8393465/25452=329.8 m^3/sq km

The sediment rate of 329.8 m^3/sq km/year has been considered to be appropriate for design purpose.

5.2.6 Sedimentation in the reservoir after 50 and 100 years

Total sediment deposition in Daudhan reservoir in 50 years and 100 years will be 206.1 MCM and 361.73 MCM respectively based on sedimentation studies carried out by NIH, Roorkee. Details are given under Para 5.2.3.

5.3 Life of Reservoir in years

The life of the Daudhan dam has been considered as 100 years.

5.4 Capacity

5.4.1 Capacities

Daudhan reservoir

Gross storage capacity	2853.01 MCM
Live storage capacity	2683.74 MCM
Dead storage capacity	169.27CM

5.4.2 Storage

Various storage details of the proposed reservoirs have been mentioned above.

5.4.3 Water tightness of the reservoir

Study related to water tightness of the Daudhan reservoir has been carried out by GSI, Bhopal for NWDA. The study revealed the presence of stratigraphic sequence of the Vindhyan Supergroup comprising interbedded sequence of sandstone, shale and subordinate limestone. The riverward slope of topography in the area by virtue of the favourable disposition of Vindhyans provide, by and large, congenial condition from reservoir tightness point of

view. There are no saddles in the topography for escaping water to the adjoining basin needing auxiliary structures for confinement of the reservoir water. Similarly, no significant interfluves pervious horizon of water divide is present in the proposed submergence area. Litho contacts, frequent occurrence of bedding/stratification and localized inferred faults and joints are some of the geological weaknesses in the bedrocks which area unlikely to cause any outlet for reservoir water in the adjoining area due to the above favourable topography. Of the five sets of joints recorded in the area, the rolling, sub-horizontal ENE-WSW trending joint and two vertical joints at right angles trending NE-SW and NW-SE, parallel and across to the dam axis, are the predominant joints/fractures in the area. They may account for some loss of water, but appears to be within the permissible limits. Rest of the joints tends to become tighter and gradually terminate with depth. Any seepage through the foundation of the dam can be taken care of by grouting during construction. A note on water tightness of the reservoir is appended as Annexure 5.5.

5.4.4 Annual losses

For reservoir capacity of 2853 MCM, annual average evaporation loss from Daudhan reservoir is 91.9 MCM. Highest evaporation loss (111.4 MCM) took place during year 1998 and the lowest evaporation (78.7 MCM) was in year 1989. Month of May accounts for maximum evaporation loss and December accounts for the least amount of evaporation.

5.4.5 Flood absorption

No flood storage is earmarked for this project. However, from reservoir routing for the first case (when 30 gates are operational), it is seen that the MWL attained was 287.88 m (maximum storage 2640 MCM) and the peak of the outflow hydrograph was at 57394 cumecs. For the second case when 29 gates are operational, the MWL attained was 288.23 m (storage 2676 MCM) and the peak of the outflow hydrograph was at 57125 cumec.

5.5 Effects on sub soil water table in the adjoining areas particularly d/s of the dam

The sub-soil water table will improve due to the impoundment of water in the Daudhan reservoir. In addition, the regulated flows from the Daudhan dam into Ken River for irrigation of Ken command in Banda district will increase the sub soil water level in the adjoining areas.

5.6 Reservoir rim stability

Study regarding reservoir water tightness of Daudhan reservoir has been carried out by GSI, Bhopal for NWDA. Observations of Geologist regarding the stability of the reservoir are included in Annexure 5.5.

5.7 Area of submergence

5.7.1 Maximum water level

Area of submergence of Daudhan reservoir at MWL is 9000 ha.

5.7.2 Full reservoir level

Area of submergence of Daudhan reservoir at FRL is also 9000 ha since FRL and MWL are kept same.

5.7.3 Submergence Ratio : submerged (Cultivated) area/CCA

Total area under submergence of Daudhan reservoir at FRL is 9000 ha. Distribution of land use under different types of land is as follows:

Forest land (Dense, open, scrub & built-up)	5258 ha
Agricultural land	2171 ha
Tanks/Rivers/Streams	1571 ha

Therefore, submergence Ratio =submerged (Cultivated) area/CCA = 2171/515210 =1/237.31 (0.0042)

5.8 Land Acquisition-Property submerged-rehabilitation

5.8.1 Land acquisition

Acquisition to be made on about 9000 ha (private land of 2437 ha comprising irrigated, unirrigated and built up land & govt. land of 6563 ha comprising forest land and water bodies) for construction works and that coming under submergence upto FRL only. For colony area, approach road and store yard etc., about 105 ha land has to be acquired. About 86 ha land for Powerhouse switchyard, transformer yard, quarries etc. will have to be acquired.

5.8.2 Details of property submerged

Total 10 number of villages are likely to come under submergence of Daudhan reservoir. All these villages come under Bijawar tehsil of Chhatarpur district.

5.8.3 Rehabilitation of oustees

1585 PAP's are likely to be affected by the submergence due to reservoir. The rehabilitation of oustees/project affected persons will be governed by the State/Central policy on R&R. Ministry of Rural Development,

Government of India has finalised the National Policy on R&R for project Affected Families (NPRR-2007). The policy addresses the R&R issues of the PAF (being displaced) in case of compulsory acquisition of land for public purpose including infrastructure projects. The central objective of the whole exercise is to ensure PAP's to regain their previous standard of living, if not better, within a reasonable transition period. Keeping in view the social dimensions of the project, some measures have been envisaged for the project and described below:

- Census socio-economic survey of PAF's
- Compensation for land
- Compensation for house building
- Compensation for loss of business
- Maintenance allowance for PAF's
- Ex-gratia payment
- Shifting allowance
- Infrastructure development
- Direct and indirect employment opportunities in project
- Training of PAP's
- Institutional arrangement
- Monitoring and evaluation
- Public information system and grievance redressal.

The main features of M.P. State R&R Policy as well as NPRR 2007 are as under:-

i Housing grant of Rs. 40,000 for each displaced BPL, PAF household.

ii. Each affected family that is displaced and has cattle shall get financial assistance of Rs. 15,000.

iii. Each affected that is displaced shall get one time financial assistance of Rs. 15,000 for construction of cattle shed.

iv. Each affected family that is displaced shall get one time financing assistance of Rs. 10,000 for shifting of the family, building materials, belongings and cattle.

v. Financial assistance of Rs. 25,000 per each PAF household who is a rural artisan, small trader and self employed person and Rs. 40,000 agricultural or non-agricultural labour.

vi. Displacement grant of Rs. 15,360 for each PAF and major child who has lost his house or house site.

vii. Provision of land to land to the extent of land acquired, to the ST PAFs.

viii. Financial assistance to the extent of

a) Rs. 48,000 whose total holding is acquired or
b) Rs. 32,000 if he becomes a marginal farmer (< 1.0 ha) after land acquisition or
c) Rs. 24,000 if he became a small farmer (>1.00 ha and <2.0 ha) after land acquisition.

5.9 Recreation facilities

Following are the recreational facilities which are proposed to be developed.

- Development of parks/gardens in d/s of dam.
- Development of Children parks in the township.
- Development of Tourist spot with boating facilities
- Development of Guest house, inspection bungalow and dormitory accommodation.
- Development of aviary.

These facilities in the area will ensure tourism development in the area.

5.10 Pisciculture

There are some existing irrigation projects namely Rajghat, Matatila, Samrat Ashok Sagar. Barwa sagar, Dukwan reservoir, etc. in the vicinity of project area of Ken-Betwa Link project, where pisciculture is being developed to generate revenue from fisheries. In the Rajghat project, about 3000 tonnes of fishes are produced annually from reservoir as well as fish seed centre. The submergence area of Rajghat project is 24531 ha. Accordingly, there is lot of scope for developing fisheries in Daudhan reservoir also. The submergence area of Daudhan reservoir is 9000 ha from which about 1300 tonnes of fishes can be produced annually which will increase the revenue from the project.

5.11 Need and recommendation for soil conservation measure in the catchment

The chances of soil erosion, if any can be prevented/minimized by adopting following measures.

- Avoid the creation of cut slopes and embankments which are of an angle greater than the natural angle of repose for local soil type.
- Implanting Shrubs and trees in the area.
- Vegetation alone may not be enough to prevent soil erosion, hence, few engineering measures may be adopted to complement the vegetation such as CAT, stone-pitching of vulnerable locations, etc.

Appropriate financial provisions have been provided for soil conservation measures in the catchment area.

5.12 Any other relevant information

Other than the above discussed details of Daudhan reservoir as a part of main component of the project, other existing major projects in the Ken basin are:

Gangau Weir

Gangau Weir, located in Chhatarpur district is an old structure constructed over Ken River. It has been in operation since 1915. It is a masonry weir with maximum height of 19.2 m and top width of 5.64 m with storage capacity of about 56 MCM.

Bariyarpur Pick Up Weir

Bariyarpur weir was built in 1906 at Ajaigarh in Panna District of M.P. d/s of Madla. The weir has a length, height and storage capacity of 1636 m, 8.23 m and 12.6 MCM respectively. Now this old structure is proposed to be restructured/renovated by a new barrage at about 1 km d/s of the existing structure, under Phase-1 of the Ken-Betwa link project.

Rangawan Dam

Rangawan dam was built in 1957 on Banne river, a tributary of Ken in Chhatarpur district of Madhya Pradesh. This is an earthen dam with a length of 2072 m, height of 27.4 m and live storage capacity of 155.24 MCM.

Mansurwari Dam

Mansurwari dam is built in Rehli tehsil of Sagar district of Madhya Pradesh on Padria Nallah in the Sonar sub-basin in the year 1978-79. This earthen dam has a length of 938.78 m, a height of 21.86 m and has gross and live storage capacity of 14.5 MCM and 13.4 MCM respectively.

5.13 Power (Prepared by CEA)

5.13.0 Introduction

Phase-I of the Ken-Betwa Link Project is an Inter-Basin Water Transfer Project that envisages diversion of surplus waters of Ken Basin to Betwa basin by means of a Ken-Betwa Link Canal. The project also aims to provide enroute irrigation in the drought prone areas of Chhatarpur and Tikamgarh districts of Madhya Pradesh and Mahoba and Jhansi districts of Uttar Pradesh and also irrigation benefits in Chhatarpur and Panna districts of Madhya Pradesh under Ken command through a low level tunnel and through Daudhan PH-I via. existing Gangau Weir/ Bariyarpur Pick-up weir.

The project is located about 19 km from Chhatarpur-Panna State Highway. The nearest Railhead and the nearest airport is at Khajuraho (31 km). The major components of Ken-Betwa Link Canal Project include :

- Daudhan dam across the Ken river, about 2.5 km u/s of the existing Gangau Weir
- Two Power Houses viz. one each at Daudhan Dam (PH-I) and another at the end of Lower Level Tunnel (PH-II)

- 220 km long Ken-Betwa Link link canal & cross drainage structures
- 57.3 km long Ken LBC & cross drainage structures

5.13.1 Present status of power development in the state/region

Details of Installed Capacity of various power projects of M.P as on 30th January 2008 are given in Table 5.6.

'*' Prepared by CEA

Table 5.6 Installed Capacity of various power projects of M.P as on 30th January 2008

Sl. No.	Power Station	Installed Capacity (MW)	MP Share (MW)
	Thermal Power Station		
1.	Amarkantak I (30+20 MW)	50.0	50.0
2.	Amarkantak II (2x120 MW)	240.0	240.0
3.	Satpura I (5x62.5 MW)	312.5	187.5
4.	Satpura II (200+210 MW)	410.0	410.0
5.	Satpura III (2x210 MW)	420.0	420.0
6.	Sanjay Gandhi, Birsinghpur–I (2x210 MW)	420.0	420.0
7.	Sanjay Gandhi, Birsinghpur–II (2x210 MW)	420.0	420.0
8.	Sanjay Gandhi, Birsinghpur–Extn (1x500MW)	500.0	500.0
	Sub-Total	2772.5	2647.5
B	Hydro Power Station		
1.	Gandhi Sagar (5x23 MW)	115.0	57.5
2.	Pench, Totladoh(2x80 MW)	160.0	107.0
3.	Rani Awanti Bai Bargi (2x45 MW)	90.0	90.0
4.	Ban Sagar I tons (3x105 MW)	315.0	315.0
5.	Birsinghpur (1x20 MW)	20.0	20.0

Sl. No.	Power Station	Installed Capacity (MW)	MP Share (MW)
6.	Rajghat (3x15 MW)	45.0	22.5
7.	Ban Sagar II Silpara (2x15 MW)	30.0	30.0
8.	Ban Sagar – III Deolond (3x20 MW)	60.0	60.0
9.	Ban Sagar - IV Jhinna (2x10 MW)	20.0	20.0
10.	Madhikha (3x20 MW)	60.0	60.0
	Jawahar Sagar & Ranapratap Sagar Station of Rajasthan (99 MW & 172 MW), 50% of 271 MW	---	135.5
	Sub-total	915.0	917.5
C	Mini/Micro Hydel*	5.455	5.455
	Grand Total	3692.955	3570.455

A) State Energy Generation

Thermal

The Target for annual thermal generation of Madhya Pradesh Power Generation Corporation Limited (MPPGCL) was 14623 MU fixed by CEA, New Delhi. MP's share out of this was 13803 MU. The actual thermal generation was 14017 MU which is 95.85% of CEA Targets. This generation during the year 2006-07 is 3.51% more compared to the previous year generation. The annual Plant Load Factor of thermal station of MPPGCL in the year 2006-07 is 70.41% . The previous year PLF was 68.02%

Hydel Generation

The total generation situated in Madhya Pradesh State (irrespective of share) was 3051 MU. The total hydel generation MP's share was 3034 MU.

B. Central Sector Energy Generation

The generation from Central Sector Station has increased by 1681 MU as compared to year 2005-06. The Station wise Generation and PLF as compared with year is as given in Table 5.7.

Table 5.7
Station wise generation of PLF

STATION	Year : 06-07		Year : 05-06	
	MU	PLF in %	MU	PLF in %
KORBA STPS	16500.10	89.69	15818.39	85.99
VINDHYACHAL STPS	18426.67	88.32	18305.60	92.46
KAWAS GPP	3606.82	62.76	2884.41	50.19
GANDHAR GPP	4550.50	79.11	4477.86	77.76
KADRAPAR APP	2445.59	63.45	2366.94	61.41
TARAPUR APP	4005.19			
TOTAL	45534.68		43853.20	82.13

C. Unscheduled Interchange

During the year 2006-07, State of Madhya Pradesh has overdrawn 105.18 MU and under drawn 357.35 MU from the western grid and earned UI Charges amounting to Rs. 56.54 Crore, whereas during the year 2005-06, Madhya Pradesh has overdrawn 439.91 MU from the western grid and paid UI charges amounting to Rs. 157.82 Crore.

D. ISP (NHDC) Energy Generation

Total eight ISP units are commissioning in Madhya Pradesh. The total injection into Madhya Pradesh grid from ISP was 2592 MU during the year 2006-07 as against target of 2698 MU. This capacity addition into Madhya Pradesh Grid has helped to improve the voltage profile in the Western part of Madhya Pradesh.

E. Sardar Sarovar Project

The unit wise commissioning dates of units are as given in Table 5.8.

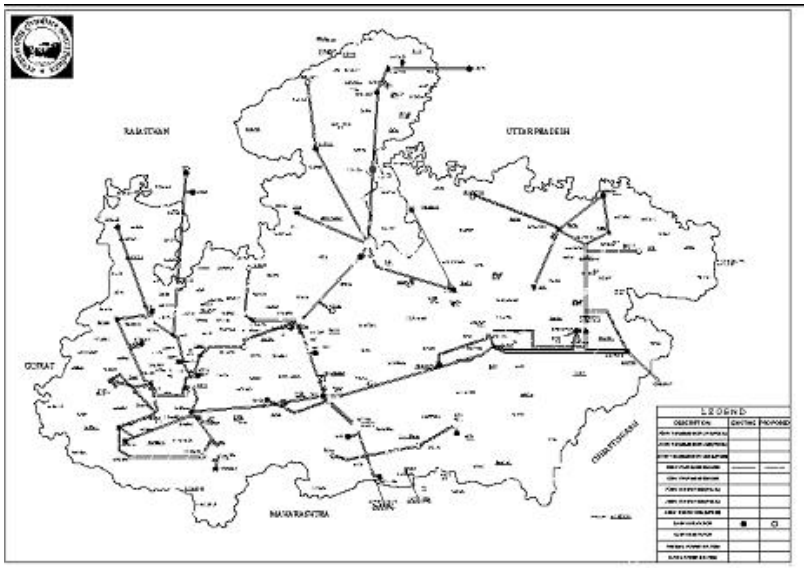
Table 5.8

Unit wise commissioning dates

Unit No	Date of Commissioning	Date of Commercial Operation
Canal Head Power House (5 x 50 MW)		
1	04.10.2004	08.10.2004
2	16.08.2004	26.08.2004
3	31.08.2004	04.09.2004

Unit No	Date of Commissioning	Date of Commercial Operation
4	03.09.2004	09.09.2004
5	15.12.2004	19.12.2004
River Bed Power House (6 x 200 MW)		
1	01.02.2005	12.02.2005
2	30.04.2005	12.06.2005
3	30.08.2005	06.09.2005
4	13.10.2005	20.10.2005
5	07.03.2006	12.11.2006
6	20.05.2006	27.06.2006

The total Share of Madhya Pradesh in Sardar Sarovar was 2017 MU during the year 2006-07 as against target of 1590 MU.



5.13.2 HYDROLOGY

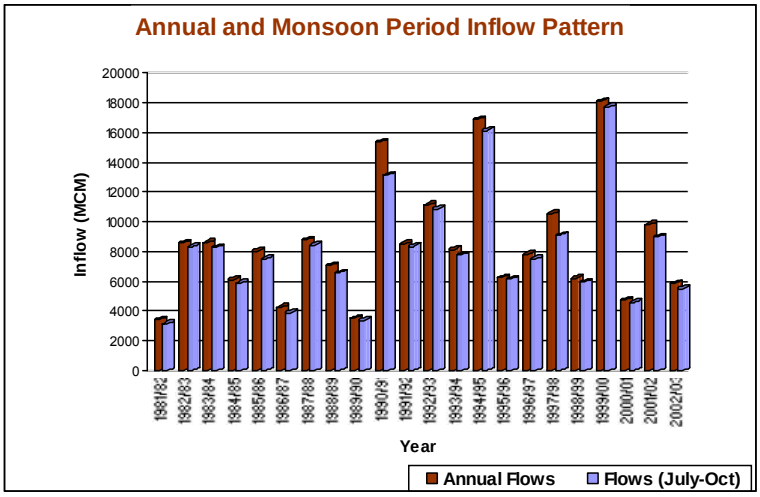
The river drains a catchment area of about 19534 km^2 upto the proposed dam site. The hydrological studies for the project have been carried out by NIH, Roorkee.

In absence of observed data at the Daudhan dam site, the yield data of two d/s sites viz. Banda and Madla were used to generate yield data at Daudhan. The variability of annual rainfall ratio for Banda catchment (ratio of annual rainfall at Daudhan catchment to that of Banda catchment) was observed to be high compared to Madla catchment. Hence, the yield series at Madla gauging site, which is also nearer to the proposed Daudhan dam was used for estimation of monthly yields at Daudhan.

Based on the above hydrological studies, an inflow series has been developed by NIH, Roorkee for the Initial as well as the Final scenarios of u/s

utilization figures (as worked out considering all existing, on-going and proposed projects) and have been vetted by CWC. The flow series for the above two scenarios have been rearranged in the cycle of hydrological years from June to May (1981-82 to 2002-03) for the purpose of planning of the project/ simulation studies.

The analysis of hydrology indicates that, in the initial scenario, the annual runoff during the study period vary from a maximum of 18113 MCM (Year 1999-2000) to a minimum of 3443 MCM (Year 1981-82) with the average being 8536 MCM. It is seen that the average inflows in the river during monsoon months from July to October constitute about 94.5 % of the total average annual run-off. Thus, the power generation during non-monsoon months would mainly depend upon the stored water available in the



reservoir.

In the Final Scenario of u/s utilizations, the average run-off will get reduced to 8142 MCM with maximum and the minimum run-off being 17525 MCM (year 1999-2000) and 2950 MCM (year 1981-82) respectively. The contribution of inflows during monsoon months from July to October would be of the order of 98.3 %.

5.13.3 Input Data for the Power Potential Study

For carrying out the simulation studies, the hydrological, topographical and other data including the demands of drinking water and irrigation, as given below, have been considered:

5.13.3.1 Hydrological Flow Data

For the preliminary power potential study, the hydrological flow data for the period 1981-82 to 2002-03 developed by NIH, Roorkee for initial as well as ultimate scenarios of u/s utilization figures, as discussed above has been utilized.

5.13.3.2 Evaporation Data

The month-wise Evaporation Data from the proposed Daudhan Reservoir, as furnished by NWDA, considered for the studies is as given in Table 5.9.

Table 5.9

Month wise evaporation of Daudhan reservoir

Month	Evaporation in mm
Jan	70
Feb	89
Mar	171
Apr	292
May	400
Jun	260
Jul	114
Aug	95
Sep	114
Oct	95
Nov	70
Dec	64
Total	1834

5.13.3.3 Area-Capacity Characteristics

The Area-Capacity Characteristics of Daudhan Reservoir, as considered for the reservoir simulation studies are given in Table 5.10.

Table 5.10

Elevation-Area-Capacity table for Daudhan reservoir

Elevation (m)	Area (ha)	Capacity (MCM)	Elevation (m)	Area (ha)	Capacity (MCM)
216.00	0	0.00	253.00	4450	615.84
220.00	150	2.00	256.00	4750	753.82
225.00	400	15.25	259.00	5150	902.28
230.00	700	42.40	262.00	5400	1060.51
230.90	735	49.48	265.00	5800	1228.48
234.50	875	77.77	268.00	6025	1405.84
235.00	981	82.40	271.00	6625	1595.52
235.50	1050	87.48	274.00	6775	1796.52
238.00	1950	124.40	277.00	7025	2003.51

Elevation (m)	Area (ha)	Capacity (MCM)	Elevation (m)	Area (ha)	Capacity (MCM)
241.00	2550	191.70	280.50	7300	2254.18
244.00	3200	277.77	283.50	7800	2480.64
247.00	3500	378.24	287.60	8650	2817.71
250.00	3950	489.92	288.00	9000	2853.01

From the above table, the gross storage available at FRL has been worked out is 2853 MCM.

5.13.3.4 Tailrace Water Level (TWL)

Daudhan Power House (PH-I)

The top of Pond level at the existing Gangau Weir is 234.9 m while the minimum operating level is 232.4 m. A constant average TWL of 234 m has been adopted for PH-I for the power potential study.

Low Level Tunnel Power House (PH-II)

FSL of the proposed Ken LBC would be 246.34 m. In absence of any information on tail water data for the proposed power house, a constant average TWL of 246 m has been adopted for PH-II for the power potential study.

5.13.3.5 Drinking Water & Irrigation Requirements

The Month wise Water Utilization flows from Daudhan Reservoir, as considered for power potential studies, are given in Table 5.11.

Table 5.11

Monthwise Water Utilization Flows from Daudhan Reservoir

Month	Daudhan dam (Cumec)	Ken-Betwa link (Cumec)	Lower Level Tunnel (Cumec)	Total (Cumec)
June	15.04	0.00	17.44	32.48
July	103.82	57.31	58.02	219.16
Aug	133.70	37.41	59.27	230.37
Sept	111.51	36.77	40.17	188.46
Oct	123.58	56.74	29.26	209.58
Nov	100.61	69.55	57.54	227.70
Dec	30.28	56.55	42.94	129.76
Jan	47.74	50.00	42.50	140.24
Feb	56.45	44.38	34.85	135.68
March	25.42	0.00	1.22	26.64
April	11.04	0.00	0.00	11.04
May	0.00	0.00	0.00	0.00

5.13.3.6 Full Reservoir Level (FRL)

The FRL for the project was initially envisaged as 287 m. However, to avoid/ minimize the pumping requirements to cater to the irrigation requirements to be met through Ken-Betwa Link Canal during certain periods when the Daudhan reservoir level falls below the level 262m, the FRL has been proposed to be kept as 288 m in order to make available additional live storage for the purpose.

5.13.3.7 Minimum Draw Down Level (MDDL)

The project, envisages the three irrigation outlets at different levels from Daudhan Reservoir to cater to the d/s irrigation and drinking water requirements and are furnished in Table 5.12.

Table 5.12

Levels & Storages for irrigation outlets

Description of Irrigation Outlet	Draw Down Level from Irrigation Considerations (m)	Gross Storage Available (MCM)
For releasing water to Bariarpur through Ken river with generation at PH-I	246	344.70
For Ken command through lower level tunnel with generation at PH-II	246	344.70
For Barwasagar through Ken-Betwa Link Canal	256	753.20

5.13.3.8 Draw Down Level for Power Generation

The draw down levels for power generation at PH-I and PH-II would be 252 m and 260 m from the consideration of permissible head variations on Kaplan Turbine which has been proposed for the two power houses. No power generation has been proposed across the Ken-Betwa Link Canal.

As per the sedimentation studies carried out by NIH, Roorkee, the New Zero Elevation after 50 years and 100 years of sedimentation would be 230 m and 235.5 m respectively which are considerably lower than the proposed outlets for irrigation and the draw down level for power generation and, therefore, may not pose any problems.

The live storage available between the FRL 288 m and the proposed draw down levels of 252 m and 260 m for power generation at PH-I and PH-II respectively would be 2279.14 MCM and 2541.75 MCM respectively.

5.13.3.9 Head Availability & Head Loss in Water Conductor System

For carrying out the power potential study, available head and the head loss in Water Conductor System for PH-I and for PH-II have been considered as given in Table 5.13 below.

Table 5.13

Maximum and Minimum Head for Power Houses

	PH-I				PH-II			
	Gross Head	Head Loss		Net Head	Gross Head	Head Loss		Net Head
	m	%	m	m	m	%	m	m
Max. Head	54	2%	1.08	52.9	42	5%	2.10	39.9
Min. Head	18	4%	0.72	17.3	14	8%	1.12	12.9
Avg. Head	43.33	4%	1.73	41.6	32.67	9%	2.94	29.7

From the above table, it is observed that the maximum gross head in case of PH-I and PH-II would be around 54 m and 42 m with minimum head as 18 m and 14 m respectively. Accordingly, for the above head range, maximum head would be three times the minimum head, which is permissible for operation of Kaplan Turbine proposed for the above project.

5.13.3.10 Operation of the Power Houses

The Ken-Betwa Link project is primarily to be operated in the interest of irrigation and drinking water supply. There is no re-regulating barrage/ structure in the d/s of PH-II. Therefore, the power house is proposed to be operated as a base Load Station.

The PH-I would be operated as a Peaking Station with re-regulation at the existing Gangau Weir where adequate diurnal pondage is available for re-regulation of the daily peaking flows.

5.13.4 Simulation Strategy

The Daudhan Reservoir is proposed to be operated on ‘Carry Over Basis’ viz. surplus flows available at the end of a hydrological cycle, after meeting the Irrigation and Drinking Water Requirements and also after generation of the Secondary Power, would be carried over for utilization in the next cycle.

For carrying out the Simulation studies, the irrigation and the other requirements to be met through different outlets of the Daudhan reservoir have been clubbed together and the reservoir has been proposed to be operated in such a manner to cater to these irrigation requirements on 75% dependable basis.

In order to obviate the need of pumping the water into Ken-Betwa Link Canal, efforts would be made to maintain the reservoir level close to 256

m during all months except the months of March, April, May and June when the irrigation requirement through the Ken-Betwa Link is zero and the level of the reservoir during these months would be allowed to be depleted up to 246m in order to meet irrigation requirement through Daudhan Dam and PH-II, if required.

As the reservoir level decreases below 260 m, the power generation at PH-II would be stopped while PH-I would continue to generate power. Subsequently, after the reservoir level decreases further viz. below 252 m, both the power houses would stop generation. However, irrigation requirement would continue to be met till the level reaches the elevation of 246 m.

The surplus water after meeting the committed irrigation and other releases would be utilized for generation of secondary power at PH-I up to the installed capacity. Any surplus waters after generation of secondary energy at PH-I would be utilized at PH-II upto the design discharge of the canal while rest of the water would have to be spilled.

5.13.5 Results of the Simulation Study

Based on the available input data and the simulation strategy described above, Reservoir Simulation Studies have been carried out by using 'SIMHYDE Model' for both Initial as well as the Final scenarios of the u/s utilizations. The installed capacity and the energy benefits from the project have, however, been finalized based on the hydrological flows available in the initial scenario.

5.13.6 Installed Capacity & Unit Size

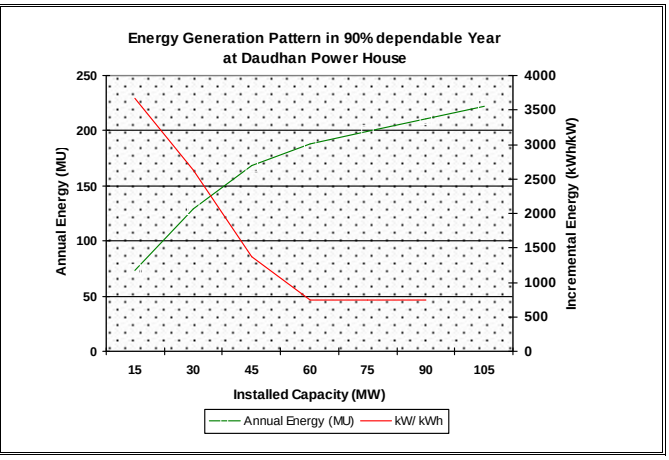
5.13.6.1 Daudhan Power House (PH-I)

i) Due to availability of diurnal pondage at Gangau Weir, the PH-I has been proposed for operation as a peaking Station. For selection of installed capacity, Simulation studies have been carried out for Daudhan reservoir and annual energy benefits in 90% dependable year have been estimated from the project in alternative installed capacity scenarios ranging from 15 MW to 105 MW at an interval of 15 MW. Subsequently, installed capacity for PH-I has been optimized based on Incremental Benefit Analysis. Results of the studies are summarized in Table 5.14 below.

Table 5.14

Annual Energy Generation at PH-I in 90% Dependable Year (1986-87)

I.C. (MW)	Annual Energy (MU)	Incre-mental Energy (MU)	kW/ kWh
15	73.62	-	-
30	128.70	55.08	3672.0
45	168.04	39.34	2622.7
60	188.51	20.47	1364.7
75	199.67	11.16	744.0
90	210.83	11.16	744.0
105	221.99	11.16	744.0

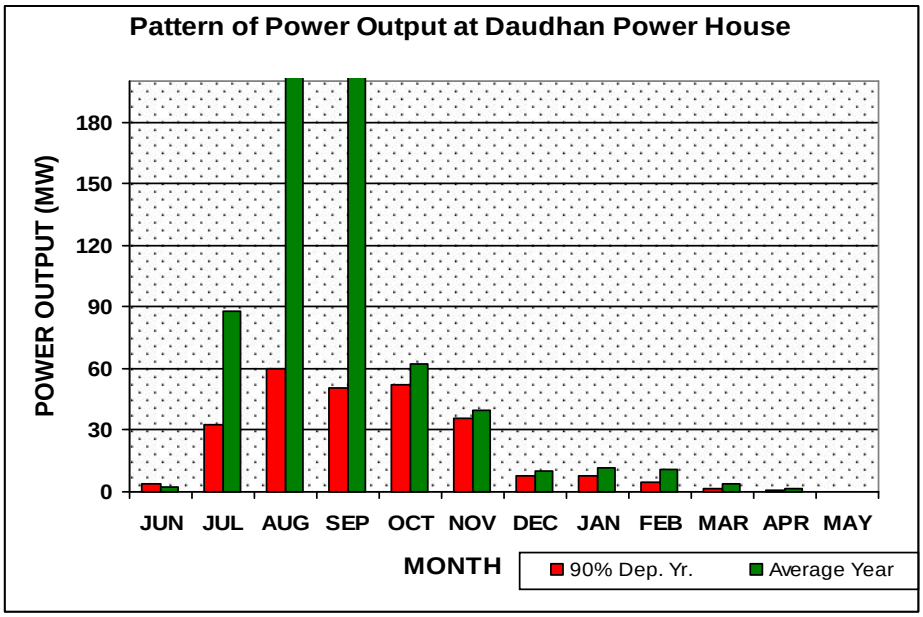


ii) Based on the above Incremental Benefit analysis, the following observations are made :

- the annual energy exhibits an increasing trend as the installed capacity is increased from 15 MW to 105 MW.
- the incremental energy falls to a low value for installed capacities beyond 60 MW.

iii) In view of the above, installed capacity for PH-I has been proposed as 60 MW. With the installation as 60 MW, the station would operate at an annual load factor of about 35.9 %.

iv) The month-wise power output pattern in 90% dependable year and on an average basis has been graphically depicted below :



It is observed from the above that there would be either no generation or significantly less generation during a number of months due to lack of irrigation demand as well as lower head availability during these months.

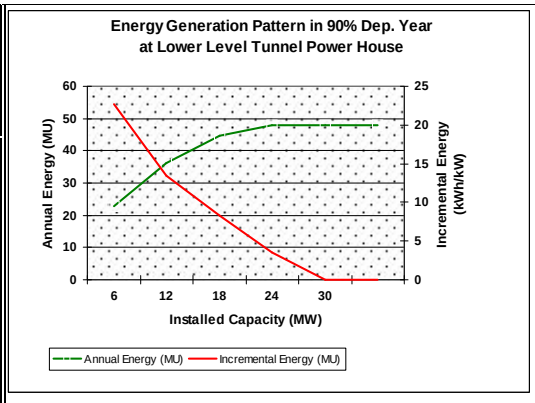
v) PH-I has been proposed to be operated as a peaking station with re-regulation at the d/s Gangau weir where adequate pondage is available. The alternative unit sizes of 20 MW and 30 MW were considered for PH-I. However, unit size is being proposed as 30 MW since the project is located close to Chhatarpur-Panna State Highway and as such, there is unlikely to be any major constraint in transportation of heavy equipment to the project site. The higher size unit would also offer greater economies due to lower per kW cost as well as savings in cost of civil works.

5.13.6.2 Lower Level Tunnel Power House (PH-II)

(i) The PH-II has been proposed to be operated as a peaking station. For selection of the installed capacity for PH-II, annual energy benefits have been estimated from the project in 90% dependable year corresponding to alternative installed capacity scenarios up to 30 MW at an interval of 6 MW. Further, Incremental Analysis has been carried out for selection of optimum installed capacity for PH-II. Results of the studies are summarized in Table 5.15.

Table 5.15
Annual Energy Generation at PH-II
in 90% Dependable Year (1982-83)

I.C. (MW)	Annual Energy (MU)	Incre-mental Energy (MU)	kW/ kWh
0	0.00		
6	22.71	22.71	0.0
12	36.19	13.48	2246.7
18	44.54	8.35	1391.7
24	48.07	3.53	588.0
30	48.07	0.00	0.0



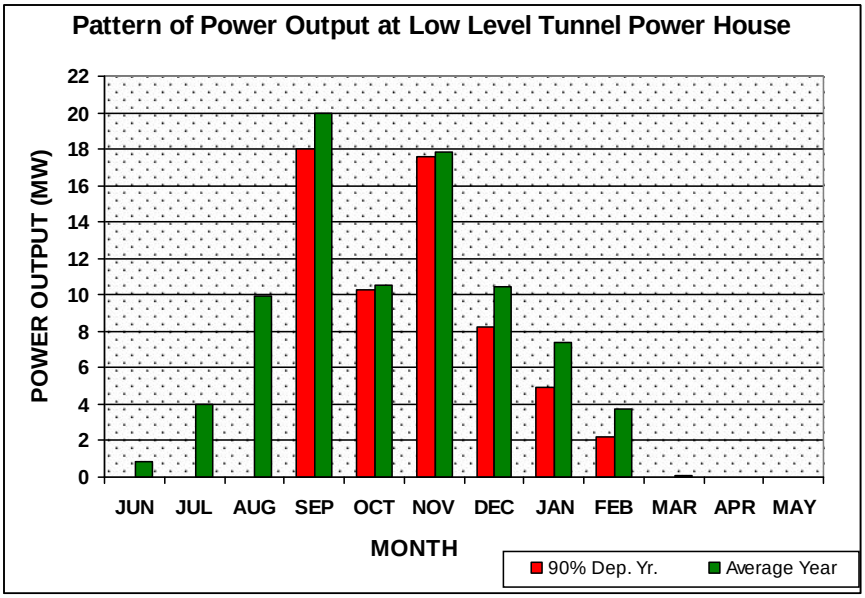
(ii) Based on the above Incremental Benefit analysis, the following observations are made :

- the annual energy exhibits an increasing trend as the installed capacity is increased. However, there is no increase in energy generation for installed capacity beyond 24 MW.

- the incremental energy falls to a low value for installed capacities beyond 18 MW.

(iii) In view of the above, installed capacity for PH-II has been proposed as 18 MW. With the installation as 18 MW, the station would operate at an annual load factor of about 28.3 %.

(iv) The month-wise power output pattern in 90% dependable year and on an average basis has been graphically depicted below:



It is observed from the above that there would be either no generation or significantly less generation during a number of months.

(v) PH-II has been proposed to be operated as a base load station since no re-regulating structure is proposed in the d/s of the power house. The unit size for the Power House has been selected as 6 MW based on the pattern of generation.

The annual energy benefits and the power house discharges are summarized in Table 5.16 below:

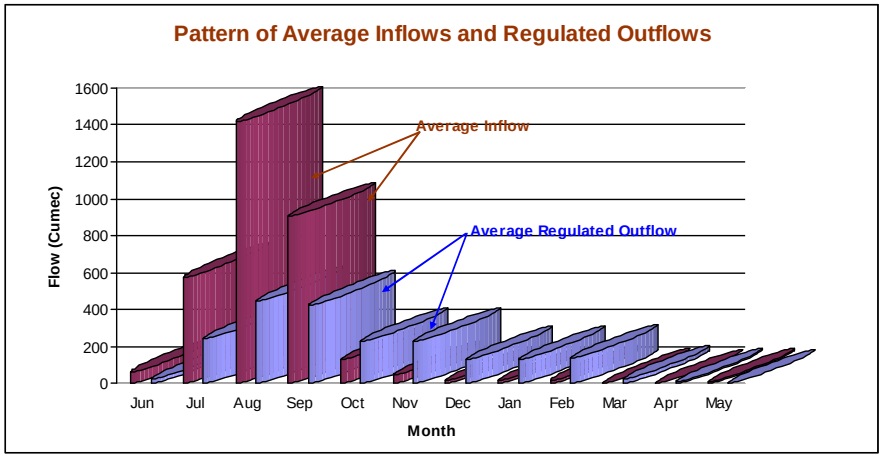
Table 5.16

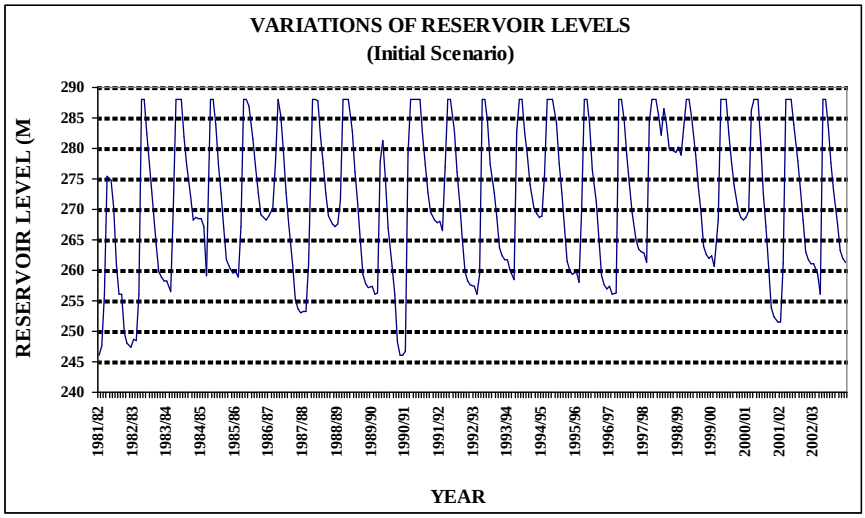
	PH-I	PH-II
Installed Capacity	60 MW	18 MW
Unit Size	30 MW	6 MW
Power House Discharge		
At Max. Head	131 cumecs	48 cumecs
At Min. Head	93 cumecs	35 cumecs
At Average Head	164 cumecs	61 cumecs
Annual Energy Benefits	188.5 MU	44.54 MU

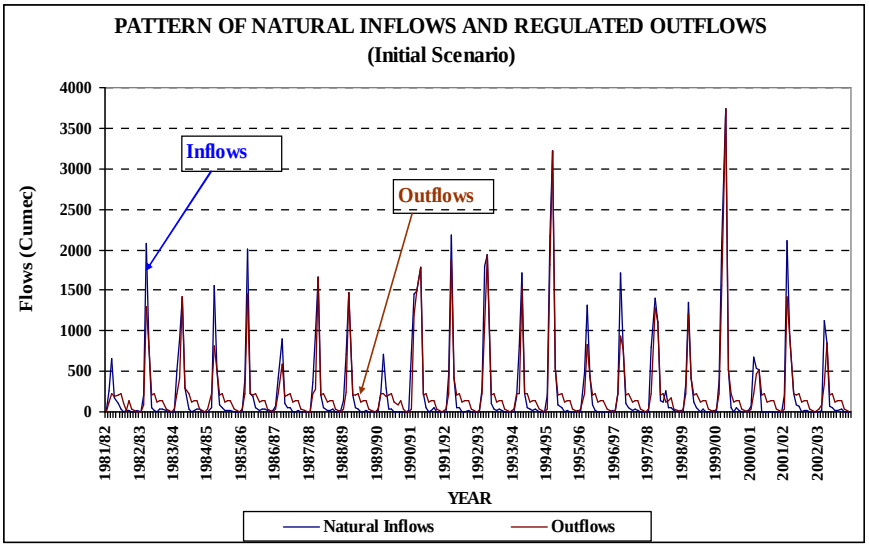
The detailed month-wise power study for the Initial scenarios of u/s

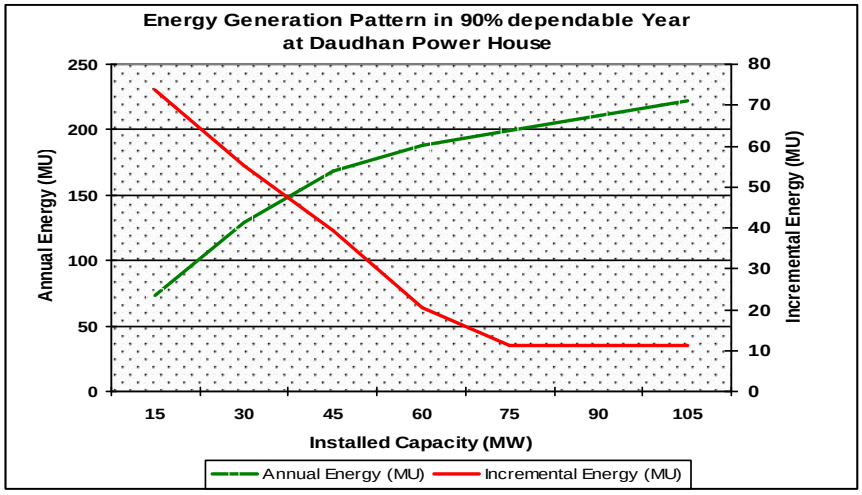
utilizations, corresponding to the installed capacity of 60 MW at PH-I and 18 MW at PH-II is given at Annexure 5.6.2 to 5.6.16.

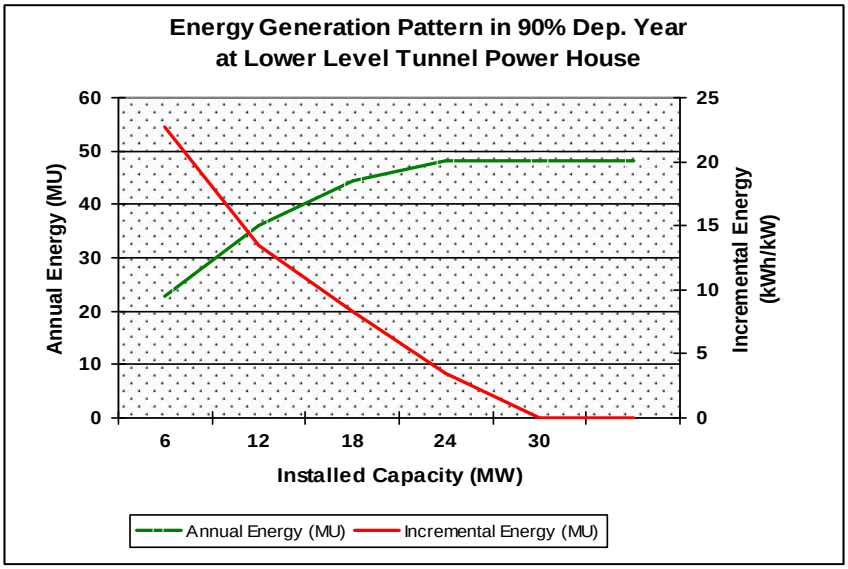
5.13.7 Graphical Analysis of Simulation Study

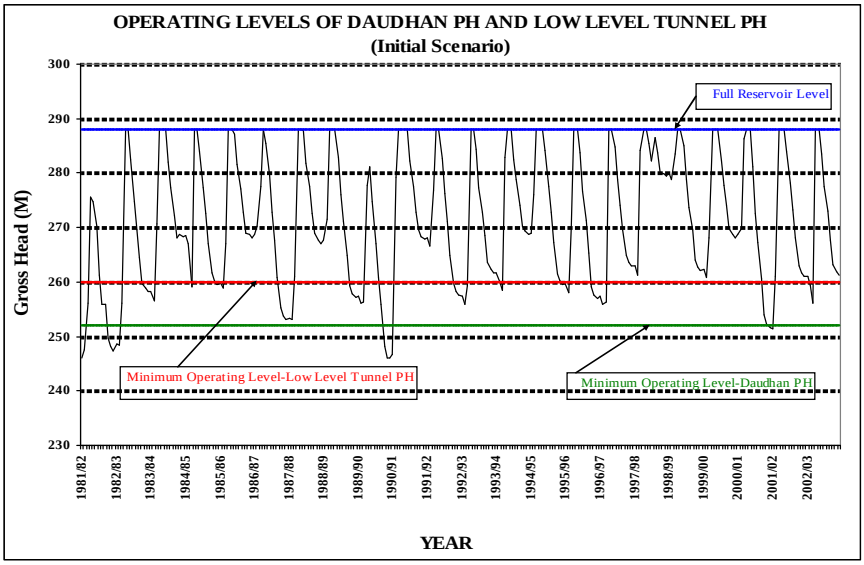







Energy Generation Pattern in 90% dependable Year
at Daudhan Power House
Annual Energy (MU)
Incremental Energy (MU)
Installed Capacity (MW)
Annual Energy (MU)
Incremental Energy (MU)


Energy Generation Pattern in 90% Dep. Year
at Lower Level Tunnel Power House
Annual Energy (MU)
Incremental Energy
(kWh/kW)
Installed Capacity (MW)
Annual Energy (MU)
Incremental Energy (MU)


OPERATING LEVELS OF DAUDHAN PH AND LOW LEVEL TUNNEL PH
(Initial Scenario)
Gross Head (M)
Full Reservoir Level
Minimum Operating Level-Low Level Tunnel PH
Minimum Operating Level-Daudhan PH
YEAR

5.13.8 Adequacy of Pondage at Gangau Weir

The elevation-capacity characteristics of Gangau Weir, as per the DPR prepared earlier, are given in Table 5.17.

Table 5.17

Elevation – Capacity of Gangau weir

Elevation (m)	Capacity (MCM)	Elevation (m)	Capacity (MCM)
211.0	0.000	226.0	3.003
214.0	0.077	229.0	5.236
217.0	0.231	232.0	8.624
220.0	0.539	235.0	14.630
223.0	1.386		

From the above, it is observed that, a pondage of about 5.0 MCM is available at Gangau Weir between the maximum and the minimum pond levels of 234.9 m (14.430 MCM) and of 232.4 m (9.425 MCM) respectively as per the FR prepared by NWDA in 1995.

The maximum discharge required for peaking at average head conditions would be 164 cumecs. As such, diurnal Pondage requirements for about 4 hours of peaking would be 2.36 MCM. Therefore, the Pondage available at Gangau Weir would be adequate to re-regulate the peak releases from the PH-I.

5.13.9 Impact of Flows in the Final Scenario

Simulation studies have been carried out for the Final Scenario of u/s utilizations.

Based on the simulation studies carried out for the Initial and the Final Scenario, the following observations are made :

Table 5.18

Sl. No.	Parameter	Initial Scenario	Final Scenario
1.	Average Inflows (Cumecs)		
	Annual	270.68	258.20
	Nov.-May	17.04	1.80
2.	Average Annual Utilisation (Cumecs)	169.6 (63.2%)	162.40 (62.9%)
3.	Average Annual Spills (Cumecs)	96.8 (33.1%)	93.4 (36.2%)
4.	Annual Energy Generation in 90% Dep. Year (MU)		
	PH-I	188.51 MU	158.32 MU
	PH-II	50.14 MU	41.10 U

5.13.10 Pumping Requirement for Ken-Betwa Link Canal

As already brought out above, it is proposed to have the three outlets from Daudhan Reservoir to cater to the irrigation and drinking water requirements etc. While the outlets for releasing water to Bariarpur through Ken River and for KMPP command through lower level tunnel are located much below the Draw Down Level of 246 m, the outlet for conveying waters to Barwa Sagar by means of Upper level tunnel/ Ken-Betwa Link Canal is located at a much higher level viz. 262 m.

As discussed above, during Initial Scenario of u/s utilizations, the reservoir shall be so operated as to obviate the need of pumping waters into Ken-Betwa Link Canal. It is, however, observed from the results of the simulation study for the Initial Scenario of u/s utilizations that the reservoir would fail to cater to irrigation and other requirements in some of the months.

Pumping is, therefore, not to be envisaged during the Initial Scenario of u/s utilizations. The same may be reviewed subsequently during Final Scenario of u/s utilizations.

5.13.11 Summary of the Study

Based on the studies carried out and the results of the Power Potential Study for Ken-Betwa Link Project are summarized in Table 5.19.

Table 5.19

Location & River	Across the Ken River near Daudhan Village in M.P., about 19 km from Chattarpur-Panna State Highway
Height of dam	about 77 m
FRL	288 m
Gross Storage at FRL (Daudhan)	2853 MCM
Draw Down Level for Power generation	
PH-I	252 m
PH-II	260 m
Draw Down Level Irrigation	
For releasing water to Bariarpur	
i) through PH-I	246 m
ii) through PH-II	
for KMPP Command	246 m

iii) through Ken-Betwa Link for Barwa Sagar	262 m	
Annual Average Inflow Data (Initial Scenario) Maximum Minimum Average Average Flows during July-Oct.	1981-82 to 2002-03 18113 MCM (year 1999-2000) 3443 MCM (year 1981-82) 8536 MCM 94.5 %	
Annual Average Inflow Data (Final Scenario) Maximum Minimum Average Average Flows during July-Oct.	1981-82 to 2002-03 17525 MCM (year 1999-2000) 2950 MCM (year 1981-82) 8142 MCM 98.3 %	
TWL PH-I PH-II	 234 m 246 m	
Operation of Power Station PH-I PH-II	 Peaking Operation Base Load Operation	
Gross Head	Max.	Min.
PH-I PH-II	54 m 42 m	18 m 14 m
Power House Discharge	PH-I	PH-II
At Max. Head At Min. Head At Average Head	131 cumec 93 cumec 164 cumec	48 cumec 35 cumec 61 cumec
Pondage Availability at Gangau Weir	About 5 MCM	
Unit Size & Installed Capacity PH-I PH-II	 2 x 30= 60 MW 3 x 6 = 18 MW	
Annual Energy Generation in 90% Dependable Year	Initial Scenario	Final Scenario
PH-I PH-II	188.51 MU 50.14 MU	158.32 MU 41.10 MU

5.14 Electrical & Mechanical Works

5.14.1 Introduction

The project is proposed to be located in the Panna and Chhatarpur districts of Madhya Pradesh. The dam site is situated in the Chhatarpur

district near the Daudhan village having latitude 24˚36'51" N and longitude 79˚50'30" E and is about 2.5 km u/s of the age old Gangau weir.

The climate in project area is semi-arid to dry sub-humid. It is generally tolerable except during the months of January, May and June. The air being mostly dry except during south west monsoon season. Summer is hot and winter is generally mild. About 90% of the annual rainfall is received during the monsoon period i.e. from June to October. The average maximum and minimum temperatures are 44.2 ^{0}C and 6.7 ^{0}C respectively.

The dam proposed at Daudhan is an earthen cum concrete dam with a side channel spillway with FRL & MWL as 288 m. The analysis of hydrology indicates that the annual runoff during the study period vary from a maximum of 18113 MCM (year 1999-2000) to a minimum of 3443 MCM (year 1981-82) with the average being 8536 MCM.

The PH-I is proposed to be located at the foot of the dam on the left bank of Ken river to the right of spill way whereas the PH-II is proposed to be located at the end of a 1.1 km long lower level tunnel on the left bank of Daudhan dam axis. The installed capacities of PH-I and II are 2 x 30 MW and 3 x 6 MW respectively.

From PH-II, a canal of length about 2.1 km is proposed to be connected to LBC of KMPP for providing irrigation to Ken command of Madhya Pradesh. An upper level tunnel of length about 2.0 km is also proposed from left bank of Daudhan dam itself and from the exit of it the Ken-Betwa Link canal of length about 118.0 km is proposed to run through Chhatarpur and Tikamgarh districts of Madhya Pradesh and part of Jhansi and Mahoba districts of Uttar Pradesh to provide irrigation and drinking water facility to the major towns/ villages in the enroute of the link.

5.14.2 Transportation Constraints

The nearest rail head to the Daudhan project site is Khajuraho from where well maintained National and State Highways are connected upto Bamitha which is about 28 km from the project site. In this reach, no low level bridges/bridges with travel restrictions exist. However, from Bamitha to the actual project site, the existing single lane roads/forest roads are to be suitably remodeled/ reconstructed to facilitate transportation of required heavy machineries. Alternate road connection from Chhatarpur to the project site via. Deogaon mod, Jhamtuli and Salaiya to the project site could also be used for transportation of the machineries by remodeling the road from Deogaon mod (on NH–76) to the project site. For both these alternatives, necessary provision has been made in the project estimates for remodelling /reconstruction.

5.14.3 Broad Scope of Works

5.14.3.1 PH-I (2x30=60 MW)

PH-I envisages an installation of 2 units, each of 30 MW in a surface power house. The scope of Electro Mechanical (E&M) works includes design, Engineering, Manufacture, Testing at Works, Supply, Transportation, Insurance, Handling, Storage at site, Erection, Service as broadly detailed below for commissioning of 2x30 MW generating units. The main equipment comprises of :-

- Two Vertical Shaft Kaplan Turbines & Main Inlet Valves of butterfly type complete with all unit auxiliaries like Governing System, Pressure oil System, High pressure and low pressure compressed air system, Grease Lubrication System, Oil Leakage Unit. Drainage & dewatering system etc.
- Two Hydro Generators, complete with Static Excitation System, Brake System, Brake Dust Collection, Lubrication Oil System, cooling water system, CO_2 System for fire protection of generator, etc.
- 11/132/$\sqrt{3}$ kV, 36.67 MVA, 3 phase, ONAF (Oil Natural air forced) cooled Generator Step-up Transformers; 11/0.415 kV, 630 kVA, 3 phase, ONAN (Oil natural air natural) cooled Station Auxiliary Transformers; 11/0.415 kV, 630 kVA, 3 phase, ONAN (Oil natural air natural) cooled Station Service Transformers and 11/0.415 kV, 500 kVA, 3 phase dry type Unit Auxiliary Transformers complete with all the accessories.
- 11 kV Isolated Phase Bus ducts for interconnection between Generator phase terminals & Generator Transformers along with terminal equipment for phase as well as for neutral side.
- SCADA system comprising of Computerized Control & Monitoring for the Main Plant, Electrical System & Plant Auxiliaries.
- 132 kV high voltage switchgear for outdoor switchyard
- Common Station Auxiliaries
- Relay & Protection System
- 415 V Station & Unit Auxiliary Supply System
- Station D.C. System comprising of 220 V DC batteries, Battery charging equipment and DC Distribution board
- Power, Control & Instrumentation Cables, Cables Trays, cable supporting racks, Hardware & fittings etc.
- Electric Overhead Travelling Crane for power house
- Elevator
- PLCC Equipment and Plant Communication System
- Earthing System
- Workshop Equipment (Common for both the power houses)
- Laboratory & Testing Equipment (Common for both the power houses)
- 500 kVA Diesel Generating Set for emergency supply

5.14.3.2 PH-II (3x6=18 MW)

PH-II envisages an installation of 3 units, each of 6 MW in a surface power house. The scope of EM works includes design, Engineering, Manufacture, Testing at Works, Supply, Transportation, Insurance, Handling, Storage at site, Erection, Service as broadly detailed below for commissioning of 3x6 MW generating units. The main equipment comprises of:-

- Three Vertical Shaft Kaplan Turbines & Main Inlet Valves of butterfly type complete with all unit auxiliaries like Governing System, Pressure oil System, High pressure and low pressure compressed air system, Grease Lubrication System, Oil Leakage Unit. Drainage & dewatering system etc.
- Three Hydro Generators, complete with Brushless Excitation System and AVR, Brake System, Brake Dust Collection, Lubrication Oil System, cooling water system, CO_2 System for fire protection of generator etc.
- 11/33 kV, 7.5 MVA, 3 phase, ONAF (Oil Natural Air forced) cooled Generator Step-up Transformers; 33/11 kV, 1600 kVA, 3 phase, ONAN (Oil natural, air natural) cooled step down Transformers; 11/0.415 kV, 630 KVA, 3 phase, ONAN cooled (dry type) station service transformer and 11/0.415 kV, 250 kVA, 3 phase dry type Unit Auxiliary Transformers complete with all the accessories.
- 11 kV segregated Phase Bus ducts for interconnection between Generator phase terminals & Generator Transformers along with terminal equipment for phase as well as for neutral side.
- SCADA system comprising of Computerized Control & Monitoring for the Main Plant, Electrical System & Plant Auxiliaries.
- 11 kV high voltage switchgear
- Common Station Auxiliaries
- Relay & Protection System
- 415 V Station & Unit Auxiliary Supply System
- Station D.C. System comprising of 220 V DC batteries, Battery charging equipment and DC Distribution board
- Power, Control & Instrumentation Cables, Cables Trays, cable supporting racks, Hardware & fittings etc.
- Electric Overhead Travelling Crane for power house
- Elevator
- PLCC and Plant Communication System
- Earthing System

- 250 KVA Diesel Generating Set for emergency supply

5.14.4 Selection of Parameters of Main Generating Units & Associated Equipment

Considering the reservoir and the tail water levels, the gross and net heads as assessed are as given in Table-5.20 below:-

a) Working Head Range:

Table 5.20

	PH–I (2x30=60 MW)		PH-II (3x6=18 MW)	
	Gross	Net	Gross	Net
Maximum	54.00 m	52.92 m	42.00 m	39.90 m
Minimum	18.00 m	17.28 m	14.00 m	12.88 m
Design	42.00 m	41.00 m	32.67 m	30.50 m

Kaplan type of turbine has been considered to be most suitable for operation over the above head range for both the powerhouses. The turbines shall be designed to develop continuous over load of 10% at design/ rated head and at higher heads.

The details of the hydraulic system of the generating units and basic data for design of turbines are given in Table 5.21.

Table 5.21

		PH -I	PH -II
	Installed Capacity	2x30=60MW	3x6=18 MW
	Reservoir Levels:		
a	Full Reservoir Level (FRL)	288.00 m	288.00 m
b	Minimum Draw Down Level (MDDL)	252.00 m	260.00 m
	Tail water levels:-		
a	Minimum tail water level	234.00 m	246.00 m
b	Maximum tail water level	234.00 m	246.00 m
c	Maximum flood water level	240.89 m	240.89 m
	Turbine operating range:-		
a	Maximum gross head	54.00 m	42.00 m
b	Minimum gross head	18.00 m	14.00 m
c	Average gross head	36.00 m	28.00 m
d	Maximum net head	52.92 m	32.67 m
e	Minimum net head	17.28 m	12.88 m
f	Design head	41.00 m	30.50 m

		PH -I	PH -II
	Turbine Discharge		
a	One unit discharge	82.75 m^3/sec.	22.30 m^3/sec
b	Total discharge	165.50 m^3/sec	66.90 m^3/sec
	Turbine Basic Data		
a	Generator Unit Rating	30 MW	6 MW
b	Turbine Rating	30612 KW	6122 KW
c	Overload capacity	33 MW	6.6 MW
d	Rated / Design head	41.00 m	30.50 m
e	Rated speed	214.29 rpm	300 rpm
f	Run-away speed	396.43 rpm	555 rpm
g	Specific speed	421.125	381.644
h	Discharge diameter (D_3)	3.40 m	2.00 m
i	Inlet diameter (D_1)	3.40 m	2.00 m
j	Spiral casing inlet diameter	4.0 m	2.40 m
k	Turbine setting	(-) 12.00 m	(-) 6 m
l	Turbine efficiency	0.92	0.92
m	Generator efficiency	0.98	0.98
n	Overall TG Efficiency	0.9016	0.9016
o	Centre line of the spiral casing	EL 222.00 m	EL 240 .00 m

Mechanical Characteristics

i)	Maximum speed rise on rated load rejection by all units simultaneously	50%
ii)	Maximum penstock pressure rise at rated load rejection by all units simultaneously	30%
iii)	Maximum cooling water temperature	20^0 C
iv)	Seismic forces	Corresponding to Zone-II

5.14.5 Electro-Mechanical Equipment

5.14.5.1 Turbines -Construction Aspects

The runner and other critical components of the turbine shall be of 13:4 stainless steel with high resistance to abrasion. For normal silt conditions and low heads i.e. heads less than 100 m, no special hard coating on the runner surface is considered necessary. However to attend to normal silt erosion and cavitations, pitting phenomenon, arrangement shall be provided for bottom removal of runner for easy maintenance and less time consuming operations for disassembly and reassembly.

The lower cone of the draft tube shall not be embedded in concrete to allow its dismantling for removal of runner and other components

downwards for maintenance and replacement. Adequate head room and space will be provided around draft tube for purpose of handling of the components. The dismantling part of the draft tube shall have the telescopic arrangement.

The turbine shaft shall be of forged carbon steel or alloy steel, which shall be connected to the runner on one side & to the generator on the other side. Suitable shaft gland of suitable material capable of sustaining of abrasive effect of silt for prevention of water leakage along the shaft shall be provided.

The spiral casing shall be fabricated from welded steel plates & shall have suitable sections for ease of transportation. The discharge through each turbine shall be regulated by set of guide vanes individually connected to the regulating ring through suitable levers and links. Shear pins shall be provided on each guide vanes to protect them against breaking during closing operation due to foreign body getting wedged in between the guide vanes. The guide vanes shall be operated by two double acting oil operated servomotors of adequate capacity.

A common system for Station Drainage & Draft Tube Dewatering shall be provided.

Turbine shall be provided with all standard set of instruments, gauges and safety devices.

5.14.5.2 Governing Equipment

Each Turbine shall be equipped with a digital speed governing system conforming to IEC 60308 to ensure control of speed under all conditions of loading. All the basic functions of the governor will have specific software. The console unit housing governor forward and feed-back command controls will be located at machine hall floor level alongwith unit control board panels. The governing system shall be complete with speed responsive temporary and permanent droop settings, load limiting devices, pressure systems etc. Each turbine will have separate oil pressure system with oil pumps, sump tank, pressure tank etc.

The governor shall regulate the Turbine Generator unit to a uniform speed free from hunting and instability and shall provide for stable operation in all stages or conditions of operation of the generating units.

High pressure oil hydraulic system with nitrogen filled piston type accumulator for turbine and MIV control shall be provided for PH-I only. The nitrogen filled piston type accumulator shall be provided with suitable number of N_2 bottles, safety relief and charging valve sufficient to operate the servomotors of turbine when the oil pumps are not operating. The

accumulator capacity shall be sufficient to cater the emergency shut down requirement.

Compressed air system will be used for governing system of PH-II.

5.14.5.3 Main Inlet Valve (MIV)

The Main Inlet Valve (Butterfly Type) having 4000 mm diameter for PH-I and 2400 mm diameter for PH –II is proposed to be provided for each turbine for shutting off pressure water supply from the Penstock to the Turbine, complete with necessary piping, control cabinet, u/s and d/s connecting pipes with companion flanges, dismantling joint, bypass, air valve, operating mechanism etc. The seals will be made of a material that has high resistance to silt erosion. The valve shall be so designed and constructed as to enable assembly of components at works and at the same time to permit easy transportation. The weights and sizes of the components/packages shall be within the permissible transport limits for the project site.

The Valve body and disc will be made of cast steel or fabricated from cast or fabricated steel components. The valve body will have a suitable base for mounting and supporting the Valve on a concrete foundation. The valve will be of Lattice Door Type.

The valve will be provided with u/s and d/s companion flanges of the full face bearing type along with necessary connecting pipe (valve inlet pipe) to match with the corresponding penstock at u/s and suitable pipe for connecting with the turbine spiral casing d/s of the valve. A dismantling cum-expansion joint will be provided with the butterfly valve on the d/s end to facilitate installation and dismantling of the valve. Necessary reducer piece of required length will be used for connecting penstock to the butterfly valve on the u/s side.

The Valve is operable by oil pressure from the OPU (common for Governing System and Butterfly Valve). The closing operation of the Valve will be by means of a counter weight and supplemented by oil pressure as an additional measure of safety.

5.14.5.4 Oil Pressure System for Governor and Turbine Inlet Valves

Each turbine shall be provided with a pressure oil system for operation of turbine wicket gates, servomotors through governors and the opening of MIV. The pressure oil system shall consist of oil sump tank, oil pumping unit, oil pressure accumulator (OPU), piping valve, fittings and switchgear for manual and automatic operation. The oil pressure unit shall have sufficient oil volume to meet all requirements of the governor guide vanes servomotors and Main Inlet Valve (MIV) servomotors.

5.14.6 Generator

i) The generator shall be vertical shaft synchronous machine with rated continuous output of 30 MW for PH-I and 6 MW for PH-II having the same rotational speed to match with that of the respective turbine.

The generator will have the following parameters:

Table 5.22

			PH - I	PH - II
a)	Rated capacity/output	:	30 MW	6 MW
b)	Overload Capacity	:	33 MW	6.6 MW
c)	Power factor	:	0.9 (lag)	0.9 (lag)
d)	Frequency	:	50 Hz	50 Hz
e)	Phases	:	Three	Three
f)	Rated speed	:	214.29 rpm	300 rpm
g)	Rated terminal voltage	:	11kV	11kV
h)	Range of Terminal voltage	:	(±)5%	(±)5%
i)	Range of Frequency	:	-5% to + 3%	-5% to + 3%
j)	Combined voltage and Frequency variations	:	± 5%	± 5%
k)	Bearing arrangement	:	Umbrella type	Umbrella type

ii) The generators will have an overload rating of about 10% of the name plate rating. Provision of this overload capacity is as per convention and will be useful during planned and forced outage of any of the units to complete partially as the capacity loss due to such outage.

iii) It is proposed to provide a three phase, 0.9 power factor salient pole type vertical shaft Synchronous Generator. The generator shall be provided with 10% continuous overload capacity to match the maximum turbine output. The generation voltage shall be 11 kV.

iv) The Generator stator & rotor windings shall be provided with Class F insulations but temperature rise at rated outputs shall be limited to that corresponding to class B insulation. The generator shall be provided with cooling system based on closed circuit air circulation principle. Generator phase terminals shall be brought out of barrel for connection to 11 kV Bus ducts. Generator neutral terminals shall also be brought out for formation of neutral. The neutral of the Generator shall be grounded through a distribution type transformer with secondary resistor.

v) For the rated as well as overload generator output, within the permissible operating conditions, the temperature rise limits of the stator and rotor windings will be restricted to correspond to Class 'B' insulation and the temperature limits will be as per prescribed Standards BIS/IEC.

vi) The combined thrust bearing and lower guide bearing shall be located below the rotor and with no upper guide bearing. The thrust bearing and its bracket shall be capable of carrying in addition to Generator loads, the maximum hydraulic thrust loads and weights of rotating parts of turbine.

vii) The Generator shall be capable of safely withstanding maximum stresses during normal operation, runway speed conditions, two phase and three phase short circuit conditions, single phase earth fault, out-of-phase synchronization, magnetic unbalance etc.

viii) The Generator shaft provided shall be made of the best quality forged carbon or alloy steel properly heat treated. The shaft shall be of ample size to operate at all speeds.

ix) The Generator coolers shall be frame mounted type with air coolers tubes made of Cupro-Nickel alloy. Each Generator shall be provided with pneumatically operated brakes of sufficient capacity.

x) Creep detector devices, vibration detectors, monitoring of moisture in bearing oil reservoir, dynamic monitoring of air gap etc. shall also be provided in addition to other required instruments.

xi) Water sprinkler system complete with water distribution mains, headers, detecting instruments, control instruments as required shall be provided for extinguishing the fire within the Generator.

xii) The generator shall be provided with twin circuit cooling water system. The primary cooling circuit shall be single pass and secondary cooling circuit shall be multi pass. The water for primary cooling circuit shall be pumped from tail race. The cooling system shall be having additional capacity to meet the cooling water requirements of the generator transformers.

xiii) Each generator shall be complete with ancillary items like lubrication oil system, heater, brake, brake dust collection system, CO_2 equipment for Fire fighting etc. Generator shall be provided with RTDs, thermostats & sensors, dial type thermometers for temperature monitoring of core, windings, pads, lubrication and cooling water system. Transducers for on-line condition monitoring, vibration monitoring, shaft current monitoring, stator winding,

partial discharge monitoring and rotor air gap monitoring system shall be provided.

Main parameters of generator have been calculated as per IS: 12800 (part 1) and result are given below:-.

Table: 5.23

			PH-I	PH-II
a)	Air Gap Diameter (D_g)	:	6600 mm	3300 mm
b)	Outer Core Diameter (D_o)	:	7400 mm	3800 mm
c)	Stator Frame Diameter (D_f)	:	8600 mm	5000 mm
d)	Inner Diameter of Generator Barrel	:	10600 mm	7000 mm
e)	Outer Diameter of Generator Barrel	:	11600 mm	8000 mm
f)	Core Length of Stator	:	600 mm	350 mm
g)	Length of Stator Frame	:	2200 mm	2000 mm
h)	Weight of Generator Rotor	:	90 ton	27 ton
i)	Proposed EOT crane capacity	:	100/30 ton	30/10 ton
Power House Dimensions				
a)	Unit spacing	:	20 m	16 m
b)	Power House Width (B Line to D Line)	:	22 m	19 m
c)	Length of Service Bay	:	20 m	24 m

5.14.7 Excitation System for Generator

5.14.7.1 For PH-I

i) The generators will be provided with static excitation system which shall have micro process based controls. The excitation equipment/system shall comprise of rectifier, excitation transformer, thyristors, field breaker with discharge resistor, field flashing circuit, automatic voltage regulator and protection and control devices along with accessories to make it a complete system. It will have features like rotor current limiter, stator current limiter, follow-up circuits, etc. for the entire range of operation.

ii) The excitation system shall be capable of operation at ceiling voltage for duration of one minute without damage. The ceiling voltage shall not be less than 1.8 times the rated load field voltage under the condition of rated load, rated voltage, rated frequency and rated power factor at 90 ^{0}C of field winding temperature. The forward gain and characteristics of frequency response shall be adjustable.

iii) The excitation system shall be capable of continuously supplying the maximum excitation power required to produce 110% of rated output, at rated generator voltage, Rated Power factor and 47.5 Hz to 51.5 Hz frequency etc. The short circuit ratio shall be greater than 1.0. The rating of the exciter shall be sufficient to maintain the nominal voltage even at 1.25 times rated current and rated power factor during short time duty.

iv) The excitation system shall be of a high initial response type. The excitation system voltage response time shall not exceed 0.5 seconds.

v) The Excitation System will by complete with Digital Voltage Regulator, a complete system for both manual and automatic Voltage Regulating, Excitation Control and Indication. All electronic devices such as amplifies and logic circuits shall be of solid state design, using integrated circuits. The AVR shall have fast response and anti hunting features. The AVR shall be provided with cross compensating devices for parallel operation of generators. The AVR shall initiate corrective action without hunting. The AVR shall be sensitive to the changes of +/-0.5% of normal voltage of the generator when operating under steady load conditions for any load or excitation within operating range.

5.14.7.2 For PH-II:

i) The generators will be provided with static excitation system (brushless type).The excitation system will be used to supply DC power to the field winding of the generator. Excitation system of the generator shall be provided by a brushless system. The excitation system shall be composed of rotating AC exciter, rotating diode bridge, excitation transformer and excitation control system etc. The system shall be complete with along with surge suppressor, automatic voltage regulator of solid state type with thyristor bridge and field suppression equipment etc.

ii) The number of Rectifier Bridge shall be so chosen that one bridge is always available as spare. The protection against voltage spikes shall be provided.

iii) The exciter shall be a synchronous generator with stationary poles and rotating armature. The voltage induced in the armature winding shall be rectified by semiconductor diodes rotating with the armature, and led to the field winding on the rotor of the main synchronous machine.

iv) The excitation system shall be of a high initial response type. The excitation system voltage response time shall not exceed 0.5 seconds.

v) The excitation system shall be capable of operation at ceiling voltage for a duration of one minute without damage. The ceiling voltage shall not be less than 1.8 times the rated load field voltage under the condition of rated load, rated voltage, rated frequency and rated power factor at 90 ^{0}C of field winding temperature. The forward gain and characteristics of frequency response shall be adjustable.

vi) Supply for initial excitation for Field Flashing will be obtained through 415V, 50Hz, 3-Phase Supply, or alternatively through 220V DC Supply.

vii) The Excitation System will be capable of continuously supplying the Maximum Excitation Power required to produce 110% of Rated Output, at Rated Generator Voltage, Rated Power Factor and 47.5 Hz Frequency, etc. The rating of the exciter shall be sufficient to maintain the nominal voltage even at 1.25 times rated current and rated power factor during short time duty.

viii) Power will be obtained through a 3-Phase, Self-cooled, Indoor, Metal-enclosed, Cast Dry Type Transformer connected to 11 kV Panels.

ix) The Excitation System will by complete with Digital Voltage Regulator, a complete system for both manual and automatic Voltage Regulating, Excitation Control and Indication. All electronic devices such as amplifies and logic circuits shall be of solid state design, using integrated circuits. The AVR shall have fast response and anti hunting features. The AVR shall be provided with cross compensating devices for parallel operation of generators. The AVR shall initiate corrective action without hunting. The AVR shall be sensitive to the changes of +/-0.5% of normal voltage of the generator when operating under steady load conditions for any load or excitation within operating range.

5.14.8 Control & Monitoring System

i) SCADA system comprising of Distributed Digital Control, Monitoring & Information System for the entire power plant & associated electro mechanical services covering the total functional requirement of control, sequence, interlocks & equipment protection, monitoring, feedbacks, system disturbance feedback etc. shall be incorporated.

ii) The control system shall be configured in mainly three control levels. The first level shall be station control level which comprises a

number of functional systems for supervisory control and man-machine communication. The second level shall be the local control level that comprises a number of functional groups such as units, switchyard, station service etc. The third level shall be the equipments such as governor, AVR etc. and mainly used for testing and adjustment.

iii) The station control level shall include functions for overall and centralised control of the station. Typical functions shall be supervision and monitoring of the machine conditions, recording the operation/faults and providing logs & operational information to assist the operators.

iv) The local control level shall be unit control board which shall be local control centre for overall sequence of operation. At start-up or shutdown, it will execute a set of sequence programmes. Based on process criteria, it shall generate commands for drive control of functional group for execution of programme. It shall check for presence of all required criteria before it shall issue a particular command. The execution time will also be monitored and if execution time exceeds the stipulated time limit, a trip or an alarm command shall be issued. It shall be possible to control the unit from unit control board in fully automatic mode, step by step mode and manual mode.

v) Equipment, control level shall have local control board/cubicle to control the equipment directly.

vi) The data transmission between station control level and local control level shall be accomplished by means of LAN with high speed large capacity data bus of optical fibre cables.

vii) A mimic bus diagram board shall be provided to depict the status and operational information of transmission lines, bus, generating units and station service circuits in real time and to operate equipment with functional switches. Dam water level indicators and recorders shall be furnished on this board.

viii) Whole system shall have a total redundancy in the main CPUs, programmable controllers of local control units, LAN system and power supply units. Even if one group has a severe failure, another back up group shall instantly succeed the operation without stoppage.

5.14.9 11 KV Bus Duct

i) 11 kV Isolated Phase Bus ducts for PH-I and segregated phase Bus Ducts for powerhouse –II conforming to IS: 8084 shall be provided with continuous current rating of 2000 Amperes for Phase-I and 400 Amperes for Phase-II respectively for the main Bus ducts connecting Generator Phase terminals to LV terminal of Generator Transformer. Bus duct shall be complete with continuous type Aluminium alloy enclosure, conductor supported on support insulator with self-aligning arrangement, wall frame assembly, seal

off bushing, flexible connections at termination points, Tap-off bus duct for connecting to Excitation Transformer, Unit-Auxiliary Transformer & LAVT cubicle. The normal current rating of the tap-off bus duct shall be 10% of the main bus ducts.

ii) The bus duct assembly shall be designed to withstand rated continuous current and required short circuit current without injury or permanent deformation of any part of the bus structure.

iii) Provision shall be made in each set of bus ducts for shorting links which shall be used for drying out of the equipment before commissioning or for carrying out the short circuit test on the equipment.

iv) Provision shall be made for removable links in the main run of neutral side of bus duct, at each tap-off connection i.e., LAVT cubicle, Excitation Transformer, Unit Auxiliary Transformer (UAT) etc.

v) Neutral Grounding Cubicle with Grounding Transformers & secondary resistor, LAVT Cubicle, and various CTs in the run off bus ducts as required for Metering & Protection of Generating unit shall be included in the scope.

5.14.10 Generator, Transformer & Other Transformers

The rating and other parameters are as given below:

Table 5.24

			PH -I	PH-II
a)	Type	:	three phase, core or shell type	three phase, core or shell type
b)	No. of transformers	:	2 Nos.	3 Nos.
c)	Rated output on all tappings (including 10% over load capacity)	:	36.67 MVA	7.5 MVA
d)	Voltage	:	HV Side 132 KV; LV Side 11 kV	HV Side 33 KV; LV Side 11 kV
e)	Rated frequency	:	50 Hz, -5% to + 3%	50 Hz, -5% to + 3%
f)	Type of cooling	:	ONAF	ONAF
g)	Cooling medium	:	Mineral oil	Mineral oil
h)	Tapping	:	Off Load Type	Off Load Type
i)	Earthing	:	HV neutral solidly earthed	HV neutral solidly earthed
j)	Installation	:	Outdoor on rails	Outdoor on rails

i) Two Nos. 36.67 MVA, 11/132 kV, Three Phase; Ynd11 Generator Transformers shall be installed for stepping up of generation voltage to 132 kV level for synchronization with the grid for PH No-I.

ii) Three Nos. 7.5 MVA, 11/33 kV, Three Phase; Ynd11 Generator Transformers shall be installed for stepping up of generation voltage to 33 kV level for synchronization with the grid for PH-II.

iii) The transformers shall be suitable for parallel operation. Off-Circuit Tap Changer shall be provided to correct the voltage imbalance in generation and grid voltage conditions. The transformers will be provided with necessary protective and monitoring devices including Buchholtz relay, oil temperature & winding temperature indicators, safety valve etc. The transformer shall conform to IS: 2026. The transformers shall be provided with EHV grade insulating oil conforming to IS : 335.

iv) Dry Type Indoor Transformers conforming to the IS : 11171 shall be fed through tap-off ducts from the Main Bus duct for meeting the power requirements of unit auxiliaries of each generating unit.

v) Provisions of 0.415 kV switchgear have been kept for catering the common Station Auxiliary Loads.

vi) 630 KVA, 11/0.415 kV, ONAN cooled Station service Transformer one each for powerhouse-I and II shall be provided to meet the power requirement of station auxiliaries as well as unit auxiliaries at the time of starting of the unit.

vii) 630 KVA, 11/0.415 kV, ONAN cooled, Station Auxiliary Transformer for powerhouse-I tap-off from the 11kV IPBD shall be provided to meet the power requirement of station auxiliaries as well as unit auxiliaries.

5.14.11 132 kV Switchyard (PH-I)

i) Generator power stepped up to 132 kV through generator step-up transformers shall be controlled at 132 kV switchyard comprising of circuit breakers, isolators, current transformers, post insulators, potential transformers and lightning arrestors etc. 132 kV incoming feeders from generator transformers in power house and outgoing feeders to transmission lines shall be connected to the 132 kV double bus with controlling switchgear elements for control and protection system

ii) Continuous and short circuit current rating of 132 kV system shall be 800 Amperes and 40 kA respectively. 132 kV switchyard package shall also include insulators and hardware, 132 kV conductors for bus and feeders, earth wire, galvanized steel structure for in-take and off-take gantries and equipment for switchyard like bay marshalling kiosks, cables and cable trays, lighting, switchyard equipment grounding etc shall also be included in the switchyard equipment package.

iii) The switchyard shall have provision for the following bays:

Incoming Feeders	2 Bays
Outgoing Feeders	2 Bays
Bus Coupler	1 Bay
Total no. of bays	5 Bays

iv) The switchyard is located adjoining to power house on the right hand side while looking towards d/s side. The 132 kV D/C lines are proposed to be constructed upto Khajurao from the switchyard.

v) The space requirement for 132 kV switchyard is assessed to be 70 m x 85.5 m. The required space for switchyard is available at the identified location of switchyard.

5.14.12 33 kV Switchyard – (PH-II)

i) Generator power stepped up to 33 kV through generator step-up transformers shall be controlled at 33 kV switchyard comprising of circuit breakers, isolators, current transformers, post insulators, potential transformers and lightning arrestors etc. 33 kV incoming feeders from generator transformers in power house and outgoing feeders to transmission lines shall be connected to the 33 kV Double bus with controlling switchgear elements for control and protection system.

ii) Continuous and short circuit current rating of the 33 kV system shall be 400 Amperes and 40 kA respectively. 33 kV switchyard package shall also include insulators and hardware, 33 kV conductors for bus and feeders, earth wire, galvanized steel structure for in-take and off-take gantries and equipment for switchyard like bay marshalling kiosks, cables and cable trays, lighting, switchyard equipment grounding etc shall also be included in the switchyard equipment package.

iii) The switchyard shall have provision for the following bays:

Incoming Feeders	3 Bays
Outgoing Feeders	3 Bays
Bus Coupler	1 Bay
Total no. of bays	7 Bays

iv) The switchyard is located adjoining to power house on the right hand side while looking towards d/s side.

v) The space requirement for 33 kV switchyard is assessed to be 60 m x 63 m. The required space for switchyard is available at the identified location of switchyard.

5.14.13 Fencing

The station fence properly grounded, covering the entire switchyard area with necessary warning, protection, gates and security shall be provided in the switchyard.

5.14.14 Power Evacuation

Power Evacuation from PH-I will be evacuated through 132 kV double circuit line from switchyard to proposed 132 kV S/Stn. at Khajuraho about 32 km from the project site.

Power Evacuation from PH-II will be evacuated through 33 kV double circuit line from switchyard to proposed 132/33 kV intermediate sub-station at Bamitha about 25 km from the project site.

The proposed power stations of this project are falling in dense forest area, therefore detail survey will be required including approval from concerned competent authority so that project can be connected to near by sub station by utilizing minimum/ escaping dense forest area.

5.14.15 Relay & Protection System (PH-I & II)

The electrical protection system for Generator, Generator Transformers, Bus bars and feeders shall be provided with numeric type integrated protection relays, with 100 % redundancy. The electrical protection shall be of modular design complete with software & MMI. It shall have facility to programme all settings on line & off-line. It shall have built in testing facility. The protection system shall be highly reliable & fully redundant. The protection system shall be designed and used for a fast and selective protection of generators, generator transformers and outgoing feeders with fast separation of faulted parts. Protection shall be covered by two completely independent current transformers, especially for Generator, Generator step up transformer, Bus bars and Transmission line feeders.

5.14.15.1 For PH-I

i) The following protection shall be provided for generating unit and step up transformers:

- 21G Generator phase fault impedance with timer
- Generator transformer winding temperature alarm and trip
- 26 T Generator transformer oil temperature alarm and trip
- Reverse power protection (37 a)
- Generator & turbine bearings temperature alarm and trip
- Generator Vibration alarm and trip
- Loss of field protection
- Negative phase sequence protection (46 a)

- 50/51 Generator over current instantaneous and time delay protection
- Over voltage protection instantaneous and time delay
- 27 Under voltage protection
- 59F Field over voltage protection
- Voltage transformer fuse protection
- Transformer Buchholz type gas protection
- 64 F Field ground fault protection
- 64 N1 100% stator ground fault protection (Time delay)
- 64 N2 90% stator ground fault protection
- 64 R Step up transformer restricted ground fault protection
- Bearing oil level alarm and trip
- 71 A Transformer oil level alarm and trip
- Transformer oil pressure protection
- 81 Frequency protection
- 87 G Generator differential protection
- 87 GT generator transformer differential protection
- Rotor excitation over current protection
- Shaft current protection
- Generator PT fuse failure protection (95 FF)
- Over fluxing cover excitation protection (97)
- Local breaker backup protection (50z)
- Inverse time over current protection (51 GT)

ii) The Following protection shall be provided for Unit Auxiliary Transformer:

- 50/51 Instantaneous and time over current protection
- 64 Earth fault protection
- 27 Under voltage protection
- 49 Transformer winding temperature alarm protection

iii) The Following protection shall be provided for Excitation Transformer:

- 50/51 Instantaneous and time over current protection
- 64 Earth fault protection
- 49 Transformer winding temperature alarm protection

iv) The Following protection shall be provided for 132 kV switchyard feeders- Generator feeders, Bus coupler and out going line feeders.

Generator feeders

- 50/51 over current protection
- 50 Z Local breaker failure protection

Bus Coupler bay

- 87 BB Bus bar differential protection
- 67/67 N Directional over current and earth protection
- 50 Z Local breaker failure protection
- CT wire supervision

Outgoing feeders

- 21 Distance relay protection for short lines
- Directional over current and earth fault protection
- 50 Z Local breaker failure protection
- Out of step blocking protection
- 59 Over voltage protection instantaneous and time delay
- Auto reclose single phase and three phase protection
- Fault locators
- Fuse failure protection
- Bus PT selection scheme
- Any other protection as required.

Electrical transducers for conversion to digital signals of important electrical parameters like voltage, current, frequency, active power, reactive power etc. of generating units, station auxiliaries and outgoing feeders shall be provided.

5.14.15.2 For PH-II

i) The following protection shall be provided for generating unit and step up transformers:

- 21G Generator phase fault impedance with timer
- Loss of field protection
- Negative phase sequence protection (46 a)
- 50/51 Generator over current instantaneous and time delay protection
- Over voltage protection instantaneous and time delay
- 27 Under voltage protection
- 64 F Field ground fault protection
- 64 R Step up transformer restricted ground fault protection
- 81 Frequency protection
- 87 G Generator differential protection
- 87 GT generator transformer differential protection
- Generator PT fuse failure protection (95 FF)
- Over fluxing cover excitation protection (97)
- Local breaker backup protection (50z)
- Inverse time over current protection (51 GT)

ii) The Following protection shall be provided for Unit Auxiliary Transformer:

- 50/51 Instantaneous and time over current protection
- 64 Earth fault protection
- 27 Under voltage protection
- 49 Transformer winding temperature alarm protection

iii) The Following protection shall be provided for Excitation Transformer:

- 50/51 Instantaneous and time over current protection
- 64 Earth fault protection
- 49 Transformer winding temperature alarm protection

iv) The Following protection shall be provided 33 kV switchyard feeders- Generator feeders, Step down transformer feeders, Bus coupler and out going line feeders.

Generator feeders

- 50/51 over current protection
- 50 Z Local breaker failure protection

Step Down Transformer feeder

- 87 ST Transformer differential
- 50/51 over current protection
- 50Z Local breaker failure protection

Bus Coupler bay

- 87 BB Bus bar differential protection
- 67/67 N Directional over current and earth protection
- 50 Z Local breaker failure protection
- CT wire supervision

Outgoing feeders

- 21 Distance relay protection for short lines
- Out of step blocking protection
- 59 Over voltage protection instantaneous and time delay
- Fuse failure protection
- Bus PT selection scheme
- Any other protection as required.

Electrical transducers for conversion to digital signals of important electrical parameters like voltage, current, frequency, active power, reactive power etc. of generating units, station auxiliaries and outgoing feeders shall be provided.

The electrical protection shall be grouped under following groups.

(i) Non-electrical lock-out faults, controlled action shutdown

The mechanical faults like turbine & generator bearing temperature “high”, originating from turbine & generator side are covered under this group. It will be ensured that tripping of 132 kV breakers of affected generator feeders is delayed till the turbine wicket gates reach no load opening position.

(ii) Urgent electrical lockout faults.

All urgent electrical faults shall initiate simultaneous tripping of 132 kV and 33 kV circuit breakers along with shutdown of the turbine. Faults like differential protection, stator earth fault protection overall differential protection, generator transformer HV restricted earth fault, transformer buchholz protection etc. are covered under this group.

The governor failure faults and machine over speed faults originating from unit side are also covered under this group.

The manual emergency shutdown of the machine shall be also be effected under this group.

(iii) Electrical non lockout failure

The faults like negative phase sequence, generator impedance back up etc., shall be covered under like group and shall trip 132 kV and 33 kV breaker and UAB breaker without shutdown of turbine/generator.

5.14.16 Auxiliary Equipment/System

5.14.16.1 Electrical Auxiliaries

i) Station Service & Unit Auxiliary Supply (LT System)

For PH-I

415 V Switchboards with adequate no of feeders complete with Air / moulded case Circuit Breakers, Bus bars etc shall be installed in the

power house for feeding the unit and station auxiliaries without any interruption under conditions. It shall conform to the requirement of IS: 13947.

630 kVA, 11/0.415 kV Station auxiliary Transformer shall be provided to feed station auxiliaries. This transformer shall be fed from 11 kV bus-ducts. The power requirement for start up of the generating units as well as essential station service requirement shall be met from either outside source available at 11 kV in the Power house-II through one no. 11/0.433 kV, 630 KVA step down station service transformer or by 500 KVA DG set in the 132 kV switchyard.

Two numbers Unit auxiliary transformer, each of 500 kVA, 11/.433 kV, shall be provided to feed unit auxiliaries. During start up of unit, unit auxiliaries shall be initially supplied from station service board. After build up of voltage at generator terminals, supply of unit auxiliary board from station service source shall be disconnected and supply to unit auxiliary board shall be started from unit auxiliary transformers. The scheme of change over of supply to unit auxiliary board shall be completely automatic and various interlocks in the schemes shall be provided to prevent change over during fault conditions. Also paralleling supplies shall be avoided.

The unit auxiliary and station service distribution boards shall have draw out type Air breakers as incomer breakers and MCCBs for outgoing feeder breakers. The short circuit rating of all breakers shall be 50 kA.

For PH-II

415 V Switchboards with adequate no of feeders complete with Air / moulded case Circuit Breakers, Bus bars etc shall be installed in the power house for feeding the unit and station auxiliaries without any interruption under conditions. It shall conform to the requirement of IS : 13947.

630 kVA, 11/0.415 kV shall be provided to feed station auxiliaries and unit auxiliaries as well as during start up of generating unit. These transformers shall be fed from 11 kV bus which shall be fed from 1600 KVA, 33/11 kV step down transformer or through an outside source at 1 kV bus. The supplies from 33/11 kV step down transformer and from outside source shall be suitably inter locked..

Three numbers Unit auxiliary transformer, each of 500 kVA, 11/.433 kV, shall be provided to feed unit auxiliaries. During start up of unit, unit auxiliaries shall be initially supplied from station service board. After build up of voltage at generator terminals, supply of unit auxiliary board from station service source shall be disconnected and supply to unit auxiliary board shall be started from unit auxiliary transformers. The scheme of change over of supply to unit auxiliary board shall be completely automatic and various

interlocks in the schemes shall be provided to prevent change over during fault conditions. Also paralleling supplies shall be avoided.

The unit auxiliary and station service distribution boards shall have draw out type Air breakers as incomer breakers and MCCBs for outgoing feeder breakers. The short circuit rating of all breakers shall be 50 kA.

ii) DC Supply System

The D.C. supply system comprise of two sets of 800 AH, 220 V DC batteries for PH-I and two sets of 400 AH, 220 V DC batteries for PH-II. Each set having provision of main and standby chargers, other control equipment, and independent DC distribution boards. These two sets of batteries shall be used for control/protection functions and also field flashing/emergency functions. There will be a separate 48 V, DC system for communication requirement etc. for both the powerhouses.

iii) Emergency Diesel Generator Supply System

500 kVA Diesel Generating Set for PH-I and 250 kVA Diesel Generating Set for PH-II capable of continuously delivering net output under site conditions at 0.8 lagging power factor, 415 V, 3 phase, 50 Hz shall be installed in the switchyard for emergency in the event of failure of station AC supply. The diesel generating set shall be complete with 4 stroke Diesel Engine, Alternator complete with accessories like flywheel, lubrication oil system, governor, air clearances, AVR, AMF panel & all electro mechanical protection & metering equipped with following machine tools. This power shall also be used to operate station drainage pumps under normal and emergency conditions.

iv) Grounding Mat

The grounding system of the power house shall be provided to establish a common low resistance reference with respect to ground for all parts of the project. The resistance with respect to earth shall be as low as practicable. The configuration and extent shall be such as to provide safe step and touch potentials within each area and to avoid harmful differences in potentials between one location and another, within the project area. The earth mat system shall extend to the penstock/ tailrace area, if required.

The powerhouse and switchyard areas would be provided with separate main ground mats and both the mats will be inter-connected by grounding strips to lower the earth resistance. All non-current carrying equipment in the powerhouse and switchyard shall be grounded separately and connected to main ground mats.

All the independent ground mats shall be of mild steel flat conductor having suitable cross section. M.S. grounding electrode rods of

suitable size will also be required to be driven into the ground and connected to the ground mats. Grounding leads (risers) will be taken to each of the power house floors for earthing of various electrical equipments.

The grounding system shall be designed with the following objective:-

(i) To provide low impedance path of fault currents to ensure prompt and consistent operation of protective devices during ground faults.
(ii) To keep the maximum voltage gradient along the surface inside and around the project complex with in safe limits during ground faults.
(iii) To protect the life and property from over voltage.
(iv) Safe touch and step voltages
(v) Short Circuit, Earth Fault and Double Earth Fault Currents will flow through the Earthing System and not through other conducting parts to a hazardous extent.

v) Illumination of Plant

The illumination system would comprise interior and exterior lights as appropriate for the entire power house area, switchyard area and at dam site. A separate emergency lighting system fed from the station battery system would be provided for all essential locations of the power house and switchyard.

All the fitting, luminaries, conduits, wires fixture etc. shall be of reputed make conforming to relevant IS codes. Indoor illumination scheme shall have mainly twin tube light fitting and high pressure mercury vapour lamps. Emergency D.C. lamps shall also be provided in machine hall, control room and areas of strategic importance.

Outdoor illumination shall be accomplished through sodium vapour lamps, mercury vapour lamps and fluorescent tubes. Power & light convenience outlets shall be provided at various locations in power house, service bay, control room, auxiliary floors. Industrial type, 3 phase convenience outlets shall also be provided at various locations.

vi) PLCC and Plant Communication Equipment

PLCC equipment for the powerhouse will provide line protection, communication, telemetry and remote control. Independent carrier channels will be provided for relaying, voice communication, computer communication, and telemetry functions. Matching equipment to cater to these functions shall also to be provided at the receiving end substation. Communication system for powerhouse, switchyard area and dam site will consist of internal

telephone system and paging system. Paging system includes public address system and visual display unit (VDU).

vii) Electrical laboratory Testing Equipment

A testing laboratory shall be maintained in the power house for testing of various electrical & mechanical equipment and installations. The Laboratory shall be equipped with testing & measuring instruments like Megger, HV Test kit, Kelvin bridges current Injection set, oil testing kit etc. This laboratory is located at power house No.-I and utilized by both the power houses.

viii) Power, Control & Instrumentation Cables & Cable Trays ETC

1.1 kV Grade PVC insulated un-armoured Aluminium Power Cables shall be used inside the power house while for control cables 1.1 kV Grade PVC insulated unarmoured copper cables conforming to IS : 1554 shall be employed. The control and 220V DC cables shall be fire retardant low smoke (FRLS) type having copper conductor. The power cables to be used outdoor shall be of armoured type. Instrumentation Cables including Fiber Optic Cables immune to electromagnetic interference shall be included in the scope. All the accessories like Cable glands, Ferrules, Cables Trays, Conduits of adequate sizes as required for the installation of Cables shall be include.

5.14.16.2 Mechanical Auxiliaries

i) EOT Cranes

The heaviest equipment/assembly required to be lifted in the power house by the EOT crane will be the assembled generator rotor. For the 30 MW generating unit, the assembled rotor weight is expected to be of the order of 90 tonnes. To lift this weight one crane with a capacity of 100/30 tonnes has been considered.

For the 6 MW generating unit, the assembled rotor weight is expected to be of the order of 25 tonnes. To lift this weight, one crane with a capacity of 30/10 tonnes has been considered

All the crane shall be cabin controlled. The crane shall provide with all accessories including runway rails, down shop leads, bumpers etc. The crane shall conform to IS: 3177. The inching operation shall be provided for the motions of the crane.

Separate trolley type gantry crane of 15 T capacity shall be provided to operate all the draft tube gates at tail race side for both the powerhouses.

The capacities of all the cranes will be reviewed during detailed engineering stage.

ii) Elevator

The PH -I shall be equipped with 1 (one) number elevator with sufficient capacity to transport 13 persons and/or material between various floors of the power house. The elevator shall be driven by an electric hoisting machine to the traction type complete with motor, brake, gearing, drive sheave and driving shaft etc. the elevator shall be provided with smooth speed control. One number elevator of the same capacity shall be provided at dam site also.

iii) Cooling Water Scheme

Cooling water system shall be provided for cooling of each generating unit. The cooling water system shall supply the water to turbine guide bearings, turbine shaft seal, governor/MIV oil sump tanks, generators, generator air coolers, generator thrust bearings, generator guide bearings, generator-transformers, ventilation and air conditioning system etc. Clear water for turbine shaft seal to be provided separately.

The water requirement for cooling water system to be tapped from the each unit of the draft tube by employing three number of pumps (Two pumps as main and other as stand by) having a common header. The pumps shall be suitable to install either in wet pit or in the dry pit (amphibious installation). The pumps shall have sufficient capacity for circulating the water in the cooling water system of the Generating Unit and Generator Transformer and the return water from the various coolers will be discharged into the tailrace above flood water level. Necessary strainers, valves, pressure gauges and pressure switches, temperature switches shall be provided. Alternately, tapping of penstocks may also be considered during detailed engineering.

iv) Compressed Air System

PH-I

The compressed air system shall consist of a low pressure compressed air system. The low pressure compressed air system shall meet the requirement of the complete power house for intermittent supply of air to cater the needs of generator brakes, bus ducts and other station service requirements. Two numbers of compressors (one main + one standby) have been proposed to cater to the requirements of the units. The capacity of the

compressor shall be adequate to cater the above needs of complete power house. All necessary piping, fittings, pipe supports, adequate number of isolating valves, non-return valve, etc. shall be provided.

PH-II

The compressed air system shall consist of a low pressure compressed air system. The low pressure compressed air system shall meet the requirement of the complete power house for intermittent supply of air to cater the needs of generator brakes, bus ducts and other station service requirements. Three numbers of compressors (two main + one standby) have been proposed to cater to the requirements of all the three units. The capacity of each compressor shall be adequate to cater the above needs of complete power house including the requirement for governing system of turbine and MIVs. All necessary piping, fittings, pipe supports, adequate number of isolating valves, non-return valve, etc. shall be provided.

v) Station Drainage System and Dewatering System.

For dewatering of any unit (penstock and draft tube), to access for inspection and maintenance, a separate common dewatering sump with two numbers submersible slurry pumps (one main & other standby) have been provided. In the first instance, the water from the penstock will be drained down by gravity into the tail pool via the draft tube up to the tail water level. The remaining water will be drained into the sump through dewatering pipes and header (complete with control valves) and simultaneously pumped out to tail race under manual control/ auto control etc.

Station drainage system will be provided to cater to any water leakages/drains from plant and equipments such as turbine top covers, shaft seals (glands) outlet water, leakages from compressors (cooling water), pump glands, seepages into power house from surroundings, discharges from sinks, wash basins etc. All such water will be led to drain through pipes and surface drain (by gravity) into the drainage/dewatering gallery below the draft tube level. From there, the water will be led to the station drainage sump and regularly pumped out by submersible pumps to the tailrace. The equipment will comprise of two nos. submersible pumps (one main & other standby) complete with the valves, piping controls & annunciation etc.

Both the pits are inter-connected with all necessary pipes, valves and fittings.

vi) Ventilation & Air Conditioning System

The ventilation system shall be sized and configured to provide sufficient air circulation as well as temperature and humidity control

throughout the main power house for the satisfactory operation of the equipment and personnel. Temperature shall be controlled by means of air to water heat exchangers. Smoke evacuation system shall be provided. Control room and shift engineer rooms will be air conditioned with suitable package type air conditioning units. No centralized air conditioning is envisaged. Air handing units will play main role in the system. The water requirement will be fulfilled through the overhead water tank.

vii) Fire detection and Fire Protection Systems

Fire protection system for power house shall be planned to timely detect the occurrence of fire & quick extinguishing of fire when it breaks and to prevent the spread of fire so as to minimize the extent of damage.

A microprocessor based Fire Alarm/Detection System completes with all accessories shall be provided for audio/visual annunciation of fire.

A storage tank of adequate capacity shall be provided at a higher elevation at out side the powerhouse for storage of Fire protection water which shall be supplied by gravity on occurrence of fire. Water can be tapped from the river or any other source of water available there and pumped to overhead tank by amphibious type pumps through automatic strainers.

Automatic High Velocity Water Spray System for Generator and Station Transformers, low and medium pressure fire hydrant system for Power Station, fire hydrants etc including piping systems with hydrant valves and fire hose cabinets at number of strategic points at all the floors. Necessary isolating and non return valves, pressure gauges, pressure switches and temperature sensors shall be provided.

Portable fire extinguishers shall also be provided at strategic points at all the floors of the power house/transformers area to control the fire in initial stage such as hand portable CO_2 extinguisher and portable foam type chemical extinguisher. Wheeled portable foam type chemical extinguisher shall be provided where ever necessary.

Separate fire protection system shall be provided for 132 kV and 33 kV outdoor switchyard.

viii) Mechanical work shop and Workshop Equipment

A Mechanical workshop shall be provided in the machine hall floor of PH-I with all latest equipments, lathe machines and machine tools etc., as required, to carry out normal repair and O&M of various electro- mechanical equipments. The work shop shall be common for the both the power houses. The workshop shall be equipped with following machine tools. This workshop is located at PH-I and utilized by both the power houses.

(a) Lathe Machine

(b) Welding sets
(c) Grinding sets
(d) Power Hacksaw
(e) Drilling machine etc.

ix) Oil Handling System for lubricating & insulation oil

It is proposed not to provide full capacity oil storage and pumping system for lubrication and insulation oils in the power house. This is to eliminate any potential fire hazards. Only a portable oil purifier will be kept in service bay for treating lubricating and insulation oils. The spare oil shall be stocked in drums at stores located away from power house.

x) Potable Water System

Potable and sanitation service water will be provided for the power house. The system will comprise of pumps, pressure filters, chemical treatment units, storage and distribution piping.

5.14.17 Construction Power

The construction power for this project can be taken from 11kV Ranguwan feeder radiated from 33/11 kV Bamitha sub station which is 7 km from Bhusour Village. The project site from Bamitha sub station is about 25 km.

5.14.18 Estimates for Electrical and Mechanical works

The estimates for electrical and mechanical works of Power House of Ken-Betwa Link Project (2x30 MW + 3x6 MW) have been worked out on the basis of prevailing rates of similar equipment and works are given separately for both the powerhouses as Annexures 5.7 & 5.8, 5.7.1 to 5.7.5 & 5.8, 5.8.1 to 5.8.5.

5.14.19 Drawings

The following drawings forming part of the DPR and pertaining to general layout plan, cross-section of power house incorporating layout details of major equipments, power house layout plans at various floors, switchyard layout and single line diagram are appended as Plate no 5.1 to 5.23 in Drawing Volume-II B.

	PH-I (2x30 MW)		
Sl.No.	Description of Drawing	Drawing Nos.	Plate nos
1	General Layout plan.	1252-CEA-HE&RM- KB-DPR-01	5.1
2	Power House Cross Section	1252-CEA-HE&RM- KB - DPR-02	5.2
3	Power House Generator floor layout at EL 229.00 m	1252-CEA-HE&RM- KB - DPR-03	5.3
4	Power House Turbine floor layout at EL 225.00 m	1252-CEA-HE&RM- KB - DPR-04	5.4
5	Power House MIV floor layout at EL 218.00 m	1252-CEA-HE&RM- KB - DPR-05	5.5
6	Power house Machine Hall & Service bay layout at EL 233.00 m	1252-CEA-HE&RM- KB - DPR-06	5.6
7	Power House Control room layout at EL 238.00 m	1252-CEA-HE&RM- KB - DPR-07	5.7
8	Power House Auxiliary Bay and Transformer deck layout at EL 243.00 m	1252-CEA-HE&RM- KB - DPR-08	5.8
9	Power House L-Section through Center line of the Units	1252-CEA-HE&RM- KB - DPR-09	5.9
10	Single Line Diagram (for PH-I and PH-II)	1252-CEA-HE&RM- KB - DPR-10	5.10
11	Layout Plan of 132 kV Switchyard & Sections	1252-CEA-HE&RM- KB - DPR-11	5.11
12	Layout Plan of 33 kV Switchyard & Sections	1252-CEA-HE&RM- KB -DPR	5.12

	PH-II (3x6 MW)		
Sl.No.	Description of Drawing	Drawing Nos.	Plate nos
1.	General Layout plan.	1252-CEA-HE&RM- KB-DPR-01	5.13
2.	Power House Cross Section	1252-CEA-HE&RM- KB - DPR-02	5.14
3.	Layout Plan at Generator floor	1252-CEA-HE&RM- KB - DPR-03	5.15
4.	Layout Plan at Turbine Floor	1252-CEA-HE&RM- KB - DPR-04	5.16
5.	Layout Plan at MIV Floor	1252-CEA-HE&RM- KB - DPR-05	5.17
6.	Layout Plan at auxiliary bay	1252-CEA-HE&RM- KB - DPR-06	5.18
7.	Layout Plan at control room	1252-CEA-HE&RM- KB - DPR-07	5.19
8.	Layout Plan at Transformer deck	1252-CEA-HE&RM- KB - DPR-08	5.20
9.	L-Section of the power house	1252-CEA-HE&RM- KB - DPR-09	5.21
10.	Single Line Diagram	1252-CEA-HE&RM- KB - DPR-10	5.22
11.	Layout Plan of 33 kV Switchyard	1252-CEA-HE&RM- KB - DPR-11	5.23

These drawings are placed in Drawing Volume.

Note: The description for common system for both the power houses have been given and wherever the system requires independently, the same is described separately for both the power houses.

CHAPTER-VI
IRRIGATION PLANNING & COMMAND AREA DEVELOPMENT

CHAPTER - VI

IRRIGATION PLANNING AND COMMAND AREA DEVELOPMENT

6.1 Existing/proposed irrigation facilities in the proposed project command area

There are three commands under Phase–I of the Ken-Betwa Link Project viz.,

(i) Enroute command
(ii) Ken command of MP
(iii) Ken command of UP

6.1.1 Enroute Command

There are quite a few existing irrigation Tanks and one proposed scheme namely Issanagar Ranipur in the enroute command of Ken-Betwa Link canal. The particulars of these projects are given in Table-6.1.

Table – 6.1
Irrigation facilities from existing and proposed projects

S. No.	District/ Tehsil	Source of irrigation	Irrigated area (ha)	Water use in (MCM)	
	Existing			Kharif	Rabi
1	Chhatarpur	Moti Sagar Tal	405	0.515	0.718
		Issa Nagar Tank	506	0.656	0.915
		Gora Tal	1295	1.648	2.296
		Amkhera Tal	40	0.05	0.07
		Nand gaon Tank	121	0.154	0.214
		Sailab Tal	121	0.154	0.214
	Nowgong	Jagat Sagar canal	186	0.176	0.414
		Naigawan	49	0.046	0.109
		Macha Bandhi	49	0.046	0.109
2	Tikamgarh				
	Jatara	Chhidari Tank	72	0.103	0.115
		Dhanera Tal	93	0.131	0.147
		Dharam Sagar	1984	2.80	3.137
		Purenia	134	0.189	0.211
		Ram Nagar Tal	81	0.114	0.128
	Tikamgarh	Tehar ka Tal	184	0.275	0.270
		Total	2549		
	Proposed				
3	Chhatarpur	Issanagar Ranipur	57	N.A.	N.A.

6.1.2 Ken Command in MP

There are quite a few existing major, medium and minor irrigation schemes in the command. The particulars of these schemes pertaining to MP part are given in Table-6.2.

Table – 6.2

Existing irrigation facilities in Ken command (MP portion)

Name of district	Name of tehsil	Name & source of irrigation	Irrigated area (ha)	Water Use in (MCM)
Chhatarpur	Chhatarpur	Nawalgarh Regulator	101.20	0.792
Chhatarpur	Laundi	Manariya Tank	111.33	0.877
Chhatarpur	Laundi	Luharuk Anicut	161.90	1.245
Chhatarpur	Laundi	Sohai Anicut	80.90	0.622
Chhatarpur	Chhatarpur	Pathargawan Regulator	101.20	0.792
Chhatarpur	Chhatarpur	Beniganj Dam	5708.50	18.253
Chhatarpur	Chhatarpur	Rangawan Dam	18727.00	56.600
Chhatarpur	Laundi	Bamhori purwa	303.60	2.348
Chhatarpur	Chhatarpur	Boodha Dam	607.30	N.A.
	Total		25902.93	81.529

6.1.3 Ken Command in UP

The details of area irrigated by existing projects in Ken command of Uttar Pradesh portion are given in Table- 6.3.

Table 6.3

Details of areas irrigated by existing projects in Ken basin (UP portion)

S No.	Name of district	Name of project	Area irrigated (ha)	Water use in MCM
1.	Banda	Bariarpur PUW/Gangau dam (existing)	65000	390.00
2.	Mahoba	Arjun Dam (existing)	9501	49.48
3.	Mahoba	Maudha dam (existing)	27690	140.20
		Sub-total	1,02,191	579.68
4.	Hamirpur	Charkhari dam (proposed)	21282	6.46
5.	Mahoba	Arjun sahayak pariyojana (proposed)	31837	264.42
		Sub-total	53,119	270.88
		Grand total	1,55,310	850.56

This is to mention here that the command area of Right Bank Canal of Bariarpur PUW is 2,16,466 ha out of which 2856 ha in the beginning falls in Madhya Pradesh whereas rest area falls in Banda district of Uttar Pradesh. Further out of this, only 87754 ha area is being irrigated through its 1074.13 km long canal net work due to less availability of water.

6.2 Existing cropping pattern

Details of existing cropping pattern & rain-fed cultivation are furnished in the following paras.

6.2.1 Existing area under rain-fed cultivation

6.2.1.1 Rainfall during monsoon (Max, Min & Normal rainfall)

Based on the statistical record from 1987 to 1991, it has been observed that the annual normal rainfalls in the districts of Chhatarpur, Panna and Tikamgarh are between 700 mm to 1200 mm and during monsoon the average annual rainfall is around 950 mm in Chhatarpur and Tikamgarh districts. As per the same statistics, the numbers of rainy days in monsoon are 40 in case of both the districts. Maximum rainfall occurs in the month of July during monsoon, which is of the order of 1400 mm and the minimum rainfall in the month of June is of the order of 50 mm.

6.2.1.2 Rainfall during non-monsoon (Max. Min & Normal rainfall)

Very little rainfall occurs during the period from October to March in the districts of Chhatarpur and Tikamgarh. The average monthly rainfall during the non-monsoon period is about 20 mm. The average non-monsoon rainfall in Upper Ken sub-basin is 56 mm. The average non-monsoon rainfall in lower Ken sub-basin is about 66 mm.

6.2.1.3 Area under Rainfed Cultivation

A Enroute command

It is proposed to provide irrigation to water scarce areas in Tikamgarh and Chhatarpur districts of Madhya Pradesh and Jhansi and Mahoba districts of Uttar Pradesh enroute of Ken-Betwa Link canal. District wise existing cropping patterns are shown in the Table 6.4.

Table – 6.4
Existing cropping pattern in enroute command

S.No.	Name of crops	% of area	Area in ha
I	Kharif		
1	Paddy	3.33	2008
2	Jowar	2.46	1484
3	Maize	0.48	288
4	Oilseeds	2.20	1326
5	Pulses	16.98	10238
6	Spices	0.38	229
7	Vegetable	0.86	518
8	Fodder	3.33	2008
	Sub-total	30.02	18099
II	Rabi		
9	Wheat	37.52	16595
10	Barley	2.12	1278
11	Gram	14.80	8924
12	Pulses	14.75	8893
13	Oilseed	10.34	6234
14	Vegetables	0.28	169
15	Fodder	0.03	18
	Sub-total	69.84	42111
III	Perennial		
16	Sugarcane	0.14	84
	Total	100	60294

B Ken Command (MP)

The total Culturable Command Area under Ken command in Madhya Pradesh portion in downstream of Daudhan dam is 2,41,306 ha. Existing cropping pattern in terms of percentages of areas under main crops is given in Table-6.5.

Table-6.5

Existing cropping pattern in Ken command (MP)

Sl no	Season	Crop	% age area of CCA	Area in ha.
1.	Kharif	Paddy	3.18	7673
		Pulses	3.00	7239
		Others	36.72	88607
		Sub-total	42.90	103519
2.	Rabi	Wheat local	21.29	51374
		Other Rabi	38.68	93337
		Sub-total	59.97	144711
3	Perennial	Sugarcane	0.13	314
		Total	103.00	248544

C Ken Command (UP)

Since Ken command in Uttar Pradesh is an existing command being irrigated through Bariarpur head works, details under rain fed condition are not relevant.

6.3 Soil surveys

6.3.1 Soil capability classification

Soil survey in the command area was carried out by the State Agriculture Department and a preliminary report had been submitted by the Joint Director of Agriculture, Sagar district. According to this report, the soil of the proposed Ken command possess slight to moderate erosion and few areas with severe erosion. The water holding capacity is low to medium. The pH value of the soil is between 7 and 8. The soils have good response to fertilizers and irrigation.

6.3.2 Land irrigability classification

Land irrigability classification done by State Government in respect of Ken command and Enroute command, are placed at Annexure 6.1(a) and Annexure 6.1(b) respectively. Similarly land capability classification in respect

of these commands are placed at Annexure-6.1(c) and Annexure 6.1(d) respectively.

6.4 Proposed cropping pattern

Keeping in view the existing cropping pattern, soil suitability, climatic conditions, water availability etc., different cropping pattern have been proposed in the Ken and Enroute commands. These are described in the subsequent paragraphs.

(i) Enroute command

The proposed cropping pattern and crop calendar in enroute command is given in Table-6.6.

Table-6.6
Cropping pattern proposed for the enroute command

			Culturable Command Area: 60,294 ha				
	S.No.	Name of the crop	%age of CCA	Area (ha)	Crop growth period starts in Month	Fort-night	Dura-tion days
Kharif	1	Paddy	27	16279	Jun	2	135
	2	Jowar	2	1206	Jul	1	120
	3	Maize	2	1206	Jul	1	135
	4	Vegetables	4	2412	Jul	1	120
Kharif	5	Pulses	4	2411	Jul	1	135
	6	Groundnut	5	3015	Jul	1	135
	7	Bajra	2	1206	Jul	1	120
	8	Fodder	2	1206	Jul	1	120
		Sub-total	48	28941			
Rabi	9	Wheat	32	19294	Nov	1	120
	10	Vegetables	6	3618	Nov	1	120
	11	Pulses	4	2412	Oct	2	135
	12	Fodder	4	2412	Oct	2	135
	13	Oil seeds	4	2411	Oct	2	135
	14	Gram	2	1206	Oct	2	105
		Sub-total	52	31353			
		Total	100	60,294			

(ii) Ken command (MP)

The proposed cropping pattern & crop calendar in the Ken command is given in Table-6.7.

Table-6.7

Cropping pattern & crop calendar proposed for the Ken command (MP)

				Gross Command Area = 3,21,269 ha Culturable Command Area: 2,41,306 ha			
	S. No.	Name of the crop	% of CCA	Area (ha)	Month & fortnight		Duration (days)
Kharif	1	Paddy	12	28957	Jun	2	135
	2	Jowar / Maize	13	31370	Jul	1	120
	3	Pulses	15	36196	Jun	2	135
	4	Oil seeds	12	28957	Jul	1	135
	5	Vegetables	8	19304	Jul	1	120
Rabi	6	Wheat(HYV)	40	96522	Nov	1	120
	7	Wheat(Local)	5	12065	Nov	1	120
	8	Gram	8	19305	Nov	1	105
	9	Linseed	5	12065	Nov	1	105
	10	Sunflower	5	12065	Nov	1	120
	11	Barseem	3	7239	Nov	1	135
	12	Masoor	8	19305	Nov	1	120
			134	323350	Total		

6.4.1 Proposed irrigation facilities

6.4.1.1 Enroute command

The proposed link canal passes through Ken basin and Betwa basin. The Culturable command area to be covered is 60,294 ha. This area is to be irrigated at 100% irrigation intensity by this project.

In addition to above proposed enroute irrigation over 60294 ha, keeping in view the demands of local farmers and public representatives, the possibility of stabilising the irrigation facilities (including drinking water supply) through existing tanks located in the vicinity of the proposed link canal alignment and presently facing water shortage has been broadly studied. Various tanks located in the vicinity of the Ken-Betwa link alignment some of which were mentioned in the FR of the Ken-Betwa link project, have been identified from the topo-sheets and all relevant data as available has been collected from the field.

Most of these tanks are very small in capacity & command area and it may not be viable to supplement them with very small quantum of water from the link canal. Further, some of the tanks are falling inside the proposed enroute command area and the command area of these tanks is deemed included in the enroute command area. The storage capacity and distribution system of these tanks could be taken over by the proposed irrigation through the Ken-Betwa link canal enroute command area system.

However, some tanks with significant capacity located outside proposed enroute command area are found to be suitable for consideration for supplementation from the waters carried in the Ken-Betwa link canal, subject to the overall respective allocation of water to MP and UP. This aspect needs further detailed study at the execution stage of the project, since most of the data presently available in respect of these tanks is inadequate. However, based on limited available data a broad requirement of these tanks is assessed and the details are presented at Annexure-6.2. The brief details of identified tanks in the vicinity of Ken-Betwa link alignment are furnished in Table-6.8.

Table-6.8
Tanks identified in vicinity of Ken-Betwa link project

Sl. No.	Tank name	CCA (in ha)	Nearest Ken-Betwa link canal RD (in km)	Remarks
1.	Jagat sagar	506	77.0	MP
2.	Gora tal	6770	85.5	Mp
3.	Motisagar tal	567	91.8	MP
4.	Issanagar tal	526	100.2	MP
5.	Madan sagar (Jatara)	2191	143.3	MP
6.	Dharm sagar	2679	150.2	MP
7.	Kachneo tal	2730	184.8	UP
8.	Sidh sagar(Siori)	7364	187.6	UP
9.	Magarwara tal	503	190.0	UP
10.	Pachwara tal	1870	190.0	UP
11.	Arjar tal	3280	214.1	Mp
12.	Baruwa sagar	1660	Out fall point	UP

6.4.1.2 Ken command (MP)

The total culturable command area for Ken command is 2.413 lakh ha. The annual irrigation to be provided from the proposed Ken canal system of Ken command is 323350 ha. Intensity of irrigation in this command is 134%.

6.4.2 Scope for double and multiple cropping pattern and change in cropping pattern on the basis of latest available data

Since intensity of irrigation in case of Ken command in Madhya Pradesh is more than 100%, double cropping pattern is feasible in this area. With the use of ground water, double cropping pattern is also feasible in enroute command. So far existing Ken command in Uttar Pradesh is concerned, even multiple cropping pattern would be possible due to enhanced allocation of assured irrigation water to Uttar Pradesh

So far cropping pattern is concerned, it has been adopted as per the suggestion of State Agricultural Deptt.

6.4.2.1 Soils

(a) Soils in Ken command (UP)

The following types of soil exist in the Uttar Pradesh portion of the Ken command.

1. Mar	16.3%	Clay
2. Kakar	17.82%]	Loam
3. Parwa	33.12%]	
4. Ranker	32.76%]	

6.4.2.2 Agro-climatic conditions

As per the agro-climatic zoning of Madhya Pradesh, major part of the command area of the Ken-Betwa Link falls in the Bundelkhand region, which is deficit in water and prone to frequent droughts. The climate of the region is tropical. The climate remains hot and is pleasant in winter. The temperature normally varies from 47.3^0C in summer to 4^0 C in winter.

6.4.2.3 Water and other inputs like seeds, fertilizers etc.

It is seen from the survey conducted by the NCAER that the farmers use sufficient inputs to take full advantage of the good situation particularly in irrigation condition. The use of manure and fertilizers is common in all the areas. Similarly, the use of pesticides and weedicides is also popular in the command areas. It also confirms the use of modern agricultural technology in the proposed command areas.

6.4.2.4 Irrigated crops in the adjoining area

The irrigated crops grown in the adjoining area of command are mainly paddy, Jowar, Bajra, Maize, Arhar, Wheat, Pulses, Potato and other green vegetables. In some areas, farmers having irrigation facilities are switching over to menthol due to availability of processing units.

6.4.2.5 Attitude of farmers towards modern irrigated agricultural practices

(i) Enroute command

During the course of field enquiry conducted by the NCAER, it was found that more than 72% of the households in the proposed command area are not satisfied with the existing irrigation facilities. This indicates the need for augmenting the irrigation facilities, which is supported by the majority of the farmers. In these areas, the preference is obviously for the canal irrigation supplemented by the use of modern agricultural machineries, which will result in higher income and enhancement of socio-economic conditions.

(ii) Ken command

The proposed command area is bordering Uttar Pradesh and Madhya Pradesh and the economic condition of farmers are comparatively inferior to that of farmers of the adjoining state of Uttar Pradesh. Hence, majority of the farmers are keen to adopt modern irrigated agricultural practices, which would naturally improve their economic conditions through better and efficient irrigation.

6.5 Crop water requirement

The annual crop water requirement for each crop has been worked out by IMO, CWC adopting Modified Penman's method & the same for various commands is given in Tables 6.9 to 6.11.

Table - 6.9
Crop water requirement for Ken command (MP portion)

S. No.	Name of crop	Area under each crop (ha)	Water requirement (MCM)
1.	Paddy	28957	273.96
2.	Jowar/Maize	31370	111.99
3.	Pulses	36196	176.41
4.	Oilseeds	28957	110.36
5.	Vegetables	19304	85.28
6.	Wheat (HYV)	96522	346.83
7.	Wheat (local)	12065	44.98
8.	Gram	19305	61.66
9.	Linseed	12065	38.67
10.	Sunflower	12065	44.59
11.	Barseem	7239	36.12
12.	Masoor	19305	74.72
	Total	323350	1405.57

Table – 6.10
Crop water requirement for enroute command

	S.No.	Crops	% of CCA	Area (ha)	Water requirement in MCM
Kharif	1	Paddy	27	16279	185.89
	2	Jowar	2	1206	5.23
	3	Maize	2	1206	6.04
	4	Vegetables	4	2412	12.09
	5	Pulses	4	2411	12.80
	6	Groundnut	5	3015	16.76
	7	Bajra	2	1206	5.50
	8	Fodder	2	1206	6.17
		Sub-total	48	28941	
Rabi	9	Wheat	32	19294	67.94
	10	Vegetables	6	3618	14.24
	11	Pulses	4	2412	10.67
	12	Fodder	4	2412	9.97
	13	Oil seeds	4	2411	8.84
	14	Gram	2	1206	3.81
		Sub-total	52	31353	
		Total	100	60,294	365.96

Table – 6.11
Monthwise water requirement for Ken command of UP

CCA = 2,13,610 ha
Assumed Intensity of Irrigation = 118%
Annual irrigation = 2,52,017 ha

S. No.	Month	Water requirement in MCM
1.	June	21.12
2.	July	216.65
3.	August	295.35
4.	September	247.88
5.	October	300.04
6.	November	201.82
7.	December	35.63
8.	January	82.87
9.	February	103.23
10.	March	66.80
11.	April	28.61
12.	May	0.00
	Total	1600.00

Fortnightly crop water requirement for different commands has been detailed in Annexure 6.3. The above crop water requirement has been computed considering field irrigation efficiency of 85% for Paddy and 75% for other crops and a conveyance efficiency of 65% for all crops.

6.6 Water planning

6.6.1 Surface water

6.6.1.1 Demand table of the project

The total demand Table (for Ken and Enroute command) for the Ken-Betwa Link project (at the diversion site) is as given in Table-6.12.

Table-6.12

Total demand Table for Ken-Betwa Project (At Daudhan dam site)

Unit: MCM

Month	Drinking water Enroute	Irrigation demand of Ken-UP	Irrigation Demand of M.P at Bariarpur	Irrigation demand for KMPP	Irrigation for enroute	Transmission losses of link	Diversion to Parichha	Total demand
1.	2.	3.	4.	5.	6.	7.	8.	9.
June	0.0	21.12	17.87	45.21	0.00	0.00	0.00	84.20
July	4.9	216.65	61.43	155.40	89.21	8.823	50.577	586.99
Aug	4.9	295.35	62.75	158.74	64.43	7.938	22.922	617.03
Sept	4.9	247.88	41.16	104.13	46.65	7.849	35.911	488.48
Oct	4.9	300.04	30.97	78.36	55.51	8.796	82.754	561.33
Nov	7.35	201.82	58.96	149.15	33.15	9.204	130.576	590.21
Dec	7.35	35.63	45.46	115.01	30.46	8.789	104.861	347.56
Jan	7.35	82.87	45.00	113.83	27.57	8.518	90.402	375.62
Feb	7.35	103.23	33.33	84.32	19.01	8.080	72.92	328.24
Mar	0.00	66.80	1.29	3.26	0.00	0.00	0.00	71.35
April	0.00	28.61	0.00	0.00	0.00	0.00	0.00	28.61
May	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	49.00	1600.0	398.22	1007.41	365.97	67.997	591.003	4079.60

Working Tables

The water demands for the project have been simulated with the hydrological yield series to ascertain the success rate of project in meeting the water demands. The minimum success rate required for an irrigation project is 75% to ensure that project will be able to meet the stipulated water demands in three out of four years.

a) Daudhan dam

The water demands for Ken and En-route command have been simulated with the yield series at Daudhan Dam site. The results of the same have been summarized in tabular form. The success rate of the project for irrigation is 87% which is above minimum 75 % required for irrigation project. Summary of the simulations has been given in Table 6.13.

Table-6.13
Summary of the simulation study(working Table) for Daudhan dam

S. No.	Year	Drinking	No. of failures	Diversion to Parichha River	No. of months Failures	Irrigation requirements of enroute command	No. of months failures	Fixed U.P demand through Bariyarpur	No. of months failures	KMPP irrigation demand of M.P	No. of months failures	KMPP irrigation demand from LBC	No. of months failures
1	1981 - 1982	S	0	S	0	S	0	S	0	S	0	S	0
2	1982 - 1983	S	0	S	0	S	0	S	0	S	0	S	0
3	1983 - 1984	S	0	S	0	S	0	S	0	S	0	S	0
4	1984 - 1985	S	0	S	0	S	0	S	0	S	0	S	0
5	1985 - 1986	S	0	S	0	S	0	S	0	S	0	S	0
6	1986 - 1987	F	1	F	1	F	1	S	0	S	0	S	0
7	1987 - 1988	S	0	S	0	S	0	F	1	F	1	F	1
8	1988 - 1989	S	0	S	0	S	0	S	0	S	0	S	0
9	1989 - 1990	F	3	F	3	F	3	F	3	F	2	F	3
10	1990 - 1991	S	0	S	0	S	0	S	0	S	0	S	0
11	1991 - 1992	S	0	S	0	S	0	S	0	S	0	S	0
12	1992 - 1993	S	0	S	0	S	0	S	0	S	0	S	0
13	1993 - 1994	S	0	S	0	S	0	S	0	S	0	S	0
14	1994 - 1995	S	0	S	0	S	0	S	0	S	0	S	0
15	1995 - 1996	S	0	S	0	S	0	S	0	S	0	S	0
16	1996 - 1997	S	0	S	0	S	0	S	0	S	0	S	0
17	1997 - 1998	S	0	S	0	S	0	S	0	S	0	S	0
18	1998 - 1999	S	0	S	0	S	0	S	0	S	0	S	0
19	1999 - 2000	S	0	S	0	S	0	S	0	S	0	S	0
20	2000 - 2001	S	0	S	0	S	0	S	0	S	0	S	0
21	2001 - 2002	S	0	S	0	S	0	S	0	S	0	S	0
22	2002 - 2003	F	1	F	1	F	1	F	1	F	1	F	1
23	2003 - 2004	S	0	S	0	S	0	S	0	S	0	S	0
	No. of failures	3		3		3		3		3		3	
% of failures		13		13		13		13		13		13	
success rate(%)		87		87		87		87		87		87	

6.6.1.2 Designed head discharge of canal systems

The canal capacities at the canal head for the different canals have been computed assuming the continuous supply of water and furnished below in Table 6.14.

Table 6.14
Canal capacity at head of canal

Dam	Canal	Capacity* (Cumecs)
Daudhan	KBL Canal or Upper Level Canal	76.226
	Ken Left Bank Canal or Lower Level Canal	65.194

* A provision of 10 % irrigation demand has been made towards rush irrigation demand in canal capacity.

6.6.2 Ground Water

6.6.2.1 Ground Water Quality

Majority of water bearing formations of command area of proposed Ken-Betwa Link consists of crystalline rocks, which by virtue of being consolidated in nature do not pose any adverse chemical effect on its waters. Chemical quality of ground water, thus, is observed to be within limits prescribed for waters of domestic and irrigation purposes. It varies from 300 to 1500 micro mhos/cm at 25^0 C. There may, however, be localized concentrations of trace elements in the waters, which are harmful for drinking purposes. This aspect could not be ascertained due to non-availability of requisite data.

In order to make an economic and efficient use of available water resources, it is essential that a judicious mix of surface and ground water are resorted to for irrigation purposes. There is considerable scope to further intensify the irrigation in the command areas by making use of the ground water resources available. This may further facilitate in checking the hazards of water logging and soil salinity in the command.

6.6.2.2 Conjunctive Use / Ground Water Support

District wise and command wise ground water resources for the districts of the en-route command and Ken command(Madhya Pradesh) assessed and duly approved by CGWB are given in Annexure 6.4 and 6.5. In the present planning, no use of ground water is proposed in any of the command. However, the available ground water resources can be utilized in future for

further intensification or augmentation of the irrigation facilities in various commands, particularly to meet the irrigation requirement during lean season.

6.7 Command Area

Three command areas are being covered under Phase-I of the Ken-Betwa Link project. These are Enroute command, Ken command (Madhya Pradesh) and stabilization of Ken command (Uttar Pradesh). The enroute command lies in Chhatarpur and Tikamgarh districts of Madhya Pradesh and Mahoba and Jhansi districts of Uttar Pradesh. The CCA of 60,294 ha is covered enroute of the link canal. The Ken command area lies in Chhatarpur and Panna districts of Madhya Pradesh. The CCA under this command is 2,41,306 ha. The stabilization of Uttar Pradesh command of 2,13,610 ha lies in Banda district. Descriptions of the commands have been given in previous Para's.

6.8 Command Area Development

Development of all commands is being described in following paragraphs:

6.8.1 Enroute Command - Details

6.8.1.1 Location

The enroute command area comprising 60,294 ha is falling in Chhatarpur and Tikamgarh districts of Madhya Pradesh and Mahoba and Jhansi districts of Uttar Pradesh. The District/tehsil wise break up of the enroute command area is given at Table 6.15. Map showing enroute command area is given as Plate 2.1.15 in Drawing Volume-I.

Table- 6.15
District/tehsil wise details of enroute command area

S. No.	District/tehsil	Geographical area (ha)	GCA falling in enroute command (ha)	CCA (ha)
Madhya Pradesh Chhatarpur District				
1	Nowgong	91368	15016	12013
2	Chhatarpur	105889	14015	11212
	Sub total		29031	23225
Tikamgarh District				
1	Palera	84801	6607	5286
2	Jatara	101691	5704	4563
3	Niwari	66806	12334	9867
4	Baldeogarh	93024	4488	3590
	Sub Total		29133	23306
	(Total M.P)		58164	46531
Uttar Pradesh Mahoba District				
1	Kulpahar	124487	5812	4650
	Sub Total		5812	4650
Jhansi District				
1	Mauranipur	55669	7374	5899
2	Tahrauli	127489	4017	3214
	Sub total		11391	9113
	(Total UP)		17203	13763
	Grand total (MP + UP)		75367	60294

6.8.1.2 Classification of land (forest, grass land, cultivable land, cultivable waste, barren land)

The classification of land in the enroute command area is furnished in Table 6.16 below:

Table 6.16
District wise land use particulars in the enroute command area during the 2004-05

Unit : ha

Type of land	Tikam-garh district	Chhatar-pur district	Jhansi district	Mahoba district	Total
Gross command area	29133	29031	11391	5812	75367
Forest land	1688	54	55	117	1914
Land under non-agricultural use	2209	1734	710	418	5071
Barren land	3096	3859	338	241	7534
Grass land	3221	3415	7	11	6654
Culturable waste land	1391	3841	692	241	6165
Fallow land	1156	1363	536	352	3407
Net sown area	15308	12948	8549	4044	40849
Other lands	1063	1817	504	389	3773

6.8.1.3 Size of land holding

The size of land holding and area in the districts lying in the enroute command area during the year 2001-02 is given below in Table 6.17.

Table 6.17
Size of land holding in the enroute command area

Description	Tikamgarh		Chhatarpur		Jhansi		Mahoba	
	No	Area	No	Area	No	Area	No	Area
Marginal farmers less than 1 ha	77592	39202	87203	45605	99696	47043	51433	30013
Small farmers more than 1 ha less than 2 ha	48778	68776	75057	109488	54032	87736	30990	43774
Below medium farmers 2-4 ha	33496	99376	48445	130856	34984	103483	22460	60620
Medium farmers 4-9.99 ha	12376	68589	24473	143072	17986	104809	12207	70576
Big farmers 10 to 20 ha	892	12295	3650	55952	1270	19033	1464	19868
Total	173134	279238	238828	484963	207968	362104	118554	224851

Note: The data for Jhansi & Mahoba districts pertains to the year 1995-96.

6.8.1.4 Climate

The climate of enroute command is as given below:

(a) Rainfall: The annual normal rainfall in the command is between 700 mm to 1200 mm and during monsoon, the average annual rainfall is around 950 mm. Maximum rainfall occurs in the month of July and the minimum rainfall occurs in June.

(b) Temperature: Moderate heat is experienced during summer. The climate is quite cold in winter. Maximum temperature recorded in Tikamgarh district is 46 °C and the minimum as 1°C. The minimum winter temperature was recorded as low as 0° C at Nowgong Meteorological Observatory.

(c) Relative humidity: The maximum and minimum relative humidity in & around the command area are 95% and 9% respectively.

(d) Evaporation: The monthly mean evaporation in the command area varies between 8 cm to 25 cm.

6.8.1.5 Irrigation

(a) Present sources of irrigation in the command

The present sources of irrigation in the proposed command area are mainly the age-old Tanks and ponds, which collect the rainwater during the monsoon season. Besides these, privately owned open wells and tube wells also provide water for irrigation to very small areas.

(b) Methods of irrigation followed

At present, the conventional method of applying water through minor irrigation channels, distributaries and water courses is being followed in these areas. However, sometimes electric/diesel pump sets are also used to lift water from the wells.

(c) Status of land development for irrigated area

(i) Condition of channels

The condition of existing irrigation channels in the command area is generally satisfactory except in some reaches where proper maintenance is required. Most of the channels are unlined, hence susceptible to loss of water through seepage.

(ii) Longitudinal slope of field

The slope in agricultural fields where irrigation channels are located, are adequate and irrigation water reaches almost every nook and corner of the fields.

(iii) Status of field channels

Field channels are almost non-existent as the existing irrigation system in the command, particularly in Bundelkhand region does not get assured water through existing Tanks etc.

6.8.1.6 Socio-economic aspects

M/s Agricultural Finance Corporation Limited, Hyderabad has carried out Comprehensive Environmental Impact Assessment for the Ken-Betwa Link project. The district wise socio-economic aspects are furnished in Table-6.18 below.

Table-6.18
Districtwise socio-economic aspects

S. N.	Description	Tikam-garh	Chhatar pur	Mahoba	Jhansi
1	Population density per sq km	238	170	262	347
2	Sex ratio (females to male for 1000 male)	886	869	864	871
3	SC	24.28%	23.26%	25.85	28.06%
4	ST	4.31%	3.50%	Negligible	0.06%
5	Landholdings	Maximum number of holdings belongs to marginal farmers owning less than 1 ha			
6	Literacy rate	55.73%	53.30%	53.30%	65.50%
7	Educational institutions	2705	2465	N.A.	4652
8	Medical and health facilities	900	816	568	2106
9	Drinking water supply				
	Problematic villages	760	1080	264	278
	Tap water supply	3	64	744	9
	Tube/pump well supply	865	1064	760	786

6.8.1.7 Infrastructure facilities

(a) Roads and railways

Details of roads and railways of the districts falling in the enroute command area as given in Table 6.19.

Table-6.19
Distribution of roads and railways in the enroute command area

District/Tehsil	Total length (km)	Length of all weather roads(km)	No. of railway station	No. of bus station stop
Mahoba/ Mahoba	174	54	3	16
Jhansi/Mauranipur	129	NA	3	13
Chhatarpur/ Chhatarpur & Nowgong	521	360	Nil	N.A
Tikamgarh/ Tikamgarh & Jatara	523	79	Nil	N.A

(b) Marketing facilities

(i) Jhansi district

Almost all the villages falling under the proposed command with in Mauranipur tehsil are dependent on the marketing facilities available in the Mauranipur and Ranipur towns. These included about 83 co-operative marketing societies available in this tehsil.

(ii) Mahoba district

The nearest marketing place for the people residing in Kabroi block in the enroute command is at Mahoba. Besides this, about 13 co-operative societies take care of marketing of various agricultural as well as household goods.

(iii) Chhatarpur district

Good marketing facilities are available for the people of the command areas in Chhatarpur, Nowgong and Isanagar towns through weekly markets spread over the entire command under Chhatarpur district. In addition, numerous fair price shops, within reasonable distances, are available in all villages.

(iv) Tikamgarh district

In the two tehsils viz. Tikamgarh and Jatara of Tikamgarh district, good marketing facilities are available.

(c) Agro-industries

(i) Mahoba district

No agro based industry is located in the area falling under the enroute command within this district.

(ii) Jhansi district

Agro based industries are not located in the area under the enroute command falling in Mauranipur tehsil of this district. However, numerous weaving related industries are located in this area.

(iii) Chhatarpur district

No major agro based industry is located in this district. However, some oil mills and flour mills are there within the command, which cater to the needs of common people.

(iv) Tikamgarh district

No major agro based industry is located in this district.

(d) Banks/credit societies etc.

(i) Mahoba district

One nationalized bank and four rural banks are located in the Kabroi block of this district falling under the command area.

(ii) Jhansi district

Three nationalized commercial banks have their branches in Mauranipur tehsil coming under the enroute command.

(iii) Chhatarpur district

About 15 commercial banks have their branches spread over the area under the enroute command falling in this district. Moreover, a number of branches of land development banks and central co-operative banks are located in these areas.

(iv) Tikamgarh district

As per 1991-92 statistical records, there are 80 branches of commercial bank in this district, out of which 66 branches are located in rural areas. In addition to these, land development banks and co-operative banks also have 17 and 7 branches respectively in this district.

6.8.1.8 Topography and soils

(i) Topography and relief

Topographical features of the command area include isolated hilltops, valleys, reserve forests, nallas, streams and rivers. The geological formations include predominant archaeon quartzite rocks. Coarse grained Bundelkhand formations are predominantly found in the command area.

(ii) Land slopes

The slopes of the lands in the command are generally moderate i.e. neither steep nor flat.

(iii) Soils

Based on the information provided by National Bureau of Soil Survey and Landuse Planning(ICAR), Nagpur, the soils in the command area can be broadly classified into five categories. They are soil in hills and hill ranges, plateau soils, pediment soils, soils of level alluvial plain and undulating flood plain and soils of dissected flood plan.

6.8.1.9 Ground Water and Drainage

Ground water assessment has been made for the enroute command area based on data collected from CGWB. CGWB, Bhopal has also assessed the pre- project and post project ground water available in the enroute command area. Details are furnished in Annexure 6.4.

The soils of the command area are characterized with good surface drainage and sub-surface drainage, the water holding capacity being low to medium except in clay patches. With the network of a number of tributaries namely Urmil, Kutri, Kusjar, Kali etc., the command area has good drainage facilities.

In the command area, the stage of groundwater development is less than 70% and hence falls under the “Safe Category”

The groundwater level in the phreatic zone, during May, 2006 is between 5 to 10 m below ground level in most of the command area. Due to

interlinking of Ken with Betwa river, the water levels may further rise by another 2 m to 4 m and may not bring in water logging conditions or other hazards.

6.8.1.10 Agriculture

The classification of lands and the present land use has already been discussed in this chapter. Proposed land use will change due to increase in cultivated area and increase in developmental activities due to this project.

6.8.1.11 Farmers' attitude towards improved agricultural practices

This farmers' attitude towards improved agricultural practices is positive. However due to non-availability of water even from the existing Tanks, they find it difficult to carry out cultivation in the entire area.

(a) Use of improved implements and seeds

The use of bullock power for ploughing of land is common in the area of proposed command. The use of tractor is also done in these areas but the percentage is very low i.e. 10%. Likewise, the use of traditional types of implements are also very common among majority of the farmers.

(b) Use of fertilizers, insecticides, pesticides, etc.

Although about 25% of the farmers use fertilizers and manures for increasing the crop yield, very few of them are particular about use of insecticides/pesticides for control of plant diseases.

(c) Extension services

Occasional extension services are provided by the State agriculture Department to educate the farmers about the use of improved and modern agriculture technology, and cultivation of high value crops viz. groundnut, soyabean, sunflower, chillies etc. But due to various reasons including inadequate financial resources, the extension services are yet to become popular among the farmers of proposed command area.

6.8.1.12 Identification of problems in enroute command area

6.8.1.12.1 Physical problems including hazards

(a) Land slopes:

The land is generally undulating; therefore, canal distribution system has to be aligned accordingly.

(b) Soil depth:

There may not be any problem on this account, as sufficient soil depth is available in the area for providing canal irrigation.

(c) Salinity/alkalinity:

Since the Ken river water is to be used for irrigation in these areas, which does not have salinity problem, it need not be a cause of concern. However, slight alkaline nature of the soils of the region is considered rather suitable for crops like jowar, soyabean, wheat and moong. In general, the soils in these areas are stable and not prone to erosion. However, in certain area, the soils may be prone to erosion due to their coarse texture. Such soils can be stabilized by putting them under permanent pastures and grazing lands.

(d) Water logging:

No water-logging problem of serious nature has been reported from the area.

(e) Drainage:

Looking the general condition and topography of the command special care should be taken for construction of field channels and drainage, which can be managed by the agricultural Department at farmers' cost or funding from the various land development banks.

6.8.1.12.2 Financial problems

There are number of wells and Tanks in the area but due to less recharge in the area, these wells and Tanks either have less water or no water during lean season. Farmers should be provided fund assistance for renovation of these Tanks and wells for better irrigation.

6.8.1.13 Proposed cropping pattern, with justification based on land irrigability classification, agro climatic conditions developed irrigated cropping pattern in adjoining project/area etc.

Proposed cropping pattern of enroute command has been developed based on the Land irrigability and capability classification study by the State Govt. The land irrigability and capability classification for enroute command are enclosed as Annexure 6.1(b) & (e). Results of Land irrigability and capability classification study along with agro climatic conditions of the region has been taken care of while finalizing the proposed copping pattern for the enroute command. The details of proposed cropping pattern for the command area have been covered in Irrigation Planning.

6.8.1.14 Land development work proposals

A provision of Rs. 273.60 lakh has been kept in the estimate for land development works. At the time of implementation of the project, detailed survey of each command will be done and based on the requirement, land development works will be taken up. This work will be done by State Irrigation Department or State Agriculture Department or command area or Command Area Development Authority (to be decided by concerned State Governments).

At present fairly good extension services exists in the command area and number of commercial banks and co-operative banks also have their branches there. Branches of land development banks are also located in some rural areas of the command. Moreover, the agricultural materials like seeds, fertilizers, insecticide, pesticides, etc. are provided to the farmers by the concerned government department at subsidized rates through different sale booths or fair price shops. However, due to numerous reasons, especially inadequacy of financial resources, extension services have not yet become very popular.

6.8.1.15 Ayacut roads

Suitable provisions for CD structures will be made to avoid traffic disruption through ayacut roads.

6.8.1.16 Benefits

(i) Crop wise increase in yield per ha and total estimated output from the command

The cropwise yields in pre & post project scenarios are given in Table-6.20.

Table-6.20

Cropwise yield under pre and post project scenarios

S. No.	Name of Crop	Pre project scenario			Post project scenario		
		Area (ha)	Yield per ha in qtls	Gross yield in qtls	Area (ha)	Yield per ha in qtls	Gross yield in qtls
A	Kharif						
1.	Paddy	2008	15	30120	16279	50	813950
2.	Jowar	1484	12	17808	1206	35	42210
3.	Maize	288	14	4032	1206	40	48240
4.	Oil seeds	1326	5	6630	0		0
5.	Pulses	10238	5	51190	2412	15	36180
6.	Bajra	0		0	1206	15	18090
7.	Spices	229	5	1145	0		0
8.	Vegetables	518	30	15540	2412	50	120600
9.	Fodder	2008	200	401600	1206	500	603000
10.	Groundnut	0		0	3013	50	150650
	Sub-total	18099		528065	28940		1832920
B	Rabi						
11.	Wheat	16595	15	248925	19294	40	771760
12.	Barley	1278	10	12780	0		0
13.	Gram	8924	8	71392	1206	20	24120
14.	Pulses	8893	5	44465	2412	15	36180
15.	Oil seeds	6234	5	31170	2412	20	48240
16.	Vegetables	169	30	5070	3618	80	289440
17.	Fodder	18	200	3600	2412	400	964800
	Sub-total	42111		417402	31354		
C	Perennial						
18.	Sugarcane	84	200	16800	0	500	0
	Total	60294		962267	60294		3967460

(ii) Estimated cost of increased production

The yield in pre and post project scenarios have been assessed in Table 6.20. Based on the increased production, cost of increased production has been assessed in Annexure- 10.9.2 in Chapter-X.

(iii) Likely socio-economic aspects

Due to increase in food grain production, the socio-economic condition of farmers will improve in general. Agricultural labourers will get employment in the nearby area. Situation of livestock will improve. Farmers will try to establish agro-based industries in the area.

6.8.2. Ken Command – Details

6.8.2.1 Location

The Ken command area comprising 2,41,306 ha is spread over Chhatarpur and Panna districts of Madhya Pradesh. The district/ tehsil wise break up of the Ken command area is furnished below at Table 6.21. Key map of Ken command area showing various canal systems is given as Plate 2.1.15 of Drawing Volume – I.

Table 6.21

District/ tehsilwise break up of the Ken command area

S.No.	District/ tehsil	Geographical area (ha)	GCA falling in Ken command (ha)	CCA (ha)
Madhya Pradesh Chhatarpur district				
1	Gaurihar	92152	89919	67948
2	Laundi	84181	67686	51148
3	Rajnagar	137835	84502	63855
4	Chhatarpur	105889	8566	6473
5	Nowgong	91368	39300	29698
		Sub total	289973	219122
Panna district				
1	Ajaygarh	91055	31296	22184
		Sub-total	31296	22184
		Grand total	321269	241306

6.8.2.2 Classification of land (forest, grass land, cultivable land, cultivable waste, barren land)

The classification of land in the Ken command area is furnished below in Table 6.22.

Table- 6.22
Land use particulars in the Ken command area (2005-06)

Unit : ha

S.No	Land use particulars	Chhatarpur	Panna	Total
1.	Forest	71868	13336	85204
2.	Area under non-agriculture use	14835	1864	16699
3.	Barren and unculturable land	536	1010	1546
4.	Permanent pastures and grazing land	21579	372	21951
5.	Land under miscellaneous crops trees and groves	106	-	106
6.	Culturable waste land	21895	2499	24394
7.	Other fallows	12873	537	13410
8.	Current fallows	10584	482	11066
9.	Net area sown	135697	11196	146893
10.	Total geographical area	289973	31296	321269

6.8.2.3 Size of land holding

The size of land holding in the Ken command area is given in Table 6.23.

Table 6.23
Size of land holding in the Ken command area

Size of land holding	No. of holding	% of holding to total holding	Area in ha	% of total area
Upto. 1.0 ha	114757	41.61	63164	11.34
1.0 to 2.0	72867	26.42	105111	18.87
2.0 to 4.0	53528	19.41	146810	26.35
4.0 to 10.0	30207	10.95	177399	31.85
Above 10.0	4448	1.61	64581	11.59
Total	275807	100.00	557065	100.00

6.8.2.4 Climate

The climate of the Ken command is described as follows.

(a) Rainfall

Ken Command region lies in the medium rainfall zone. About 93.2% of the total annual rainfall is received during monsoon season from June to October. The maximum and minimum rainfall values of various rain gauge stations in and around command area and the year of occurrence are given in Table-6.24.

Table-6.24
Maximum and minimum rainfall values (mm)

S.No	Raingauge station	Year	Maximum value	Year	Minimum value
1	Chhatarpur	1906	1576.32	1905	326.64
2	Ajaygarh	1971	2169.50	1962	360.40
3	Nowgong	1980	1628.30	1974	259.80
4	Mahoba	1980	2081.75	1913	319.28
5	Naraini	1919	1810.26	1997	300.00
6	Charkhari	1980	2178.30	1918	280.92
7	Khannah	1916	1329.69	1963	181.60
8	Maudah	1982	1903.66	1918	248.67
9	Pailani	1924	1225.30	1963	275.00
10	Banda	1934	1778.51	1966	421.20
11	Panna	1980	2137.10	1918	514.35
12	Bijawar	1980	1931.70	1905	350.52

(b) Temperature

The data for mean monthly maximum and minimum temperature of Sagar, Nowgaon and Banda IMD observatories have been collected. The average maximum and minimum temperature are 43^{o} C in May and 7.5^{o}C in December respectively.

(c) Wind velocity

Mean monthly wing velocity value observed at the Sagar, Nowgaon and Banda IMD observatories are collected for the study. The maximum and minimum wind velocity in the region are 11.0 km/and 0.7 km/hr respectively.

(d) Relative humidity

The relative humidity values observed at the Sagar, Nowgaon and Banda IMD observatories are collected for the study. It is seen that humidity (Mean) is as low as 20.0% during summer and as high as 90% in monsoon.

(e) Cloud cover

Mean monthly cloud cover data in okras at the Sagar, Nowgaon and Banda IMD observatories are collected for the

study. It is seen that maximum cloud cover occurs in July August whereas the minimum cloud cover occurs during December.

6.8.2.5 Irrigation

a) Present sources of irrigation in the command

The present sources of irrigation in the proposed Ken command area are mainly canals and lift irrigation schemes. Besides these, privately owned open wells and tube wells also provide water for irrigation to very small areas.

The district wise breakup of the Ken command area showing various canals proposed by MP Govt in their KMPP report are shown in Table - 6.25.

Table 6.25
Canal wise break-up of Ken command area

S. No.	Name of district	Name of canal	G.C.A. (ha)	C.C.A. (ha)
1.	Chhatarpur	(a) Ken LBC	67801	42203
		(b) Mukuna Lift	3988	2492
		(c) Kuraha Lift	24154	18275
		(d) Lugasi & Satna Lift	25298	19751
		Urmil LBC	110441	90132
		Bariarpur LBC	58291	46269
2.	Panna	(a) Bariarpur RBC	21989	15107
		(b) From existing Ken	9307	7077
		Total	323350	241306

b) Methods of irrigation followed

At present, the conventional method of applying through irrigation canals/channels, distributaries and water courses is being followed in these area. However, sometimes electric/diesel pump sets are also used to lift water from the wells.

c) Status of land development for irrigated area

(i) Condition of channels

The condition of existing irrigation channels in the command area is generally satisfactory except in some reaches where proper maintenance is required. Most of the channels are unlined, hence susceptible to loss of water through seepage.

(ii) Longitudinal slope of field

The slope in agricultural fields where irrigation channels are located, are adequate and irrigation water reaches almost every nook and corner of the fields.

(iii) Status of field channels

Before providing water for irrigation to the areas under existing irrigation system, the existing canal system will need to be reviewed and resectioning, repairing and realigning may be called for wherever necessary.

6.8.2.6 Socio-economic aspects

The socio-economic aspects of enroute command including Ken command has been discussed in Para 6.8.1.6

6.8.2.7 Infrastructure Facilities

a) Roads and railways

Connection of the command area with the main roads is an integral part of the project. The command area network planning will have to be done in co-ordination with PWD (B&R) and other development agencies.

Recently Khajuraho is also connected by railway. Train services are expected to commence soon.

b) Marketing facilities

A mandi is located at Laundi with sub-mandi at Chandla. The mandis at Rajnagar and Ajaigarh have also been started by Agriculture Produce and Marketing Board of Madhya Pradesh Agriculture Department. These institutions are in initial stage and require strengthening at an approximate cost of about Rs. 5.0 lakh per mandi and sub-mandi. These proposals are suggestive and are to be implemented from the funds outside the project estimate.

c) Agro industries

No agro based industry is located in the command area.

d) Banks, credit societies etc.

Branches of some nationalized banks and Rural Development Banks are located in the nearest towns of the command area, which provide credit facilities to the farmers. Moreover some co-operative societies are also there to provide financial help to the farmers of the proposed command area.

6.8.2.8 Topography and soils

(i) Topography and relief

The command area is gently undulating and contains isolated hill tops, varies forests, Nallah. The geological formations include predominant archaeon quartzite rocks. Coarse grained Bundelkhand formations are predominantly found in the command area.

(ii) Land slopes

The slopes of the lands in the command are generally moderate i.e. neither steep nor flat.

(iii) Soils

The soils of the command area are formed out of parent rock such as quartzite, granite and sand stone. The soils are pale red and light red. The major portion of the command area is covered with sandy loam to sandy clay loam and rest of it is under clay loam and clay. Soil exhibits slight erosion with signs of severe erosion only in small patches.

Soil survey in the command area was carried out by the State Agriculture Department and a preliminary report had been submitted by the Joint Director of Agriculture, Sagar district. According to this report, the soil of the proposed Ken command posses slight to moderate erosion and few areas with severe erosion. The water holding capacity is low to medium. The pH value of the soil is between 7 to 8. The soils have good response to fertilizers and irrigation.

6.8.2.9 Ground water and drainage

The soils of the command area are characterized with good surface drainage and sub-surface drainage, the water holding capacity being low to medium except in clay patches. With the network of a number of tributaries namely Urmil, Kutri, Kusjar, Khurar, Kali etc., the command area has quite good draining facilities.

In this area, the mode of ground water occurrence and transmission are largely controlled by the nature of rock, i.e. whether they are consolidated or unconsolidated. A study of water levels of the 20 observation dug-wells in the command area, spread over all available hydro- geological units for the year 1974-75 reveal that in pre-monsoon, there is wide variation from 5.8 m to 14 m below the ground level whereas the variation in the post-monsoon season is 2 m to 10.8 m below the ground level. Ground water assessment has been made for these command areas based on data collected from CGWB. CGWB Bhopal has also assessed the pre project and post project ground water available in the Ken command area. Detail are furnished in Annexure 6.4.

6.8.2.10 Agriculture

The classification of lands and the present land use has already been discussed in this chapter. Proposed land use will change due to increase in cultivated area and increase in developmental activities due to this project.

6.8.2.11 Farmers' attitude towards improved agricultural practices

This farmers' attitude towards improved agricultural practices is positive. However due to non-availability of water even from the existing Tanks, they find it difficult to carry out cultivation in the entire area.

(a) Use of improved implements and seeds

The use of bullock power for ploughing of land is common in the area of proposed command. The use of tractor is also done in these areas but the percentage is very low. Likewise, the use of traditional types of implements are also very common among majority of the farmers.

(b) Use of fertilizers, insecticides, pesticides, etc.

Although about 25% of the farmers use fertilizers and manures for increasing the crop yield, very few of them are

particular about use of insecticides/pesticides for control of plant diseases.

(c) Extension services

Occasional extension services are provided by the State agriculture Department to educate the farmers about the use of improved and modern agriculture technology, and cultivation of high value crops viz. groundnut, soyabean, sunflower, Chillies etc. But due to various reasons including inadequate financial resources, the extension services are yet to be come popular among the farmers of proposed command area.

6.8.2.12 Identification of problems in command area

6.8.2.12.1 Physical problems including hazards

(a) Land slopes:
The land is generally undulating; therefore, canal distribution system has to be aligned accordingly.

(b) Soil depth:
There may not be any problem on this account, as sufficient soil depth is available in the area for providing canal irrigation.

(c) Salinity/alkalinity:
Since the Ken river water that is to be used for irrigation in these areas does not have salinity problem, it need not be a cause of concern. However, sleight alkaline nature of the soils of the region is considered rather suitable for crops like jowar, soyabean, wheat and moong.

In general, the soils in these areas are stable and not prone to erosion. However, in certain area, the soils may be prone to erosion due to their coarse texture. Such soils can be stabilized by putting them under permanent pastures and grazing lands.

(d) Water logging:
No water-logging problem of serious nature has been reported from the area.

(e) Drainage:

Looking the general condition and topography of the command special care should be taken for construction and field channels and drainage, which can be managed by the agricultural Department at farmers' cost or loans from the various land development banks.

6.8.2.12.2 Financial problems

There are a number of wells and Tanks in the area but due to less recharge in the area, these wells and Tanks either have less water or no water during lean season. Farmers should be provided fund assistance for renovation of these Tanks and wells for better irrigation.

6.8.2.13 Proposed cropping pattern, with justification based on land irrigability classification, agro climatic conditions developed irrigated cropping pattern in adjoining project/area etc.

Proposed cropping pattern of Ken command has been developed based on the Land irrigability and capability classification study by the State Govt. The land irrigability and capability classification for Ken command are enclosed as Annexure 6.1(a) & (d). Results of Land irrigability and capability classification study along with agro climatic conditions of the region has been taken care of while finalizing the proposed copping pattern for the enroute command. The details of proposed cropping pattern for the command area have been covered in Irrigation Planning.

6.8.2.14 Land development work proposals

A provision of Rs. 1903.20 lakh has been kept in the estimate for land development works. At the time of implementation of the project, detailed survey of each command will be done and based on the requirement land development works will be taken up. This work is done by State Irrigation Department or State Agriculture Department or command area or CAD Authority (to be decided by State Governments).

At present fairly good extension services exists in the command area and number of commercial banks and co-operative banks also have their branches there. Branches of land development banks are also located in some rural areas of the command. Moreover, the agricultural materials like seeds, fertilizers, insecticide, pesticides, etc are provided to the farmers by the concerned government department at subsidized rates through different sale booths or fair price shops. However, due to numerous reasons, especially

inadequacy of financial resources, extension services have not yet become very popular.

6.8.2.15 Ayacut roads

Suitable provisions of CD structures will be made to avoid traffic disruption through ayacut roads.

6.8.2.16 Benefits

(i) Crop wise increase in yield per ha and total estimated output from the command

The crop wise yield in pre & post project scenarios are given in Table- 6.26.

Table-6.26

Crop wise yield under pre and post project scenarios (MP + UP)

S. No.	Name of Crop	Pre project scenario			Post project scenario		
		Area (ha)	Yield (qtls/ha)	Gross yield in qtls	Area (ha)	Yield (qtls/ha)	Gross yield in qtls
A	Kharif						
1.	Paddy	22780	15	341700	68411	50	3420550
2.	Jowar	14819	12	177828	49271	35	1724485
3.	Bajra	579	7	4053	2264	15	33960
4.	Maize	530	14	7420	0		0
5.	Oil seeds	13489	5	67445	28957	20	579140
6.	Pulses	36302	5	181510	47111	15	706665
7.	Vegetables	2317	30	69510	19304	50	965200
8.	Fodder	7546	200	1509200	0		0
9.	Spices	989	5	4945	0	0	0
10.	Groundnut	134	7	938	0	0	0
11.	Soyabean	9	10	90	0	0	0
	Sub-total	99494		2363611			7430000
B	Rabi						
12.	Wheat (HYV)	0	18	0	96522	40	3860880
13.	Wheat (local)	94886	15	1423290	94027	40	3761080
14.	Masoor	0	9	0	44595	15	668925
15.	Toriya	0	4	0	299	10	2990
16.	Mustard	347	6	2082	1324	20	26480
17.	Peas	379	4	1516	449	8	3592
18.	Barseem	0		0	7239	400	2895600
19.	Sunflower	4	16	64	12065	20	241300
20.	Linseed	224	1	224	12065	12	144780
21.	Alsi	501	5	2505	2478	12	29736
22.	Barley	5065	10	50650	854	10	8540
23.	Gram	73911	8	591288	88131	20	1762620

S. No.	Name of Crop	Pre project scenario			Post project scenario		
		Area (ha)	Yield (qtls/ha)	Gross yield in qtls	Area (ha)	Yield (qtls/ha)	Gross yield in qtls
24.	Pulses	21090	5	105450	0	15	0
25.	Oil seeds	31490	5	157450	0	16	0
26.	Vegetable	1288	30	38640	0	80	0
27.	Fodder	124	200	24800	0	400	0
	Sub-total	229309		2397959	360048		13406523
C	Perennial						
28.	Sugarcane	287	200	57400	0	500	0
	Total	329090		4818970	575366		20836523

(ii) Estimated cost of increased production

The yield in pre and post project scenarios have been assessed in Table 6.26. Based on the increased production, cost of increased production has been assessed in Annexure 10.9.1 of Chapter-X.

(iii) Likely socio-economic aspects

Due to increase in food grain production, the socio-economic condition of farmers will improve in general. Agricultural labourers will get employment in the nearby area. Situation of livestock will improve. Farmers will try to establish agro-based industries in the area.

CHAPTER-VII
CONSTRUCTION PROGRAMME, MAN POWER DEPLOYMENT & PLANT PLANNING

CHAPTER-VII

CONSTRUCTION PROGRAM, MANPOWER DEPLOYMENT & PLANT PLANNING

7.1 General

This chapter describes the construction methodology and equipment planning for construction of the main components under Ken-Betwa Link Project Phase-I. The construction methodology for each type of structure has been described under the relevant sub sections of this chapter. The type and sizes of the equipment to be used have also been indicated while describing the construction methodology. The number of machines required for construction of each component of the project has been worked out and total requirement for each type and size of the major equipment has been arrived at after preparing the construction/ deployment schedule for main components of the project. In case, the work is executed through award of contract, the contractors in all probability may suggest their own construction techniques and equipment for execution of the job based on equipment actually available with them. The tentative requirement of machines as worked out herein will help in analysis of rates of works, cost estimation and in evaluating the reasonableness of the participating bidders' construction techniques and equipment, within overall construction schedule and cost estimate.

7.2 Main Project Components

Ken-Betwa Link Project Phase-I envisages diversion of the surplus water available in Ken basin to water short Betwa basin. Main project components of the Project involve construction of a 77.00 m high and 1233 m long earth dam across river Ken near Daudhan village. A 798 m long concrete dam with 536 m long channel spillway on left flank has been proposed. Two power houses viz. PH-I with an installed capacity of 2 x 30 MW and PH-II with 3 x 6 MW installed capacity have also been planned. PH-I will be located at foot of the dam and PH-II will also be a surface power house at the end of 1.10 km long tunnel. The tunnel with a finished diameter of 5.5 m serves as water conductor for PH-II. A 675 m long TRC will thereafter discharge the water into the Ken LBC.

The surplus water available in Ken basin up to Daudhan dam will be diverted through a 218.70 km long link canal to water short Betwa basin and for enroute utilization. In this entire length of the canal, seven aqueducts, six super passages, four syphon aqueducts, thirteen canal syphons, ten pipe culverts and eighteen road bridges and one railway crossing are required to be constructed.

7.2.1 Salient Features of main Components

Salient Features of main Components of the Project are given in Table 7.1.

Table - 7.1

Salient Features of main Components of Phase-I of the Project

(i)	Earth Dam	(Daudhan)
	Type	Earthfill dam with central core
	Height	77.00 m
	Length at the top	1233 m
(ii)	Concrete Dam	
	Length	798.0 m
	Height	77.0 m from deepest foundation level
(iii)	Spillway	
	Type	Channel spillway with ski-bucket
	Gates	27 nos. of radial gates (16.0 m x 18.5 m)
(iv)	PH-I (Dam Power House)	
	Intake structure	
	Length	215 m long penstock
	Diameter	
	Shape	Circular
	Power House	
	Type	Surface
	Installed Capacity	2 x 30 MW
	Turbine	vertical shaft type Kaplan
(v)	PH-II (Canal Power House)	
	Intake structure	
	Length (low level tunnel)	1100 m
	Diameter	5.5 m
	Shape	Modified horse-shoe
	Surge Shaft	

Salient Features of main Components of Phase-I of the Project

	Length	62.0 m
	Diameter	18.0 m
	Shape	Circular
	Power House	
	Type	Surface
	Installed Capacity	3 x 6 MW
	Turbine	vertical shaft Kaplan
	Tail Race Channel	
	Length	675 m
	Lining	Concrete lined
(vi)	Link Canal	
	Length	220.624 km including 1.929 km long, 6 m diameter tunnel
	Lining	Concrete lined
	Bed width	13.20 m at head
	Bed slope	1:9000 to 1:12000

7.3 Basis for Study

7.3.1 General

Methodology adopted for construction of Ken-Betwa Link Project takes into consideration the construction schedule, the compatibility of the construction equipment to site conditions and the quantities as well as the utilization factor of the equipment within the scheduled construction period. Number of machines required for construction of each component of the project has been worked out and the total requirement for each type and size of machine for the project as a whole has been arrived at after drawing up the construction/deployment schedule for the main components of the project.

Mechanized construction has been planned for almost all types of construction jobs so as to achieve consistent quality at a faster rate and also to minimize the requirement of skilled manpower. Moreover, very high degree of quality standards are required to be maintained as underground works are normally not available for regular maintenance after the completion.

Sequencing of construction activities, wherever possible, has been attempted in such a way that equipment from one activity, on its completion can be shifted to the other. This way, the total requirement of equipment at

a time would be reduced and also, sufficient utilization of equipment on the project would be ensured.

7.3.2 Construction Material Sources

Locations of different borrow areas and quarries for construction material with respect to the dam location has been described in the Chapter on Surveys & Investigations.

Suitable fill material for the earth fill dam has been found in the borrow area upstream of the proposed Daudhan dam. About 46.0 MCM of soil is available in Daudhan, Palkohan and Kharyani borrow areas located in the upstream of proposed Daudhan dam. Borrow areas with minimum lead should be utilized during dam construction. For the purpose of equipment planning, average distance of these three borrow areas from dam axis has been considered. The material to be used for filter is available at Daudhan, Gangau, Palkohan and Kharyani borrow areas. However, during construction, appropriate decision may be taken to select the borrow areas which meet the requisite specifications. For the purpose of equipment planning, average distance of these borrow areas to the dam site has been considered.

Construction material for concrete, viz., sand/fine aggregate, rock/coarse aggregate, for both non-wearing and wearing surfaces are also located in the vicinity of dam site. For fine aggregate Banne river sand quarry and Barne river sand quarry have been identified. Banne river sand quarry is located at about 25 km from dam axis on the left side of approach road. The other sand quarry is situated at about 30 km from dam axis. The Daudhan village quarry and Palkohan village quarry at a distance of 1.2 km and 1.3 km, respectively and extending up to 2 km have been identified for meeting the requirement of coarse aggregate.

Total concrete requirement of different grades for the main components of the project has been estimated to be approximately 51 lakh cum.

The area for disposal of excavated material has been considered at an average distance of 2.0 km from the dam site for equipment planning purpose.

7.3.3 Basic Considerations

Based on past experience, about 8 working months in a year are available in the area where the project is situated. Other projects in the region have also been planned with this consideration. However, all underground works like tunnels can be constructed throughout the year.

All the surface works are proposed to be executed in two shifts. All the underground works are proposed to be executed in three-shift operation throughout the year.

7.3.3.1 Scheduled Working Hours

Equipment planning for calculating requirement of equipment is carried out based on the number of working days available, which further depends upon climatic conditions of the project area. In the present scenario, the monsoon sets in during June and continues till October in the project area. For equipment planning purpose the monsoon season has been considered from 15th June to 15th October. Thus, for over ground works i.e. dam and appurtenant works a working season of eight months would be available. The underground works are generally not affected by the vagaries of weather and work has, thus, been planned to continue throughout the year. However, since the production capability would be affected during monsoon months especially for the supplies/ services and muck disposal, etc., suitable reduction in the progress has been taken into account for the year as a whole. The scheduled working hours considering 25 working days per month is given in Table 7.2.

Table-7.2

Scheduled working hours

Type of Work / Type of Shift	Over ground works (hr)	Under ground works(hr)
Single shift work/day	8 x 25 x 6 = 1200	12 x 25 x 6= 1800
Two shift work/day	8 x 25 x 11=2200	12 x 25 x 11= 3300
Three shift work/day	8 x 25 x 15 = 3000	12 x 25 x 15= 4500

Two shifts working of equipment is normally considered most economical in view of the high cost of three shift working on account of low availability of equipment and higher stand-by equipment requirement. Thus planning for all over ground works has been carried out based on two shifts per day working. Underground works in any case, are planned for three shifts working as these involve cyclic operations, which do not follow normal shift operation. Provision of standby equipment has been considered as follows:

1. Single shift working	10%
2. Two shift working	20%
3. Three shift working	30%

7.3.3.2 Construction Period

A total period of eight years has been considered for completion of the project. The infra-structural development, pre-construction surveys and investigations, preparation of design/ specifications and tender documents are proposed to be taken up during the first two years. In case the works are to be executed through award of contract, it is planned to award contracts for all major works by the 4th quarter of 2nd year . However, some of the works like diversion channel, spillway channel and link canal may have to be undertaken from the 4th quarter of the 1st year itself and therefore award of work for these works may be planned accordingly. The work on infrastructure facilities like project colonies, approach roads, workshop, haul roads, stores, office buildings etc. will also start in the second year itself. Some of these activities will continue for some time during the third year also. The construction of all civil structures is proposed to be completed within 1st quarter of year 8. The erection, commissioning and testing of units would be required to be planned so that full benefits could be accrued at the end of the proposed construction period.

A total construction period of 51 months have been earmarked for completion of main canal including branch canals, distributaries and other canal structures like aqueducts, super passages, siphons', pipe culverts, road bridges and railway crossings.

The detailed construction schedule for the project in the form of a bar chart is attached as Annexure 7.1.

7.4 Construction Methodology and Equipment

The construction methodology and equipment planning along with construction programme for different components of the project have been described in the succeeding sub-sections.

7.4.1 River Diversion Works

To facilitate construction of earth fill dam, the river will be diverted through left flank by constructing diversion channels. The portion corresponding to 2 blocks of overflow section of the concrete dam will be utilized for diverting the river. Initially, the excavations in these 2 blocks will be carried out and the same will be connected to the river by excavating u/s diversion channel and d/s spillway channel. The excavations will be limited to the extent required for diverting the river.

For diversion works, 12,25,000 cum of excavations will have to be carried out. A period of 1 working season has been planned to undertake the above quantity. The required concreting for this portion is proposed to be

carried out in a period of 3 months. The following construction methods have been considered for river diversion works:

- Excavation and loading of the material by 2.5 cum hydraulic excavator.
- Transport to the disposal area by means of 18/20 t rear dumpers.
- The rock excavation to be undertaken by drilling & blasting. Jack hammers and wagon/crawler drill with hole patterns of 1m and 2.75 m c/c respectively to be deployed for drilling of charge holes.

Separate provision of the equipment for this activity has not been kept as some of the equipment to be deployed for earth dam can be utilized on this activity.

7.4.2 Earthfill Dam (Daudhan)

The construction of the dam involves surface excavation, placement of fill material, spreading & wetting and compaction of the fill material. The quantities involved in construction of the dam are given in Table 7.3.

Table-7.3

Quantities involved in construction of the dam

Description of Work	Type / Material	Quantity, in-situ	Unit
Stripping	-	2,69,680	cum
Excavation	Common	2,25,573	cum
	Rock	19,169	cum
Fill placement	Hearting material	23,44,958	cum
	Casing material	102,13,782	cum
	Filter, Fine	5,19,691	cum
	Filter, Coarse	5,64,639	cum
	Rock toe	1,72,247	cum

7.4.2.1 Surface Excavation

The surface excavation for main dam as well as for cofferdams involves both common and rock excavations. The volume of required excavation is given in Table 7.4.

Table-7.4: Volume of Surface Excavation

Type / Description	Common excavation (cum)	Rock excavation (cum)
Stripping	2,69,680	Nil
Excavation for trenching and preparation of base	2,25,573	19,169
Total	4,95,253	19,169

One working season has been earmarked for undertaking surface excavation pertaining to main dam. Although work in the river bed can be undertaken only after completion of river diversion work, the work of stripping can be taken up earlier. The requirement for which provision of equipment for the surface excavation is to be made is given in Table 7.5.

Table-7.5
Estimation of hourly quantity of excavation

Type / Description	Common Excavation	Rock Excavation
Total volume (cum)	495253	19169
Time period (months)	8	8
Shift proposed	2	2
Total operational hours (hr)	2200	2200
Volume to be handled in-situ (cum/hr)	225	9
Volume to be handled loose (cum/hr)	281	15

Total quantity = 281+15 = 296 cum/hr

Peak quantity = 370 cum/hr

Following construction methods are proposed for surface excavations:

- Stripping and excavation for trenching & preparation of base of dam and loading of the soft material (earth and alluvium) by 2.5 cum hydraulic excavators assisted by 180 HP crawler dozer.
- Transportation to the disposal area by 18/20 t capacity rear dumper.
- A 180 HP bulldozer is also considered to stay in the disposal area for spreading of the unloaded materials.

- The rock excavation to be undertaken by drilling & blasting. Jack hammers and wagon/crawler drill with hole patterns of 1 m and 2.75 m c/c respectively to be deployed for drilling of charge holes.

7.4.2.2 Fill Placement

The construction of earth fill dam involves placement of 1,36,43,030 cum of fill materials. As per construction schedule the fill placement is to be undertaken in a period of 32 months excluding the monsoon period. The break-up of total quantity into different types of fill material to be placed in different zones and their expected source of supply is given in Table 7.6.

Table-7.6
Quantities and source of fill material

S. No.	Fill Material	Quantity (compacted) (cum)	Average distance of borrow area/quarry (km)
1.	Hearting Material	23,44,958	6.0
2.	Casing material	102,13,782	6.0
3.	Filter, Fine	5,19,691	5.25
4.	Filter, Coarse	5,64,639	2.25
5.	Rock toe	,72,247	.25
	Total	1,36,43,030	

The fill placement will require excavation and loading of material at the borrow areas/quarries, transportation of the material to the placement site and unloading. It is necessary that various alternative methods and equipment are evaluated and appropriate construction methods and suitable construction equipment are selected.

Hydraulic excavator-rear dumper combination is the most commonly used method of material transportation in a river valley project. The selection of hydraulic excavators depends on the quantities to be handled, limitations of space at the site and the availability of standard equipment. Matching rear dumpers are estimated taking into account the distance to be travelled, the load ratings of haul roads and traffic intensity. This method is considered quite flexible as this allows introduction of additional equipment to supplement the capacity, if required. These equipments are available as standard items and most of the sizes which may be required on river valley projects are manufactured indigenously.

Belt conveyor system is considered a good alternative for transportation of material over long distances. In this method the capital cost

of equipment is high, but the disadvantage is offset by the low running and maintenance costs. However, some limitations are posed by the maximum lump size, which can be transported through these belt conveyors.

In the present case, since fill material is available within a distance of 6 km and borrow areas are scattered over different locations, the conventional method of material transportation, i.e., hydraulic excavator-dumper combination has been considered for material transportation.

(i) Hearting Material

As mentioned above, the fill quantities are to be placed in four working seasons. The hourly placement quantities for hearting material have been worked out and given in Table 7.7.

Table-7.7
Estimation of hourly quantity of hearting material placement

S.No	Description	Quantity	Unit
1.	Total volume	23,44,958	cum
2.	Time period	32	month
3.	Shift proposed	2	-
4.	Operational hours/month	275	hr
5.	Total operational hours	8,800	hr
6.	Volume to be handled (in-situ)	267	cum/hr
7.	Volume to be handled (loose)	333	cum/hr
8.	Peak quantity	417	cum/hr

The following construction methods have been considered for hearting fill:

- Excavation and loading by means of 2.5 cum hydraulic excavator.
- Transport to the embankment by means of 18/20 t capacity rear end dumpers.
- Spreading by 180 HP bulldozer.
- Moisture adjustment by 8000 L water sprinklers.
- Compaction by 8 passes of 10 t pad foot vibrating roller.

An average distance of 6.0 km from dam site has been considered for the borrow areas for impervious material.

(ii) Casing Material

The total quantity of semi-impervious material to be placed in the earth dam is 1,02,13,782 cum. It is proposed that all the material will be transported from the borrow areas which are within a distance of 6.0 km (average distance) from the dam axis.

The hourly placement quantity for semi pervious material has been worked out and given in Table 7.8.

Table 7.8

Estimation of hourly quantity of semi-impervious material placement

Description	Quantity	Unit
Total volume	102,13,782	cum
Time period	32	month
Shift proposed	2	-
Operational hours/ month	275	hr
Total Operational hours	8,800	hr
Volume to be handled (in situ)	1,160	cum/hr
Volume to be handled (loose)	1,450	cum/hr
Peak quantity	1,814	cum/hr

The following construction methods have been considered for semi-impervious earth fill:

- Excavation and loading of the material at borrow area by 2.5 cum hydraulic excavator.
- Transport to the embankment by means of 18/20 t rear dumpers.
- Spreading by 180 HP bulldozer.
- Moisture adjustment by 8000 L water sprinklers
- Compaction by 8 passes of 10 t pad foot vibrating roller.

(iii) Fine, Filter

The fine filter will have a total volume of 5,19,691 cum and this quantity will be brought from quarries located at an average distance of 5.25 km from dam site. The material will be processed in a processing plant located suitably near the quarry itself. The fine filter material will be processed and brought to the dam site for placement.

As the quantity of filter material is comparatively less, single shift work/day is proposed for filter placement. The hourly rate at which placement of filter is to be carried out is given in Table 7.9.

Table-7.9

Estimation of hourly quantity of filter material placement

Description	Quantity	Unit
Total volume	5,19,691	cum
Time period	32	month
Shift proposed	1	-
Operational hours/month	150	hr
Total operational hours	4,800	hr
Volume to be handled (in-situ)	108	cum/hr
Volume to be handled (loose)	135	cum/hr
Peak quantity	169	cum/hr

The filter materials will be placed in accordance with the following construction methods.

- Loading at the quarry by 2.5 cum hydraulic excavator and transportation up to filter processing plant by 18/20t capacity rear dumper.
- Processing at the filter processing plant of capacity, 350 tph installed near the quarry.
- Loading by 1.5 cum loader and transport to the dam site by 18/20 t capacity rear dumper.
- Spreading on the embankment in layers up to 50 cm thick by bulldozer with flywheel power of 180 HP.
- Compaction with 6 passes of 10t smooth drum vibratory roller.

(iv) Coarse Filter and Rock-toe

The requirements of coarse filter and rock-toe is approximately 7,36,886 cum, which will be met from rock quarries. The rock will be transported to the placement site. As in the case of fine filter material, the coarse filter and rock-toe material quantity being less, a single shift working is proposed for placement. The estimation of hourly quantities involved is given in Table 7.10.

Table-7.10
Estimation of hourly quantity of coarse filter and rock-toe material placement

Description	Quantity	Unit
Total volume	7,36,886	Cum
Time period	32	Month
Shift proposed	1	-
Operational hours/month	150	hr
Total operational hours	4800	hr
Volume to be handled/hr (in situ)	154	cum/hr
Volume to be handled/hr (loose)	246	cum/hr
Peak quantity	307	cum/hr

The following construction methods and equipment are considered suitable for rockfill placement:

- Drilling of charge holes at the quarry by means of jack hammers and crawler drills with hole patterns of 1-2.75 m c/c.
- Blasting by means of electric detonators connected to proper wire circuits.
- Loading at the quarry by 2.5 cum hydraulic excavator and transportation up to filter processing plant by 18/20t capacity rear dumper.
- Processing at the filter processing plant of capacity, 500 tph installed near the quarry.
- Loading at the filter processing plant by 2.5 cum loader and transport to the dam site by 18/20 t capacity rear dumper.
- Spreading of the unloaded material on the embankment to about 70 cm layer thickness, by means of 180 HP flywheel power bulldozer.
- Compaction by 10 t smooth drum vibrating rollers.

7.4.2.3 List of Major Construction Plant and Equipment for Earth Dam

Based on above methodology and equipment planning the list of equipment required for construction of earth dam (Daudhan) is given in Table 7.11.

Table-7.11
List of equipment required for construction of earth dam (Daudhan)

S. No.	Description	Size/capacity	Quantity
1.	Hydraulic excavator	2.5 cum	15
2.	Crawler/wagon drill	600 cfm	4
3.	Jack hammer	120 cfm	24
4.	Front end loader	2.5 cum	3
5.	Front end loader	1.5 cum	3
6.	Rear end dumper	18/20t	144
7.	Crawler dozer	180 HP	10
8.	Vibratory compactor (pad foot)	10t	6
9.	Vibratory compactor (smooth drum)	10t	2
10.	Water sprinklers	8000 L	8
11.	Air requirement	cfm	5000
12.	Filter processing plant	500 tph	1
13.	Filter processing plant	350 tph	1
14.	Truck	8/10 ton	8

7.4.2.4 Construction Programme

The excavations for the dam will start from the abutments above river bed level in the 4th quarter of year 2 and will be completed within 1 working season. Excavations in the river bed including cut-off trench will start as soon as the work area in the river bed becomes dry. The dam foundation treatment, which includes consolidation grouting and curtain grouting, will start locally as the excavation is completed in that area. The timely completion of the surface treatments for the core foundation in the river bed is essential in order to allow the beginning of the clay placement. Thereafter, this work will proceed slightly in advance of the raising of the core where it is required.

Embankment construction will start by 1st quarter of year 4, once the excavation and foundation preparation works in the river bed are sufficiently advanced. The period before the beginning of the embankment construction shall be devoted to the preparation of the haul roads and development of the borrow area.

A total period of 32 months, excluding the monsoon period has been allowed for the completion of the dam embankment with the aim to reach crest elevation by the end of 4th quarter of year 7.

7.4.3 Concrete Dam (Daudhan)

Main activities to be undertaken for construction of concrete dam (over flow & non-over flow sections) are surface excavations and concreting. Surface excavations will comprise of common excavation in overburden and rock excavation. The quantities involved in construction of dam are given in Table-7.12.

Table-7.12
Quantities involved in construction of concrete dam
(over flow & non-over flow)

S. No.	Description	Common Excavation (cum)	Rock Excavation (cum)	Concreting (cum)
1.	Over Flow Section	-	11,27,716	9,47,426
2.	Non-over Flow Section	25,227	1,35,910	4,61,676
3.	d/s Spillway Channel (Balance Qty.)	-	96,80,650	-
4.	u/s Diversion Channel (Balance Qty.)	-	50,98,000	-
	Total	25,227	1,60,42,276	14,09,102

7.4.3.1 Surface Excavations

In addition to the quantity of excavation for concrete dam, the balance quantities of u/s diversion channel and d/s spillway channel will also be undertaken simultaneously. Spillway being a gated structure enough time is required for concreting and erection of gates. The surface excavations have been planned to be completed within 5 working seasons (32 months). The excavated material will be transported to the disposal area using conventional excavator and rear dumper combination. The estimation of hourly quantity of excavation is given in Table 7.13.

Table-7.13

Estimation of hourly quantity of excavation

Type / Description	Common Excavation	Rock Excavation
Total volume (cum)	25,227	1,60,42,276
Time period (months)	40	40
Shift proposed	2	2
Total operational hours (hr)	11000	11000
Volume to be handled in-situ (cum/hr)	2	1458
Volume to be handled loose (cum/hr)	3	2333
Peak Volume to be handled (cum/hr)	4	2916

Total quantity = 4 + 2916 = 2920 cum/hr

The construction equipment for surface excavations is as under:

- Excavation and loading of the soft material (common excavation) by 2.5 cum hydraulic excavators assisted by 180 HP bulldozers.
- For rock excavations requiring drilling & blasting, drilling the very steep areas by hand-held rigs (jack hammer) of 38 mm diameter with hole patterns of about 2.75 sq m and drilling the accessible areas by crawler drill.
- Loading of blasted rock by 2.5 cum hydraulic excavator, shovel attachment and assisted by 180 HP dozers.
- Transportation to the disposal areas/main dam by 18/20t rear dumpers.
- Crawler dozer, 180 HP to be deployed at the disposal area to spread the material.

7.4.3.2 Concreting

For concreting of main dam and appurtenant structures, total quantity of the order of 15 lakh cum, will have to be placed. A period of 3 working seasons has been planned for the placement. The rate of placement works out to 150 cum/hr approximately. The concrete required for main dam is proposed to be produced in a centralized Batching and Mixing Plant of capacity 180 cum/hr. The plant shall be located in the vicinity of the dam. In addition, two numbers mobile batching & mixing plant each of capacity, 18 cum/hr will be provided. The concrete from the plant will be transported with the help of transit mixers, 4.5 cum capacity.

Following construction equipments have been considered for concreting of main dam and appurtenant structures:

- Placing of concrete with the help of travelling type tower cranes. 4 Nos. tower cranes, 10 ton @ 30 m radius are proposed to be deployed at suitable locations. In addition, 3 Nos. 38 cum/hr concrete pumps with 25 m boom will be used for concrete placement.
- Concrete transportation by transit mixers of 4.5 cum capacity.
- Batching and mixing plant of capacity 180 cum/hr to be located preferably within a radius of 2 km from the concrete dam.
- The aggregate crushing and screening plant of 350 tph for preparation of coarse and fine aggregates.

7.4.3.3 List of Major Construction Plant and Equipment for Concrete Dam

Based on above construction methodology, major construction plant and equipment required for construction of concrete dam are given in Table 7.14.

Table-7.14
Major construction plant and equipment required for construction of concrete dam

S. N0.	Equipments	Size/capacity	Quantity
1	Hydraulic excavator	2.5 cum	16
2	Crawler dozer	180 hp	10
3	Front End Loader	2.5 cum	4
4	Crawler/wagon drill	600 cfm	14
5	Jack hammer	120 cfm	54
6	Rear dumper	18/20t	96
7	Tippers	4.5 cum	20
8	Hydraulic Rock breaker		2
9	Tower Crane, travelling type	10t@30m	4
10	Aggregate processing plant	350 tph	1
11	Batching & mixing plant	180 cum/hr	1
12	Mobile Batching & mixing plant	18 cum/hr	2
13	Transit mixers	4.5 cum	18
14	Concrete pump with 25m boom	38 cum/hr	3
15	Concrete Vibrator (electrical/pneumatic)		30
16	Compressed air	cfm	8000
17	Grout pump	20 kg/m^2	4
18	Trucks	8/10 ton	10

7.4.3.4 Construction Programme

The sequence of construction of concrete dam takes into account the following aspects:

- Surface excavation of concrete dam to start during the 4^{th} quarter of Year 2.
- The excavation of balance quantities of u/s diversion channel and d/s spillway channel to be taken up simultaneously with the dam excavation.
- The total quantity of excavation to be completed in a period of 5 working seasons. The activity to be completed by the end of 2^{nd} quarter of year 7.

- Concreting to start in the 4th quarter of Year 4 and will continue for 3 working seasons and to be completed by the end of the 2nd quarter of year 7.
- Since a part of over-flow section (two blocks) is to be used for diversion of river during construction of earth dam, the phasing of concreting is to be planned in such a way that the work of these two blocks is completed during lean season.
- Gate installation work to start in the beginning of 1st quarter of year 7 and will be completed by the end of 2nd quarter of Year 8.

7.4.4 PH-I (Dam Power House) Complex

PH-I complex (Dam power house) will house two nos. of Vertical Shaft Kaplan turbines.

7.4.4.1 Excavation and Concreting

Main activities to be undertaken for construction of power house complexes are surface excavations and concreting along with erection of electro-mechanical equipment. The quantities involved in the dam power house complex are given in Table 7.15.

Table-7.15
Quantities involved in the dam power house complex

S. No.	Description	Quantity (cum)
1.	Surface excavations	
	a) Common Excavation	10,000
	b) Rock excavation	1,02,000
2.	Concreting	62,630

The sequence of operations for power house complex is based on the following construction methods and equipment:

- Excavation and loading of the soft material by 2.5 cum hydraulic excavators assisted by 180 HP dozer.
- For rock excavations requiring drilling and blasting, drilling the very steep areas by hand-held rigs with 38 mm diameter with hole patterns of about 1-2.5 sq m and drilling the accessible areas by crawler rigs with 76 mm bits and hole patterns ranging from 7.5 to 9.0 sq m.
- Loading of the blasted rock by 2.5 cum hydraulic excavator bucket shovel attachment and assisted by 180 HP dozers.
- Transportation to the disposal areas by 18/20 t rear end dumpers.

- Placing of concrete with 20 cum/hr concrete pumps with 25 m boom.
- Concrete transportation by 4.5 cum transit mixers.
- Concrete production in a Batching and mixing plant of capacity 180 cum/hr.
- The aggregate crushing and screening plant of 350 tph for preparation of coarse and fine aggregates.
- Tower crane of 10 t at 30 m radius is to be utilized for handling of construction material, shutter forms etc.

7.4.4.2 List of Major Construction Plant and Equipment

No separate equipment for construction of PH-I has been provided as equipment deployed for concrete dam shall be utilized for construction of PH-I.

7.4.4.3 Construction Programme

As the excavation quantities are not much, a period of 5 months has been planned beginning in the 4th quarter of year 5. The construction of the concrete structures will begin by the 1st quarter of Year 6 starting from the structures of the erection area. Almost 14 months have been considered necessary to complete the first stage structures to the extent required to allow the erection of main powerhouse cranes.

The encasement of the draft tubes and spiral cases and the subsequent construction of the second stage structures of the powerhouse will continue according to the equipment erection schedule. All works including electro-mechanical works will be essentially completed by 2nd quarter of year 8.

7.4.5 PH-II (Canal Power House) Complex

The structures for PH-II include a lower level tunnel, surge shaft, and surface type power house. The water from the power house shall be discharged through a TRC in to Ken LBC. An arrangement to bye-pass power house and discharge water directly into Ken LBC has also been made to feed water into Ken LBC when the power house is not running.

7.4.5.1 Intake Structure

The intake structure for PH-II, i.e. lower level tunnel shall be modified horseshoe shaped having 5.5 m diameter and 1100 m length. In view of its size, the intake tunnel is proposed to be excavated by full face drill and blast method.

Heavy duty rock drills mounted on work platform will be utilized for drilling of charge holes. Pull of 2.0 m per cycle of operation has been planned in good rock strata.

The method of excavation for a pull of 2.0 m in good rocks using heavy duty rock drills is as under:

- Drilling with heavy duty rock drills for which cycle time would be around 8 hrs.
- Charging operations of explosive executed by means of platform jumbo.
- Wheel loader of 1.5 cum bucket capacity in combination with 10 ton tippers will be deployed for mucking operation.
- Shotcrete with the help of 10-15 cum capacity wet shotcrete machine.
- Rock bolting by using rock drills for drilling holes and inserting and tightening of rock bolts manually using work platform.

The cycle time for excavation of lower level tunnel (2.0 m pull) is given in Table 7.16.

Table-7.16 : Cycle time for excavation of lower level tunnel

S. No.	Item of work	Time (hr)
1.	Preparation	0.5
2.	Drilling	8.0
3.	Loading/blasting/ defuming	1.5
4.	Removal of jumbo	0.5
5.	Shotcreting (primary)	1.0
6.	Scaling	1.0
7.	Shotcreting (secondary)	2.0
8.	Mucking	4.0
9.	Rock bolting	3.0
Total cycle time		21.5

With this progress rate, excavation of 1100 m length can be completed in 16 months by working simultaneously on both the faces.

The concrete lining of tunnel shall start after the completion of excavation. The concrete will be placed in the overt section with the help of 12 m long shutter form and in invert with the help of open screen. A peak progress rate of 10 m per day is expected at each face.

7.4.5.2 Surge Shaft

A surge shaft of 18.0 m diameter and having height of 62.0 m is a part of water conductor system.

Considering the dimensions of shaft and ease of construction, the surge shaft will be excavated in two stages, first a pilot shaft will be excavated throughout the length and thereafter, the shaft will be widened to final dimensions. The pilot shaft of 2.5 m diameter would be consequently utilized for the mucking of the second stage widening.

Excavation of pilot shaft will be undertaken manually using conventional drilling and blasting method from top to bottom with jack hammers. Men and material will be lowered from the top using winch-operated hoist.

The construction methods for excavation of pilot shaft of 2.5 m diameter from the top are as follows:

- Drilling of charge holes by jack hammer and charging them with explosives.
- Blasting after taking the man and material up using hoist.
- Defuming by spraying a mixture of air and water from top.
- Mucking using 1.0 cum skip bucket lifted by 10t winch installed on the top of the shaft. Loading of muck on the skip bucket will be done manually.

Once the pilot shaft has reached the excavated level of the surge shaft the pilot shaft shall be enlarged to the final size. An elevator (rack & pinion type) will be installed for the movement of men. The area to be enlarged shall be subjected to drilling and blasting with an average pull of 1.0 m. While drilling at the top and mucking through the bottom, top of the pilot shaft will be covered with a steel baffle plate as a safety precaution. During enlargement, drilling will be done on a slightly inclined plane so that the blasted muck can be pushed down through the shaft manually. Muck can be removed from the bottom of the shaft by deploying wheel loader of 1.5 cum bucket capacity in combination with 10 ton tippers. This mode ensures excavation at a fast pace and with little effort. Material will be lowered from the top using winch-operated hoist.

The construction method for widening of shaft with 1.0 m lift is as under:

- Drilling of charge holes by jack hammers after covering the pilot hole with a steel baffle plate to ensure safety for the crew.

- Drilling length to be controlled to produce tunnel profile to facilitate flow of blasted material towards pilot shaft.
- Pushing of remaining blasted material through pilot shaft manually by hand shovel.
- Loading of muck at bottom of pilot shaft by deploying wheel loader of 1.5 cum bucket capacity in combination with 10 ton tippers.
- Rock bolting and Shotcreting as per design parameters.

A typical cycle of widening one fourth of surge shaft for a lift of 1.0 m is given in Table 7.17.

Table-7.17
Cycle time for surge shaft enlargement

S.No.	Item of work	Time (hr)
1.	Preparation Time	1.00
2.	Lowering drilling Machinery and Men	1.00
3.	Drilling	2.70
4.	Charging	0.50
5.	Retrieving drilling Machinery and Men	1.00
6.	Loading/Blasting/Defuming	1.00
7.	Lowering shotcrete m/c and men	1.00
8.	Pushing of muck	1.00
9.	Stabilization measures	2.00
10.	Retrieving shotcrete m/c and men	1.00
11.	Mucking	0.50
12.	Miscellaneous activities	1.00
Total cycle time (approx.)		13.70

Concreting of surge shaft will be undertaken in the last. Concreting of surge shaft will be carried out from bottom to top. The formwork for concreting would be 2.0 m height. Concrete shall be poured either by chute from the top or by concrete pump from the bottom. A typical concrete cycle is given in Table 7.18.

Table-7.18
Cycle time for concreting

SN	Schedule of Work	Time (hr)
1.	Move, set form	5.00
2.	Place concrete	4.00
3.	Setting Time	12.00
4.	Removal of set form and misc. time	3.00
Total cycle time		24.00

A pour can be achieved every alternate day. The average monthly progress that can be achieved is 25 m.

7.4.5.3 PH-II

PH-II will be surface type to house three vertical shaft Kaplan turbines.

Main activities to be undertaken for construction of PH-II are surface excavations and concreting along with erection of electro-mechanical equipment. Surface excavations will comprise of common excavation in overburden and rock excavation. The quantities involved in the main structures of powerhouse are given in Table 7.19.

Table 7.19
Quantities involved in the main structures of powerhouse

S. No.	Description	Quantity (cum)
1.	Surface excavations	
	a)Common Excavation	10,000
	b) Rock excavation	45,900
2.	Concreting	21,450

The sequence of operations for power house complex is based on the following construction methods and equipment:

- Excavation and loading of the soft material by 2.5 cum hydraulic excavators assisted by 180 HP dozer.
- For rock excavations requiring drilling and blasting, drilling the very steep areas by hand-held rigs with 38 mm diameter with hole patterns of about 1-2.5 sq m drilling the accessible areas by crawler rigs with 76 mm bits and hole patterns ranging from 7.5 to 9.0 sq.m.
- Loading of the blasted rock by 2.5 cum hydraulic excavator bucket shovel attachment and assisted by 180 HP dozers.
- Transportation to the disposal areas by 18/20t rear end dumpers.
- Placing of concrete with 20 cum/hr concrete pumps with 25 m boom.
- Concrete transportation by 4.5 cum transit mixers.
- Concrete production in a Batching and mixing plant of capacity 30 cum/hr.
- The aggregate crushing and screening plant of 70 tph for preparation of coarse and fine aggregates.

- Tower crane of 5t at 30 m radius is to be utilized for handling of construction material, shutter forms etc.

7.4.5.4 List of Major Construction Plant and Equipment

Based on the above methodology, major construction plant and equipment required for construction of PH-II complex have been worked out and given in Table 7.20.

Table-7.20
Major construction plant and equipment required
for construction of PH-II complex

S. No.	Equipments	Size/capacity	Quantity
1.	Hydraulic excavator	2.5 cum	2
2.	Front End Loader	1.5 cum	2
3.	Crawler/ wagon drill	600 cfm	1
4.	Jack hammer	120 cfm	5
5.	Heavy duty rock drill mounted on platform jumbo	4 x 120 cfm	2
6.	Rear dumper	18/20 t	10
7.	Tippers	4.5 cum	8
8.	Crawler dozer	180 HP	1
9.	Aggregate processing plant	70 tph	1
10.	Batching & mixing plant	30 cum/hr	1
11.	Concrete pump with 25 m boom	20 cum/hr	3
12.	Shotcrete m/c	10-15 cum/hr	2
13.	Transit mixers	4.5 cum	4
14.	Grout pump	20 kg/m^2	2
15.	Tower crane	5 t/30 m	1
16.	Mobile crane	20 t	1
17.	Crawler crane	30 t	1
18.	Concrete Vibrator (electrical/pneumatic)		20
19.	Compressed air	Cfm	5000
20.	Electric winch	20 t	2
21.	Concrete Shutter Form	2m x 6 m	4
22.	Concrete Shutter Form	10 m x 5.5 m	1

7.4.5.5 Construction Programme

The excavation of tunnel from both the faces will start simultaneously in the beginning of 2nd quarter of year 4 after the completion of portals. The excavation from the two faces will be completed by the end of 2nd quarter of

year 5, after which concreting will be carried out and will be completed by the end of year 5.

The construction sequence and programme of surge shaft is as follows:

- Excavation of pilot shaft will start after the completion of open excavation and to complete within a span of 4 month.
- Enlargement of surge shaft will start subsequently and to continue for 6 months till the end of May of year 5.
- Concreting will start after the work of enlargement is over and will be completed within a period of 6 months.

For power house excavation, a period of 8 months has been planned starting from 4th quarter of year 4. The construction of the concrete structures will begin in the 4th quarter of Year 5 starting from the structures of the erection area. Almost 14 months excluding the monsoon period have been considered necessary to complete the first stage structures to the extent required to allow the erection of main powerhouse cranes. After that, 3 additional months will be required to complete all first stage structures.

The encasement of the draft tubes and spiral cases and the subsequent construction of the second stage structures of the powerhouse will continue according to the equipment erection schedule.

7.4.6 Ken LBC

The construction of Ken LBC and associated branch canals involve surface excavation in some reaches and placement of fill material in others. The excavations include common excavation and rock excavation which may require drilling and blasting. For fill reaches, spreading & wetting and compaction of the fill material will have to be undertaken. In addition, the canal will be lined with concrete lining. The quantities involved in construction of the Ken LBC and associated branch canals are shown in the Table 7.21.

Table-7.21

Quantities involved in construction of the Ken LBC and associated branch canals

Description of Work	Type / Material	Quantity, in-situ	Unit
Excavation	Common Rock	91,90,490 3,78,910	cum cum
Fill placement		64,31,500	cum
Lining	Concrete	30,21,000	cum

The estimation of hourly quantity of excavation is given in Table 7.22.

Table-7.22
Estimation of hourly quantity of excavation

Type / Description	Common Excavation	Rock Excavation
Total volume (cum)	91,90,490	3,78,910
Time period (months)	48	48
Shift proposed	2	2
Total operational hours (hr)	13200	13200
Volume to be handled in-situ (cum/hr)	696	29
Volume to be handled loose (cum/hr)	870	46
Peak volume to be handled (cum/hr)	1088	58

Total quantity = 1088+58 = 1146 cum/hr

The construction methodology and equipment for the activities involved in the construction of Ken LBC and associated branch canals will be similar to those required for Ken-Betwa Link Canal and have been described in the relevant section.

7.4.6.1 List of Major Construction Plant and Equipment

Based on above construction methodology, major construction plant and equipment required for construction of Ken LBC are given in Table 7.23.

Table-7.23
Major construction plant and equipment required for construction of Ken LBC

S. N0.	Equipments	Size/capacity	Quantity
1.	Hydraulic excavator	2.5 cum	8
2.	Front End Loader	1.5 cum	2
3.	Crawler dozer	180 HP	4
4.	Crawler/wagon drill	600 cfm	2
5.	Jack hammer	120 cfm	20
6.	Rear dumper	18/20 t	40
7.	Tippers	4.5 cum	10
8.	Aggregate processing plant	100 tph	3
9.	Batching & mixing plant	45 cum/hr	3
10.	Mobile Batching & mixing plant	18 cum/hr	2

S. N0.	Equipments	Size/capacity	Quantity
11.	Transit mixers	4.5 cum	18
12.	Concrete pump with 25m boom	38 cum/hr	3
13.	Concrete Vibrator (electrical/pneumatic)		20
14.	Compressed air	cfm	4000
15.	Grout pump	20 kg/m^2	4
16.	Trucks	8/10 ton	10
17.	Vibratory compactor (pad foot)	10 t	4
18.	Vibratory compactor (smooth drum)	10 t	2
19.	Water sprinklers	8000 L	8

7.4.6.2 Construction Programme

The sequence of construction of Ken LBC takes into account the following aspects:

- A period of 6 working season beginning 4th quarter of year 2 has been planned for undertaking surface excavation as well as fill placement.
- Concreting to start in the 4th quarter of Year 5 and will continue for 27 months and to be completed by the end of the year 8.
- Cross-drainage works and other canal structures to be completed within the above period.

7.4.7 Ken-Betwa Link Canal

The proposed link canal for transferring the surplus water from Ken basin up to Daudhan dam to Betwa basin is 218.695 km long. The water from the reservoir will be led through a tunnel (Upper Level Tunnel) into link canal.

7.4.7.1 Upper Level Tunnel

The tunnel to be excavated is 6 m dia. and 1929 m long. The tunnel will be excavated by drill & blast method by working from two faces simultaneously.

The methodology and equipment for construction of upper level tunnel will be similar to that of the lower level tunnel that have been described under relevant section.

7.4.7.2 Link Canal

Main activities to be undertaken for construction of canal are main canal, branch canals, distributaries and other canal structures like siphons, bridges, railway crossings, super passages along with concrete lining of the main canal. Earth work comprises of both the common excavation in overburden and rock excavation. For fill reaches, spreading & wetting and compaction of the fill material will have to be undertaken. The quantities involved in construction of the Link Canal and associated branch canals are shown in the Table 7.24.

Table-7.24

Quantities involved in construction of the Link Canal and associated branch canals

Description of Work	Quantity, in-situ	Unit
Excavation	4,36,75,204	cum
Fill placement	1,17,41,438	cum
Lining	7,08,599	cum

It is proposed to divide the entire length of canal into four segments and take up the work in all the segments simultaneously so the work can be completed within the stipulated time period. The estimation of hourly quantity is given in Table 7.25.

Table-7.25

Estimation of hourly quantity excavation

Type / Description	Excavation	Fill Placement
Total volume (cum)	4,36,75,204	1,17,41,438
Av. Volume in each of 4 segments	1,09,18,801	29,35,360
Time period (months)	48	48
Shift proposed	2	2
Total operational hours (hr)	13,200	13,200
Volume to be handled in-situ (cum/hr)	827	222
Volume to be handled loose (cum/hr)	1,034	278
Peak Volume to be handled (cum/hr)	1,292	348

Total quantity $= 1,292 + 348 = 1,640$ cum/hr

The sequence of operations for Ken-Betwa Link Canal is based on the following construction methods and equipment:

- Excavation and loading of the soft material by 2.5 cum hydraulic excavators assisted by 180 HP dozer.

- For rock excavations requiring drilling and blasting, drilling the very steep areas by hand-held rigs with 38 mm diameter with hole patterns of about 1-2.5 sq.m and drilling the accessible areas by crawler rigs with 76 mm bits and hole patterns ranging from 7.5 to 9.0 sq m.
- Loading of the blasted rock by 2.5 cum hydraulic excavator bucket shovel attachment and assisted by 180 HP dozers.
- Transportation to the disposal areas by 18/20 t rear end dumpers.
- For fill reaches spreading by 180 HP bulldozer. Moisture adjustment by 8000 L water sprinklers and compaction by 8 passes of 10t pad foot vibrating roller.
- For concrete lining and concreting works, placing of concrete by 20 cum/hr concrete pumps with 25 m boom.
- Concrete transportation by 4.5 cum transit mixers.
- Concrete production in a Batching and mixing plant of capacity 90 cum/hr.
- The aggregate crushing and screening plant of 250 tph for preparation of coarse and fine aggregates.

7.4.7.3 List of Major Construction Plant and Equipment

Based on the above methodology, major construction plant and equipment required for construction of link canal including upper level tunnel have been worked out and given in Table 7.26.

Table-7.26
Major construction plant and equipment required
for construction of link canal including upper level tunnel

S. No.	Equipments	Size/capacity	Quantity
1.	Hydraulic excavator	2.5 cum	32
2.	Front End Loader	2.5 cum	4
3.	Front End Loader	1.5 cum	2
4.	Crawler/ wagon drill	600 cfm	15
5.	Jack hammer	120 cfm	60
6.	Rear dumper	18/20 t	160
7.	Tipper	4.5 cum	8
8.	Crawler dozer	180 HP	16
9.	Crawler dozer	90 HP	8
10.	Aggregate processing plant	250 tph	4
11.	Batching & mixing plant	90 cum/hr	4
12.	Concrete pump	38 cum/hr	8
13.	Mobile concrete mixers	18 cum/hr	8
14.	Transit mixers	4.5 cum	100

S. No.	Equipments	Size/capacity	Quantity
15.	Concrete Vibrator (electrical/pneumatic)		60
16.	Grout pump	20 kg/m^2	8
17.	Mobile crane	20 t	4
18.	Compressed air	Cfm	16000
19.	Trucks	8/10 ton	20
20.	Vibratory compactor (pad foot)	10 t	8
21.	Vibratory compactor (smooth drum)	10 t	4
22.	Water sprinklers	8000 L	12

7.4.7.4 Construction Programme

As the main canal stretches over a significant distance, sufficient time is required to carry out detail surveys for main canal, branch canals, distributaries, minors and to finalize portions of canals for irrigation along with specific emphasis on time required for land acquisition. The contracts for all major works are to be awarded by the first year itself so that all the basic infrastructure required for the canal construction can be completed within second year itself.

A construction period of 6 working seasons has been planned starting from beginning of 4th quarter of year 23. A period of 27 months excluding the monsoon period have been considered necessary to complete the lining of link canal along with the all canal structures.

For construction of upper level tunnel, the excavation from both the faces will start simultaneously from the 2nd quarter of year 2 after the completion of portal construction. Excavation is expected to be completed by 1st quarter of year 4, after which concreting will be carried out and will be completed by the 1st quarter of year 5. An additional 3 months have been provided for grouting and cleaning activity.

7.5 Deployment Schedule

Based on equipment planning and construction programme described in preceding Sections, a construction schedule for whole of the project has been prepared in the form of a Bar Chart and is placed at Annexure 7.1. Keeping this construction schedule as one of the major criteria, a deployment schedule of major construction equipment that would be required for the project is shown in Annexure 7.2. The number of equipment shown in the list has been arrived at after scheduling the equipment in such a way that minimum number of equipment, in general, would be needed. The basis for planning, indicating the type of equipment to be used, has already been dealt with in the respective sections and sub-sections corresponding to different

items of the structures. As the deployment schedule may differ depending upon the number of executing agencies, the total number of equipment required will have to be reviewed at the time of project execution.

7.6 Total Requirement of Major Construction Equipment

A list of major construction equipment and plants, which would be required for the project, is shown in Annexure 7.3. The latest budgetary prices of the equipment have been indicated in the list which could be utilized for working out the analysis of rates as required. The total cost of construction equipment has been worked out as Rs 39114.55 lakh.

The provision on this account will not be included in the sub-head Q - Spl T&P of Cost Estimate when works are to be executed by the contracting agencies.

7.7 Organisation Set Up

The project will be implemented under an organisation set-up headed by an officer of the rank of General Manager. The works will be executed under the overall supervision of Officers of the rank of Chief Engineers who will report to General Manager. In addition, there will be four officers of the rank of Superintending Engineer to assist General Manager viz., Director (Administration), Director (Finance), Director (technical) and Superintending Engineer (Quality Control). Each will be assisted by appropriate subordinate officers and staff. The organisation chart for the project is appended as Annexure 7.4.

There will be three Chief Engineers for the Project to look after the works, viz., Chief Engineer (Head works), Chief Engineer (Canals) and Chief Engineer (Electrical & Mechanical). Each will be supported by three or four officers of the rank of Superintending Engineer who will be heading the field formations of circles. Each circle will have three to four division offices which will be headed by the officers of the rank of Executive Engineers. Executive Engineers in turn will have Assistant Engineers as their subordinate officers who will man Sub-Divisional offices.

Chief Engineer (Head Works) will be responsible for execution of works related to Daudhan earth/concrete dam. One of the Superintending Engineers under him will be responsible for civil designs for these components of the project. Two Superintending Engineers, one each for concrete dam and earth dam will oversee the construction of these components. They will be supported by appropriate subordinate officers as elaborated under the organisation chart.

Chief Engineer (Canal) will be responsible for construction of link canal and Ken LBC. For the purpose of ease in control and supervision, the length of link canal will be divided into different segments and each segment will be

under the control of one Superintending Engineer. The Design unit will be attached with each circle office to provide design of main canal as well as cross-drainage works and other structures. The Chief Engineer (Electrical & Mechanical) will look after the electro-mechanical works of the two power houses. His formation will also provide assistance in respect of electrical and mechanical works for whole of the project.

Detailed manpower requirement has been indicated in Annexure 7.5 to 7.7.

7.8 General Purpose Equipment and Inspection Vehicles

In case the works are to be executed through award of contract, the general purpose equipment for infra-structure works and inspection and transport vehicles which are required to be procured and used by the project owners for the project have been estimated and indicated in the Annexure 7.8. The total cost of general purpose equipment and inspection vehicles has been worked out as Rs. 1869.20 lakh.

7.9 Reconstruction and Remodelling of Bariyarpur PUW and Parichha weir.

After the circulation of DPR of Ken-Betwa link project during Feb.2009, the Govt. of UP requested that the cost of remodelling/renovation of existing Bariyarpur PUW and Parichha weir (both of which are proposed to be integrated with the Ken-Betwa link project) be included in the Phase-I of the DPR of the Ken-Betwa link project since both these structures are quite old and have outlived their expected life and need reconstruction to function as integral part of the proposed link project. And subsequently, the Irrigation Department, Govt. of UP submitted the following two estimates.

1. Project estimate for construction of Barrage and link Channel at Ken river Near Bariyarpur (1 km down stream of existing structure) : Rs.503.53 crores.
2. Construction of a New Dam at Betwa river in the down stream of Existing Parichha weir : Rs.202.23 crore.

As per the irrigation Department, Govt. of UP, construction of new structures is necessitated by the fact that the existing structures are quite old and not fit for repairing and remodelling. The location of new structures on down stream side of existing structures is proposed in order not to interrupt the existing irrigation facilities under these two weirs.

Since the above two proposals/estimates are received from the State Govt. at a much later stage, the detailed examination of these proposals has not been taken up by NWDA and the cost of these proposals as submitted by the state Govt. is taken as it is without any scrutiny.

However, these proposals need further detailed investigation and scrutiny and consensus between both the concerned state Governments viz., MP and UP.

In view of above, no time scheduling, plant planning and man power planning are carried out for the above two proposals viz., Bariyarpur and Parichha weirs at this stage. If approved/agreed upon both these schemes are expected to be taken up simultaneously with the Phase-I of the Ken-Betwa link project.

7.10 Year wise allocation of cost

The total cost of the project including Bariarpur Barrage and Parichha dam proposed by UP State, Irrigation Department is worked out to be Rs. 939298.56 lakhs. The yearly phasing of the same is given in Table 7.27.

Table – 7.27
Yearly Phasing of cost of project

Year	Requirements of funds (Rs. Lakhs)
1	45407.10
2	80326.03
3	119596.63
4	161275.64
5	172741.38
6	172642.14
7	113608.05
8	7370.59
Total	939298.56

The detailed headwise yearly phasing of the cost of the project is furnished as Annexure-7.9.

CHAPTER-VIII
ENVIRONMENT IMPACT ASSESSMENT & ENVIRONMENT MANAGEMENT PLAN

CHAPTER-VIII

ENVIRONMENT IMPACT ASSESSMENT & ENVIRONMENT MANAGEMENT PLAN

The objective of the EIA study is to identify the possible environmental effects to the proposed Ken-Betwa Link Project and to suggest measures to mitigate or ameliorate the anticipated adverse impacts on the environment. The comprehensive study of combined Ken-Betwa link project proposed earlier was assigned to M/s. AFC Ltd., Hyderabad. A brief account of the study including baseline information on various environmental aspects and issues, environmental impact assessment of the project and an appropriate environmental management and monitoring plan along with the costs for the proposed Ken-Betwa Link Project Phase-I are presented in this chapter.

8.1 The Proposed Project

Ken-Betwa Link Project Phase-I involves impoundment of water by construction of a dam across river Ken at Daudhan for Irrigation, drinking and hydro-electric purpose besides transfer of water from Ken river to Betwa river in u/s of Parichha weir. Water, so transported to Betwa is further proposed to be utilized in Upper Betwa basin on substitution basis through projects in Ken-Betwa Link Project Phase-II. As is well known, any Water Resources Development Project may result in both positive and negative impacts on the environment. Such projects require a detailed study of various aspects for identifying positive and negative impacts that may occur in the area and also to formulate a meaningful and applicable Management Plan to mitigate these adverse environmental impacts, or if possible completely eliminate.

8.1.1 Project Background

Ken and Betwa rivers have their origin in Madhya Pradesh and the rivers flow through Madhya Pradesh and Uttar Pradesh. No Major Irrigation Projects were taken up in the Ken River Basin in Madhya Pradesh upto Gangau Weir to harness the waters to irrigate the backward and drought prone areas in the districts of Chhatarpur, Panna and Tikamgarh of Madhya Pradesh and Jhansi and Mahoba of Uttar Pradesh.

A large population in the districts of Chhatarpur, Tikamgarh and Panna in Madhya Pradesh and Jhansi and Mahoba of Uttar Pradesh experience acute shortage of drinking water. It is in this context, the proposed Ken-Betwa Link finds significance. As the proposed project has been found to be techno-economically viable, it is expected that the proposed project is likely to meet the requirements to the tune of 6.35 lakh ha besides providing drinking water facility to about 13 lakh people generating in the process 78 MW of power.

8.1.2 Project Justification

The National Water Policy (2002) emphasizes the need for interlinking of rivers in the country from water surplus areas to water short ones based on a NPP after taking into account the requirement of the surplus areas/basins. This shall be a significant step forward to achieve the objective of equitable distribution and utilization of our limited water resources.

8.1.3 Project Description

The proposed Ken-Betwa Link project Phase-I comprises the following:

(a) Daudhan Dam:

Dam site is located across Ken river near Daudhan village in Chhatarpur and Panna districts of Madhya Pradesh and is accessible by road which is 19 km from Chhatarpur - Panna National Highway. The nearest Railway Station and Airport are at Khajuraho, 31 km. by road. Two tunnels, viz. upper level tunnel and lower level tunnel off-take from left flank of Ken river in the u/s of Daudhan dam. Apart from this, there are two Power Houses, PH-I & PH-II. PH-I is located at toe of dam and PH-II at the exit of lower level tunnel.

(b) Link Canal:

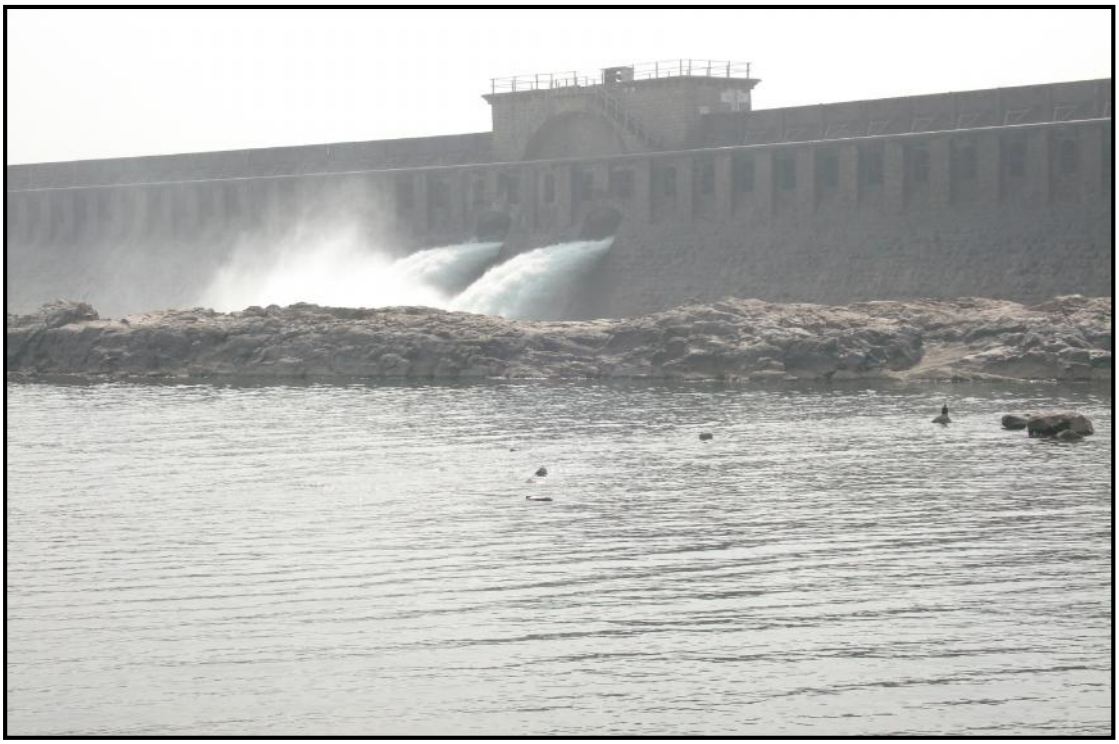
The length of link canal is 220.624 km including a 1.929 km long tunnel starting from the left flank of the reservoir in Chhatarpur district of Madhya Pradesh and terminating into Barwa Sagar Reservoir in Jhansi district of Uttar Pradesh. From there, the water will be diverted to Betwa river in the u/s of Parichha weir through Barwa Nallah of about 7.1 km length.

(c) Ken LBC:

The length of the Ken LBC is 57.30 km. The water from Daudhan to Ken LBC will be passed through a 1.1 km long lower level tunnel and a 2.2 km connecting canal.

The study area considered for the Comprehensive EIA studies and preparation of EMP comprise the following:

- 1 km on either side of the canal
- 10 km radius around the project area from periphery of the project site
- submergence area under the proposed reservoir, including dam
- catchment area of dam/ reservoir
- command area on the d/s side of reservoir and en-route link canal
- areas of backwater influence on u/s side of dam



Front view of the Dukwan Dam on Betwa river

Top view of Parichha weir on Betwa river

8.2 Site Selection

With a view to provide irrigation facilities in the backward regions of Chhatarpur and Panna districts of Madhya Pradesh and to improve the socioeconomic conditions of the people, the State Government proposed to construct Greater Gangau dam on Ken river 210 m d/s of Gangau weir for irrigating 2.41 lakh ha of CCA in the districts of Chhatarpur and Panna. FRL under this proposal was worked out to be 278.89 m with live storage of 2062 MCM. In the context of linking of rivers, NWDA carried out exhaustive studies and revised FRL to 284.2 m with live storage of 2544 MCM.

During review of the PFR with the above proposal, it was opted to increase the FSL of link canal to 260 m to serve the command area at higher elevations. Also, due to construction of Greater Gangau Dam, the existing Gangau Weir functioning well since 1915 would be submerged. Therefore, it was considered to locate the dam site u/s of Gangau weir with the possibility of utilizing the pondage in between the dam and the weir for generation of hydro power as a pumped storage scheme.

8.2.1 Alternate Site

While investigating the potential reservoir sites on Ken river to realign the Ken-Betwa Link with higher off take levels, three reservoir sites were considered on the d/s side of Sonar and Bearma tributaries of Ken are:

(a) Jhalar Reservoir Site,

(b) Ghari Ghat Reservoir Site and

(c) Daudhan Reservoir Site.

After considering several parameters like submergence area, capacity of reservoir, number of villages likely to be affected, forest and cultivable area, Daudhan dam site located about 2.50 km u/s of Gangau weir had been found most suitable and preferred on account of the following reasons:

(i) It would not submerge the existing Gangau weir.

(ii) It would provide enroute irrigation to higher level command of link canal.

(iii) Additional power generation can be achieved.

The FRL & MWL of Daudhan reservoir had finally been proposed at 288 m with gross storage capacity of 2853 MCM. This site also conforms to the geological aspects of the region.

8.2.2 No Project Option

If no project is constructed at the proposed dam site at Daudhan, available 75% dependable yield of Ken at Daudhan cannot be usefully utilized to meet the irrigation requirement of the projected Ken command, within Ken basin particularly in Madhya Pradesh. Even existing Ken command of Uttar Pradesh would get irrigation water at 40-50% of intensity of irrigation due to insignificant storage of Gangau weir. Further, enroute command would also not get requisite quantum of water and the present trend of migration of people from command area to other places would continue. Large part of Bundelkhand region which had been suffering due to frequent occurrence of drought would continue to suffer. The area does not have any mineral deposit based on which some related industry can be set up for Socio-economic up-liftment of the area. Water is the only available natural resource which can be developed through proposed Ken-Betwa Link Project Phase-I for the betterment of area at reasonable cost.

8.3 Legal Status of the Project

Though there are large benefits that may accrue after implementation of the project, due weightage has to be given to social, environmental and economic concerns. One of the important social considerations is the process of public consultation. It has two components viz. public hearing at site or its close proximity for ascertaining concerns of local affected persons and obtain responses in writing from concerned persons having a stake in the environmental aspects of the project. While formulating the various components of the Ken-Betwa Link project Phase-I, the provisions of National Water Policy (2002) have been kept in view. Similarly, the Forest (Conservation) Act-1980 has been completely complied with while dealing with the forest area in the project. As the Ken-Betwa Link project Phase-I, across Ken river submerges a forest land of 5258 ha, a provision for double the area has been proposed towards compensatory afforestation as per the Forest (Conservation) Act-1980.

The Wildlife (Protection) Act – 1972 provides for protection of listed species of flora and fauna and establishes a network of ecologically important areas. The provisions of this Act have also been kept in view while dealing with the wildlife issues in the project area. Permission of Central Empowered Committee would be obtained for conservation of Wildlife before taking up implementation of the project. Similarly, clearance of MOEF would be required to be obtained and techno- economic clearance of the project is required from the CWC. NOC is required from Ministry of Coals and Mines stating that no potential minerals are likely to be submerged due to the project. Also, a NOC would be required from the Ministry of Archaeology about the submergence of monuments of archaeological importance. Due attention has been paid to the various provisions of National Policy on R&R and the policy enunciated by the GoMP regarding the R&R of displaced people due to the construction of Daudhan project.

8.4 Baseline Environmental Data

Before initiating any step for studying EIA of the project, it is essential to identify 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. A similar approach has been adopted for conducting comprehensive EIA study for the proposed Ken-Betwa Link project. A scoping matrix has been formulated to identify various parameters that are likely to be affected. Baseline status has been ascertained for air, water, land, public health and biological (terrestrial and aquatic) environment.

8.4.1 Air Quality

The status of ambient air quality has been observed at 8 sites viz. Barwa Sagar, Sukhwa river, Link canal crossing, Gharauli, Rahne fall, Bhusor, Gangau weir site and Daudhan dam site. The monitoring of the air quality has been done for monsoon season of 2007, post monsoon 2007 and pre-monsoon 2008. The parameters like SPM, sulphur dioxide and oxides of nitrogen have been studied. As observed, the values of SPM varied between 112 and 148 µg/Nm^3. The sulphur dioxide ranged between 13 and 17 µg/Nm^3. The oxide of nitrogen varied between 10 and 13 µg/Nm^3. The existing noise level at various locations of Ken-Betwa Link areas has been observed during monsoon of 2007. The levels found to range between 33 and 60 dB.

8.4.2 Meteorology

The climate of the region is tropical, semi-arid to dry sub humid. It is generally tolerable except during the months of January, May and June. The air is mostly dry except during the southwest monsoon season. Summer is hot and winter is mild. About 90-95 % of annual rainfall is received during monsoon months. Average maximum and minimum temperature are 44.2 °C and 6.7 °C respectively. The four major factors that determine the climate of area are rainfall, temperature, relative humidity and wind velocity.

(a) Rainfall

Analysis of rainfall data of 17 rain gauge stations for fifteen years in the catchment of Daudhan dam revealed that rainfall varied from 4 mm to 58 mm during pre monsoon, from 637 mm to 1375 mm during monsoon and from 11 mm to 63 mm during post monsoon. Mean total annual rainfall is 1080 mm. Sagar rain gauge station received maximum average annual rainfall of 1495 mm whereas Sirmaria of Panna district received minimum average annual rainfall of 671 mm.

(b) Temperature

Analysis of 4 IMD Meteorological stations for Daudhan dam area revealed that mean maximum temperature is 32.3°C while mean minimum temperature is 19.5°C.

(c) Relative Humidity

The average Relative Humidity (RH) for Daudhan dam area at 08.30 hr is 64% while it is 47% at 17.30 hr. Mean RH is 57%.

(d) Wind Velocity

Average Wind velocity for Daudhan dam area is 4.0 km/hr.

8.4.3 Water Quality

The proposed Ken-Betwa Link project, Phase-I is located in an area with low population density ranging between 104 to 347 per sq km with no major sources of pollution. The habitats in the project area and the catchment area are highly scattered and generally are away from streams. As at present, the area under assured irrigation is quite less and agro-chemicals being used in both irrigated and un-irrigated lands are limited, there seems to be virtually no hazards of pollution.

8.4.3.1 Surface Water Quality

As a part of the field study, surface water samples were collected from Ken river and analyzed for various physiochemical parameters. As an example, the test results of water samples (collected during monsoon of 2007) for various parameters analyzed are furnished in the Table 8.1.

Table-8.1
Physiochemical analyses of surface water samples collected from Ken at Bhusor on September 2007

S. No.	Parameter	Units	Ken at Bhusor	Standard
1	p^H	-	7.28	6.50-8.50
2	Electrical Conductivity	Micro mhos/cm	180	-
3	Dissolved Solids	mg/L	120	500
4	Turbidity	NTU	1.80	5
5	Total Hardness as $CaCO_3$	mg/L	84	300
6	Alkalinity to phenophthaline as $CaCO_3$	mg/L	Nil	200
7	Alkalinity to methyl orange as $CaCO_3$	mg/L	65	200
8	Non-Carbonate Hardness as $CaCO_3$	mg/L	19	-
9	Calcium as Ca	mg/L	21	75
10	Magnesium as Mg	mg/L	08	30
11	Sodium as Na	mg/L	02	-
12	Potassium as K	mg/L	01	-
13	Chlorides as Cl	mg/L	13	250
14	Sulphates as SO_4	mg/L	05	200
15	Nitrate as NO_3	mg/L	2.5	45
16	Fluorides as F	mg/L	0.70	1.00-1.50
17	Silica as SO_2	mg/L	08	5
18	Iron as Fe	mg/L	0.05	0.3
19	Colour	-	Colourless	Colourless
20	Feacal Coliforms	x 10^2/100 ml	1	100cfu/250ml
21	Total Coliforms	x 10^2/100 ml	2	100cfu/1ml
22	COD	mg/L	18	250
23	BOD	mg/L	11	100
24	Nutrient Status			
	a) N	mg/L	1	45
	b) P	mg/L	1	NA
	c) K	mg/L	01	NA

The test results presented in the table indicate that quality of surface water is generally safe category. It is further reinforced by the test results of other surface water samples collected from various sites in the project area.

8.4.3.2 Ground Water Quality

The occurrence and behaviour of ground water depends on climatology, geological structure and hydro-geological factors. The Ken river sub- basin, which form part of the Ganga basin, are varied in their geological settings. The older metamorphic rocks occur in Panna, Chhatarpur and

Tikamgarh districts of Madhya Pradesh. The Purana formations of both Vindhyan and Cuddapah age comprising Ortho-quartzites, limestone's and shale sequence are found in parts of Panna district. The depth of ground water in the wells is generally upto 25 to 30 m in the lean part of the year.

Ground water analysis has been done for the monsoon season 2007 which are presented in the following Table 8.2.

Table-8.2
Physiochemical analysis of ground water samples during the monsoon season of 2007.

S. No.	Parameter	Units	Mauranipur-Tikamgarh road crossing (Enroute)	Standard
1	p^H	-	7.01	6.50-8.50
2	Electrical Conductivity	Micro mhos/cm	364	1500
3	Dissolved Solids	mg/L	240	500
4	Turbidity	NTU	1.80	05
5	Total Hardness as $CaCO_3$	mg/L	176	300
6	Alkalinity to phenophthaline as $CaCO_3$	mg/L	Nil	200
7	Alkalinity to methyl orange as $CaCO_3$	mg/L	140	200
8	Non-Carbonate Hardness as $CaCO_3$	mg/L	36	-
9	Calcium as Ca	mg/L	42	75
10	Magnesium as Mg	mg/L	17	30
11	Sodium as Na	mg/L	1.5	-
12	Potassium as K	mg/L	1.5	-
13	Chlorides as Cl	mg/L	21	250
14	Sulphates as SO_4	mg/L	8.5	200
15	Nitrate as NO_3	mg/L	04	45
16	Fluorides as F	mg/L	0.80	1.00-1.50
17	Silica as SO_2	mg/L	08	5
18	Iron as Fe	mg/L	0.05	0.3
19	Colour	-	Colourless	Colourless
20	Feacal Coliforms	x 10^2/100 ml	Nil	
21	Total Coliforms	x 10^2/100 ml	Nil	
22	COD	mg/L	Nil	
23	BOD	mg/L	Nil	
24	Nutrient Status			
	a) N	mg/L	01	
	b) P	mg/L	01	
	c) K	mg/L	1.5	

It can be observed from the above table that the test results are within permissible limits. As such, the quality of ground water is satisfactory in the project area. Thus, it may be generally said that the ground water in the area is good and fresh for use.

8.4.3.3 Ground Water Levels

Monitoring of water levels is required to gain an understanding of the regional and temporal variations in quantity and quality of ground water resources. CGWB, North Central Region, Bhopal, monitors the regional behaviour of ground water levels and quality under phreatic aquifer under different hydro-geological situations to assess the ground water scenario so that judicious use of available ground water resources can be planned. Monitoring is done from identified dug wells and / or piezometers. The distribution of network hydrograph Stations in the districts falling in the Phase-I of Ken-Betwa Link Project area and in the neighbourhood are given in Table 8.3 below:

Table 8.3
Number of network hydrograph Stations in the Ken-Betwa Link Project, Phase -I

District	Dug wells	Piezometers
Chhatarpur	25	7
Tikamgarh	13	7
Panna	15	4

8.4.3.4 Depth to Water Level

The ground water level is subject to change both due to natural and manmade causes. Ground water level is an important indicator for the recharge of the aquifer, ground water abstraction and the discharge from the aquifer to surface water. Ground water levels vary significantly over time and season. Decline in ground water levels occur as a result of natural climatic conditions such as low rainfall, changes in land use and as a result of over abstraction. Rise in ground water levels occur due to heavy rainfall, changes in land use or as a result of artificial recharge to ground water. The pre-monsoon water levels in the project area were measured in May, 2006. It was observed that water levels between 5 to 10 m below ground level occur in most of the project area covering almost 60 %. In the remaining 40 % area, water levels between 10 to 20 m were observed mainly in the Chhatarpur and Tikamgarh area.

The peak water levels were measured in August, 2006 in the area. Water levels in the range of 2 to 5 m depths were observed in about 60 % of the project area covering parts of Panna and Tikamgarh. In about 30 % of the study area the water levels were seen at 5 to 10 m depth in parts of Chhatarpur and Tikamgarh districts.

The post monsoon water levels were observed in November, 2006 In the area covering parts of Tikamgarh and Chhatarpur districts, water levels between 5 to 10 m were observed. Observation made in January, 2007, indicated that most of the area covering parts of Panna, Tikamgarh and Chhatarpur districts had water levels depth of 5 to 10 m.

8.4.3.5 Ground Water Level Fluctuations

The analyses of water level data collected for the period 2006-07 indicated that there has been a general rise in water level during 2006 (Rainy Season) when compared to May, 2006, in the entire study area. Similarly, water level fluctuations were observed in respect of observations taken in November, 2006 and May, 2006. The long term behaviour of water levels of the phreatic zones comparing the water level of May, 2006, with the average water level data of May 1996 indicated a marginal fall varying from 0 to 2 m in the command areas under Daudhan. Almost similar decadal water level fluctuations were observed for the periods August, 2006 vis-à-vis August, 1996, November, 2006, vis-a-vis November 1996 and January, 2007, vis-a-vis. January 1997.

8.4.3.6 Ground Water Assessment

The ground water assessment for the districts falling in the study area as carried out by the CGWB in March, 2004, has been summarized in Table 8.4

Table-8.4

Ground water assessment in the Ken-Betwa Link Project, Phase-I

S No	District	Total annual replenishable ground water resource	Natural discharge during monsoon	Net annual ground water availability	Annual ground water draft	Projected demand domestic & industries	Ground water availability for further irrigation	Stage of ground water Development
		(ha m)	(ha m)	(ha m)	(ha m)	(ha m)	(ha m)	%
	MP							
1.	Chhatarpur	99840	4999	94841	53810	3043	40898	57
2.	Tikamgarh	80647	4032	76614	38373	3766	35497	51
3.	Panna	51258	2563	48695	11907	2042	36541	24
	UP							
1.	Jhansi	70914	4091	66824	28817	3230	36913	43
2.	Mahoba	47047	4705	42342	20979	1488	20864	50

In the study area, the stage of ground water development is less than 70 % and hence falls under the “SAFE CATEGORY”. However, due care needs to be taken with intensive and extensive monitoring in respect of levels and quality as development of ground water progresses in long run in the area.

8.4.4 Land Environment

For discussing land environment, study area of Phase-I of the proposed Ken-Betwa Link Project has been divided into following three parts.

1. Catchment area of Ken river up to Daudhan dam.
2. Daudhan dam area.
3. Link canal/Enroute command.

8.4.4.1 Land Use

The land use/ land cover in the study area of link canal has been generated on the basis of Remote Sensing Data and GIS applications and furnished in Table 8.5.

Table-8.5
Land Use / Land Cover in the Ken-Betwa Link Canal Study Area
(1 km on either side)

S. No.	Classification	Link Canal	
		Area (ha)	% of total area
1.	Forests	5927	13.55
2.	Settlements (Built up lands)	917	2.10
3.	Open scrubs	3710	8.48
4.	Cropped lands	24757	56.60
5.	Water Bodies	8428	19.27
	Total:	43739	100.00

The average culturable area is little less than 70 % of the geographical area. 106 villages have been identified in the link canal area. These villages fall in districts of Jhansi, Mahoba, Tikamgarh and Chhatarpur.

The total catchment area of Ken basin upto Daudhan dam site is 19633 sq km. The average annual land use particulars are shown in Table 8.6.

Table-8.6
Average Land Use in Ken Sub-basin upto Daudhan Dam Site

S. No.	Classification	Area in (Sq km)	%
1.	Forests	6780	34.53
2.	Land under non-agricultural use	971	4.95
3.	Barren and uncultivable land	934	4.76
4.	Permanent pastures and other grazing land	945	4.82
5.	Land under miscellaneous crops	8	0.04
6.	Culturable waste land	822	4.19
7.	Old fallows	352	1.79
8.	Current fallows	275	1.40
9.	Net area sown	8546	43.52
	Total Area	19633	100.00

The average culturable area of the Ken sub-basin upto Daudhan dam site is little more than 70% of the geographical area. 106 villages have been identified in the link canal area. These villages fall in districts of Jhansi, Tikamgarh and Chhatarpur.

8.4.4.2 Mineral Resources

The catchment area of Ken sub-basin falls in the districts of Damoh, Sagar, Narsimhapur and Satna in Madhya Pradesh. The districts are richly endowed with minerals such as limestone, Galera, asbestos, barytes, coal, copper, feldspar, fireclay, gold, iron, mica, bauxite, china clay and ochre. However, the study area in the catchment area does not contain any minerals to a significant extent. The study area falls in Panna and Chhatarpur district of Madhya Pradesh. The Panna district is endowed with rich minerals such as diamonds and bauxites, whereas Chhatarpur district is endowed with minerals such as quartz, feldspar, white clay, soap stones, diaspore, rock, phosphate and limestone. However, the study area of interest around Daudhan dam site does not contain minerals to any significant extent.

8.4.4.3 Geology

The geology around the proposed alignment at Daudhan indicates the presence of ferruginous chert breccaias, sandstone, siltstone, limestone and shells belonging to Vindhyan Super Group. These rocks exhibit dip of 5 to 6 degree towards the South Westerly direction and are overlain by flood plain deposits and channel fill deposits over a substantial part of the dam alignment. Thickness of these deposits varies between 3 to 10 m. The rock is thinly to thickly bedded and fairly well jointed. Bedding is often manifested by colour banding. Dark reddish blotches and elongated cavities upto 6 cm long and 1 cm wide are present occasionally along bedding plane.

8.4.4.4 Soils

Command area is covered in the districts of Chhatarpur, Tikamgarh, and Panna in Madhya Pradesh and Mahoba and Jhansi in Uttar Pradesh. The dominant soil orders available in these districts are inceptisol, vertisol, alfisol and entisols. The soils are neutral to slightly alkaline in reaction, relatively salt free, poor in nutrient status and organic content and are deep to very deep. Soil samples taken from enroute command were tested in the laboratory and test results are given in Table 8.7

Table 8.7
Command Area General Soil Analysis Report

Sl.No	Parameter	Units	YS-6	YS-7
1	P^H	-	8.16	6.78
2	Electrical Conductivity	Micro Mhos/cm	74	54
3	Total Nitrogen as N	(%)	4.12	3.54
4	Total Phosphates as P	(%)	2.70	2.22
5	Total Potassium as K	(%)	1.88	1.60
6	Sodium Absorption Ratio		1.84	1.64
7	Total Organic Carbon	(%)	1.42	2.56
8	Cation Exchange Capacity	(meq/100g)	8.0	7.6
9	Sulphates as SO_4	mg/lt	08	06
10	Chlorides as cp	mg/gm	12	08
11	Total Volatile Solids	mg/gm	62	118
12	Cadmium as Cd	mg/gm	0.050	0.040
13	Chromium as Cr	mg/gm	0.068	0.054
14	Lead as Pb	mg/gm	0.024	0.0.14
15	Nickel as Ni	mg/gm	0.028	0.018
16	Copper as Cu	mg/gm	0.066	0.050
17	Zinc as Zn	mg/gm	0.092	0.066
18	Manganese as Mn	mg/gm	0.044	0.030
19	Total Iron as Fe	mg/gm	0.28	0.26
20	Cobalt as Co	mg/gm	0.042	0.030
21	Arsenic as As	mg/gm	0.04	0.030
22	Selenium as Se	mg/gm	0.030	0.022

YS - 6 Mauranipur to Tikamgarh at Canal Crossing
YS - 7 Nowgong Chhatarpur Ken-Betwa Link Canal Crossing near Mau

8.4.5 Public Health

In order to make a meaningful and effective use of water resources development projects, it is imperative that health planning is also thought of both during construction and operation phases to maintain healthy conditions for the population around the project and also safeguard the health of labour force. In the case Phase-I of Ken-Betwa Link Project, the districts benefited are Chhatarpur, Panna and Tikamgarh in Madhya Pradesh and Jhansi and Mahoba in Uttar Pradesh. It has been observed that the public health facilities in these districts are average to below average as indicated in Table 8.8

Table-8.8
Medical and Health facilities available in the various districts falling in Ken-Betwa Link Project Phase-I (2005-06)

S. no	Particulars	Chha-tarpur	Panna	Tikam-garh	Jhansi	Mahoba
1	Allopathic hospitals/dispensary	2	1	7	33	18
2	PHC	45	19	2318	60	28
3	Sub centre	186	139	156	0	42
4	Ayurvedic/Homeopathic dispensaries	29	16	31	0	NR
5	Doctors					
	Allopathic	62	41	47	425	121
	Other Medicines	37	0	33	840	212
6	Health inspectors	4	1	0		NR
7	Nurses	247	57	262		NR
8	Compounders	20	20	45		NR
9	Others	184	375	295	748	147

8.4.5.1 Sanitation

Lack of proper sanitary facilities and sanitary waste disposal in the rural area are the root causes of many diseases. In this project too, the rural areas are lacking in drainage system. Even in the semi-urban areas, open drainage systems occur which expose the sewage to the disease transmitting organisms like flies, insects, germs etc. These organisms contaminate the water and food to be consumed by the people leading to water borne diseases like diahorrea, ameobiasis, gastroenteritis etc. depending upon the type of infecting organism. Open-air defecation is still a predominant practice in all the villages under consideration that is a potential hazard for spreading of diseases in the area.

8.4.5.2 Drinking Water Supply

It is necessary to ensure that the drinking water is safe, pure and free from organisms to avoid incidence of water borne diseases. Urban, semi-urban and many rural areas in the project area have been provided with

protected water supply which has been responsible for containing the spread of the water borne diseases to a large extent. However, in view of wide spread illiteracy in the area, people do not observe proper sanitary conditions whereby water is being contaminated and facilitates the spread of some of the common water borne diseases like cholera, hepatitis and dysentery.

8.4.5.3 Water Borne and Communicable Diseases

Water borne diseases like diahorrea, gastroenteritis and hepatitis are prevalent in the project area due to inadequate sanitation. Many a times, the infected members of the family act as source of infection for others. The project area has also reported cases of malaria though mild in nature. Malaria is influenced by stagnant water, poor drainage facilities, low socio-economic status of the people living in the unplanned settlements prone to periodical epidemics. Asthma, tuberculosis and other pulmonary diseases are also prevalent in the project area. Also, special care has to be taken to avoid the spread of disease like AIDS in the project area in view of the migrant labour deployed in the construction activity.

8.4.5.4 Nutrition

Many children in the rural areas are suffering from malnutrition due to under nourishment. Non availability of balanced food at affordable prices to feed the children adequately, improper cooking habits, low crop yields and persistent worm infestations due to lack of proper sanitation are also acting synergistically leading to nutritional problem. Malnutrition is by and large the result of poverty, ignorance, illiteracy, lack of proper knowledge of nutrition value of different foods and large family size in these areas. Malnutrition leads to recurrent infections thereby reducing the full working capacity of the people.

8.4.5.5 Construction Phase

Large number of workers, both qualified and unqualified shall be deployed at the project site during the construction phase. It is a common practice that people are provided with good accommodation with satisfactory sanitation facilities. However, it is the unskilled labour, who constitute the majority of the workers, live in crammed places with little or no sanitation facilities. Therefore, this large population may become susceptible to water borne diseases as discussed above. Improper sanitation facilities provided to unskilled workers may cause health hazards for not only them but neighbouring people also. As such this aspect needs proper attention. It may be pointed out that the heavy traffic movement and use of machines like crushers, welding machines etc. during the construction phase may also lead to air pollution resulting in respiratory tract diseases like bronchitis, asthma etc.,

8.4.5.6 Post Construction Phase

Large impoundment of water in the reservoir and also places where the water gets stagnant are the likely places for breeding of malaria spreading mosquitoes. Also, some of the workers may settle down in the project area after completion of the project work. Mingling of these workers with local populace may lead to spread of diseases such as tuberculosis.

8.4.6 Biological (Terrestrial and Aquatic) Environment

According to FSI, the total forest cover in Madhya Pradesh was 76429 sq km in 2003 constituting 24.8% of the land area. There are 9 National Parks and 25 Wild Life Sanctuaries in the State. These forested areas possess a wide and rich variety of flora and fauna. An extensive survey of flora and fauna of Phase-I of the Ken-Betwa Link Canal Project and its environs extending upto a radius of 1 km was carried out between November, 2007, and July, 2008, covering the winter, summer and monsoon seasons. Extensive field surveys were undertaken for collection of primary data during November, April and July months. A comprehensive list of plant species for the study area was made and the plant species collected during the different seasons by the team. The species were further separated into trees and shrubs, medicinal plants and aquatic plants. Owing to large variation in topography, soils, disturbances of different frequency and magnitude, climate and biotic pressure, the vegetation showed patchiness with contagious type of distribution.

8.4.6.1 Flora of the Project Area

About 25 % of the project area is covered by reserved forests, protected forests and miscellaneous forests. The main types of forests and vegetation that are found in the project area include mixed forests, teak forests, saal forests, bamboo trees, miscellaneous forests, medicinal plants etc. The mixed forests include such species as Saja (Terminalia tomentosa), bija (Pterocarpus marsupium),lendia (Lagerstroemia paviflora), haldu (Admina Cardifolia), dhaora (Anogeissus latifolia), salai (Boswellia serrata), amla (Phyllanthus emblica), amaltas (Cassia fistula), gamhar (Gmelina arborea) etc. Besides, Arjun, Palas, Thur, maze of grasses, plants and bushes are found in the area. Common teak (Tectona granis) is by far the most important timber species widely distributed in the study area.

8.4.6.2 Nonwood Forest products

There are many important nonwood forest products found in the area which include tendu leaves or bidi leaves (Diospyros Melonoxylon,) harra(Terminalia chebula), Gum, Chironge (Buchanania Lanzan) and seeds of mahua (Madhuca Indica). Besides Rudrakha (Elaeocarpus Sphaericus) is yet another important forest product found in the area. The collection and trade of this Nonwood forest product is regulated by the State Government.

8.4.6.3 Medicinal Plants

Medicinal trees and plants of various kind are found in abundance in the forests of the study area. Important ones are: Aegle marmelos, Azadirachta Indica, Bixa orellana, Butea monosperma, Asparagus racemosus, Argemone mexicana, Buchanania lanzan, Aloe barbadensis, Acorus calamus, Cassia tora, Curuligo orchioides, Curcuma longa, Embelia ribes, Clitoria tematea, Mangifera indica, Cassia fistula, Evolvulus alsinoides, Commiphora mukul, Helicteres isora, Holorrhaena antidysenterica, Glycyrrhiza glabra, Woodfordia fruitcosa, Dioscrorea spp, Plumbago zeylaniea, Terminalia bellirica, Tamarindus indica, Mucuna pruriens, Pongamia pinnata, Terminalia bellirica, Psoralea corylifolia, Phyllanthus embilica, Ocimum americanum, Rauvolfia serpentine, Tinospora Cardifolia, Withania somnifera, Swertia chirayita, Tribulus terrestres, Chlorophytum fuberosum, Cyprus Rotundus.

8.4.6.4 Physiognomy and indices of diversity

Physiognomy is essentially a qualitative character which refers to the overall external appearance of a community and it helps in differentiating among the various types of formations. During rainy season the whole area appears green, whereas in summer season the area looks dry without any foliage. Indices of diversity indicate a total variety and variability of all living plants of the given area. The indices of diversity are calculated based on the typical representative samples of one hectare so that any two or more areas can be compared. Although, there are different indices of diversity, Shannon – Wiener indices of diversity are widely employed since they take the quantitative attributes of species in consideration.

Seasonal variation in floristic composition, diversity and dominance of plant communities of different areas were studied during the rainy, winter and summer seasons. All the trees, shrubs plants and other woody climbers were present in all the seasons. Most annuals were found during the rainy season and some of them continued in the winter season. However, due to death of certain species in summer, there was a slight decrease in its diversity in the project area.

8.4.6.5 Orchids and other species of the Ken-Betwa Catchment Area

The important Orchids found in the area are Vanda teseellata, Vanda coerulea, Vanda pumila, Dendrobium densiforum, Dendrobium agreegatum, Dendrobium aphyllum, Dendrobium fimbriatum, Dendrobium moschatum, Dendrobium nobile, Bulbophyllum leopardinum, Cymbidium pendulum, Cymbidium longifolium, Cymbidium munronianum, Cymbidium macrorhizon, & Vanilla planifolia. The algal species found in Ken & Betwa rivers, in paddy fields and other water bodies of the link command areas are Macrophytic algae (Chara and Nitella), Spirogyra and members of Cyanophyceae. Similarly, a number of fungal species were observed in the

catchment area, reservoir and command area of Ken-Betwa Link project mainly in the rainy season.

8.4.6.6 Status of the Fauna

The catchment area of the Ken river includes the Panna National Park which is a notified tiger and wildlife park located on the banks of the river. A large number of herbivores such as Sambar, Nilghai, Chital, Gazelle and Spotted deer were seen in small groups in the grass lands on top of the hills in Panna National Park. Langoor and Rhesus Monkeys were abundantly present. According to rough estimates, the Panna National Park is inhabited by 10 - 15 tigers. Similarly, Gharial and Mugger crocodiles were found in the Ken river. Nearly 200 species of either resident or local migrant birds were reported from the area. A wide variety of butterflies, moths and honey bees were also reported in the area.

8.4.6.7 Fish Fauna of Ken river

A large number of native species of fish were found in Ken river but none of them was endemic to the river. About 19 exotic species, introduced in India, have been found in the river.

8.4.6.8 Other Fauna of the Ken-Betwa Catchment and Command Areas

The accumulation of litter especially due to leaf shedding during pre-monsoon period, contributes to the development of a detritus eco-system consisting of earth worms, millipedes, centipedes, reptiles, scorpions, beetles, termites, ants, crickets, micro arthropods and bacteria. The action and activity of all these litter and soil surface, flora and fauna is responsible for litter composition, nutrients release and recycling. These nutrient cycles become intra-biotic because of extensive mycorhizal associations.

8.5 Environmental Impact Assessment

EIA consists of a systematic investigation of both positive and negative impacts on the physical, biological and socio-economic environment that would be caused or induced due to a proposed developmental project. Its primary objective is to encourage the inclusion of environmental considerations in planning and decision-making and to ultimately arrive at actions that are environmentally more compatible. Most of the environmental attributes are spatial in nature and to understand these attributes, suitable spatial database management system is required. GIS is a tool for collection, storing, retrieving, transforming and displaying spatial data for a particular set of purposes can provide all desirable requirements.

For generation of maps through Remote Sensing and GIS applications, SOI, topography maps on 1:250,000 and 1:50,000 scale,

satellite data and secondary information have been collected from various sources. The maps that have been generated are preliminary base maps, land use and land cover maps, slope maps, hydro-geomorphologic maps, soil maps, land irrigability maps, sediment yield index etc. Based on the information generated, a detailed treatment plan for the catchment area has been developed. Similarly, treatment plan for command area has also been devised.

8.5.1 Impact on Air Environment

The Ken-Betwa Link Project Phase-I is being proposed for transfer of waters from Ken river to Betwa river with benefits of irrigation and power supply in adjoining districts by construction of dams, tunnels and canals. The sites have been selected considering less submergence, better storage capacities, socio-economic interest and economic aspects. Besides, drinking water facilities shall be provided along the canal system to adjoining habitats.

The activities that will cause the air pollution are the vehicular movement, excavation, tunnelling and other related construction activities. The air pollution will also be generated due to the activities of temporary human settlements. The same activities will also have impact on the noise environment.

8.5.1.1 Noise Environment

It may cause loss of sleep, fatigue, chronic psychological disturbances, decrease in speech reception, diminished concentration and in certain extreme cases, cardiovascular, respiratory and neurological disorders. A study was conducted to know the existing noise levels in the canal alignment region and dam location. It has been observed that the noise levels are mostly in a normal range except for the areas where there are highway and habitations. Though, the possible impacts due to project proposal on noise environment are little, the main impacts would be during the construction, excavation and tunnelling activities.

8.5.1.2 Air Environment

The air pollution Impact on surroundings shall be mainly during construction phase. Most of the operations are mechanized and operated on diesel. There are several equipments and vehicles used that will generate air pollution. These are drilling machines, grouting equipment, road rollers, mobile cranes, crawler tractors, dumpers, concrete mixers, concrete batching plants, stone crushers, tankers for water supply, diesel pump sets, air compressors, wagon drills, scrapers, tractors, DG sets and different types of vehicles.

The emissions of the vehicles and equipments are expected to be moderate in quantity and quality since the activity shall be short term in view of the fact the vehicles and equipments shall be operated for few hours only

in the region. The generated air pollution shall be disbursed easily as the region where the activity has been proposed has moderate to reasonably high wind speeds. The average wind speed in the region is 4 kmph and above thereby the dispersion of the air emission shall be rapid and easier.

Ambient air quality survey was carried out for pollutants such as SPM, sulphur dioxide and oxides of nitrogen at few places in the project area and the values are presented in Table- 8.9.

Table-8.9
Values of Air Pollutants in the Project Area

S.No.	Station	SPM (micrograms per Nm^3)	SO_2 (micrograms per Nm^3)	NO_2 (micrograms per Nm^3)
1)	Daudhan	242	13	16
2)	Gangau	191	8	15
3)	Kawar	234	10	12
4)	Burduwaha	172	9	12
5)	Shyamra	154	9	12
6)	Chauka	201	7	13
7)	Barwa Sagar	236	9	12

It is clear from the table that the present quality of air was quite normal at most of the places except for those where there is a motorable road adjacent to it. It is expected that during the construction phase, a short term increment in the levels of pollutants may occur. However, in the operation phase of the project there will be good improvement in aesthetics, greenbelt, air quality, water levels, etc.

8.5.2 Impact on Water Environment

Water Pollution is the presence in water of some contaminants that produce a change in its physical, chemical and biological characteristics that can harm the health and welfare of living organisms or natural system. Besides the quality of water, the other adverse impacts that are encountered because of developmental process are likely changes in the regime of the river, change in hydrological cycle, acidification of lakes and water bodies and adverse impacts on drainage system.

8.5.2.1 Flood Studies and Flood Routing

Studies for PMF for the proposed Daudhan Dam site were carried out by the unit hydrograph method based on rainfall in Ken catchment and

corresponding flows in the river at gauge & discharge site at Banda. The daily flows at Banda and rainfall data upto Banda were used for the analysis.

The design flood was worked out as 57202 cumecs. There are 27 gates provided over the spillway crest and all are proposed to be in operation for passing the flood. It was found that the flood could be safely passed at FRL of 288 m. Therefore, the MWL had also been fixed same as FRL i.e. 288 m.

As the FRL of the proposed Daudhan reservoir had been fixed at 288 m which was about 53 m above the present FRL of existing Gangau Weir (2.5 km d/s of the site), the storage of Daudhan Dam will definitely contribute in mitigating floods in the d/s portion of Ken basin.

The average annual evaporation losses from the reservoir obtained from the simulation analysis was about 92 MCM. This worked out to be 3.2 % of the total storage of the reservoir. The total annual water requirement on the d/s side of the proposed dam was estimated to be 1998 MCM out of which regular release will be made into the river throughout the year for its use at Bariarpur Headwork. As such, no separate provision of minimum flow for environment & ecology has been made.

8.5.2.2 Siltation

Due to the water spread area of 9000 ha of Daudhan reservoir at FRL, the long hill streams joining the river will get shortened which may result in widening of the channels close to the periphery of the reservoir. This widening will cause more silt deposit at the reservoir site and at the mouths. The rate of siltation at 329.8 cum/sq km/ year has been considered for this project. The sediment distribution had been worked out for two periods viz. 50 years and 100 years by Empirical Area Reduction method as given in the Technical Report No. 19 on Life of Reservoir, published by CBIP, New Delhi. For this purpose, the MWL of 288 m has been considered and bed level of the reservoir as 216 m. The type of reservoir has been considered as “Hill Type” and the standard classification has been taken as “Type-III”. The total sediment for 50 years has been computed to be 20610 ha m and total sediment of 100 years has been worked out to be 36173 ha m. Thus, the impacts due to siltation of the reservoir have been taken into cognizance while fixing the MDDL and size of reservoir. Apart from this, provision of CAT has been kept in the estimate to arrest the flow of additional silt into the reservoir.

8.5.2.3 Acidification of Lakes and Water Bodies

The recent acidification observed in many lakes and water bodies could be attributed to the effects of acidic pollution from the burning of fossil fuels by mankind. In general, the acidification of the water bodies was predominately linked to geology of the region. Besides, natural causes such

as acid rains are also responsible for causing acidification. Fishes thrive in acidified fresh water. Soft bodied animals such as leaches, snails and cray fish are early victims. Few insect species are highly resistant to acidification whereas species such as mayfly disappear even under moderate acidification. In view of the general geology of the area of interest, no significant impacts are likely due to acidification of the Daudhan reservoir in the project area due to presence of soils with rich mineral.

8.5.3 Impact on Surface Water Quality

8.5.3.1 Construction phase

During the project construction phase the major sources of surface water pollution shall be sewage from labour colonies and effluents from crushers and other sources. It is expected that the actual project construction is likely to last for a period of 8 years. The peak labour strength likely to be employed during the construction phase shall be in the vicinity of 2000 unskilled workers and 500 skilled ones. The construction phase also leads to mushrooming of various allied activities to meet the demands of the labour population in the project area. Normally, during construction phase, a large proportion of the labour population brings in their families as well. Thus, the population of labour along with family shall be of the order of about 5000.

Based on the domestic water requirement of 70 lpcd, the total water requirement works out to be 0.35 mld. It has been assumed that about 80% of the water supplied will be generated as sewage that worked out to the order of 0.28 mld. The BOD load contributed by domestic sources shall be the order of 300 kg per day. It has been assumed for brevity sake that this untreated sewage shall outfall into the river at a common point. For such a condition, the minimum flow required for dilution of sewage is about 0.5 cumecs. However, the minimum flow that has been observed in the month of April in the Ken river is about 1.16 cumecs. (on average) which is higher than the flow required for disposal of untreated sewage. Therefore, no significant impact is anticipated on river water quality because of disposal of sewage from labour colonies.

During construction phase, it is expected that number of crushers shall be employed at the project site. The effluent from the crusher would contain highly suspended solids. About 12 to 15 m^3/hr of wastewater is expected to be generated from each crusher. The effluent, if disposed without treatment can lead to marginal increase in turbidity levels in the receiving water bodies. The natural slope in the area is such that the affluent from the crushers will find its way to Ken River. This amounts to a discharge of 0.0033 to 0.0042 cumecs. Even the lowest flows in river Ken is much higher than this flow as already discussed above. The effluent from the crusher will have suspending solid level of 3000 to 4000 mg/l. On the other hand, suspended solid as observed at various sampling locations, during water quality monitoring studies was observed to range between 1.8 to 3.0 mg/l. The level

of suspended solids in the composite sample would increase by less than 1 mg/l. Therefore, the increase in suspended solids is not expected to cause any significant adverse impact. To ameliorate the marginal impacts, it is proposed to commission adequate treatment facilities in the form of a settling tank to treat the effluent from both labour camps and crushers.

8.5.3.2 Operation Phase

The major sources of water pollution during project operation phase shall include:

- Effluent from Project Colony
- Impacts on reservoir water quality
- Eutrophication Risks

During project operation phase, affluent from project colony may not cause water pollution to any considerable extent as the colony will have a Sewage Treatment Plan. About 750 families with a total population of about 2000 will be residing in the project colony. About 0.3 mld of sewage might be generated. The total BOD loading shall be of the order of 90 kg/ day. The BOD loading is significantly low to cause any adverse impact on water quality of river Ken. Thus, with the commissioning of sewage treatment facilities, the quality of water may not get adversely affected.

The depth of the proposed reservoir is 77 m, which is high. The annual variation upto MDDL would prevent formation of any significant temperature stratification. Thus, no problems related to reservoir stratification are anticipated. The flooding of previously forested and agricultural land in the submergence area will increase the availability of nutrients resulting from the decomposition of vegetative matter. Enrichment of impounded water with organic and inorganic nutrients will be the main water quality problem immediately on commencement of the operation. However, this phenomenon is expected to last for a short duration of few years from the filling up of the reservoir.

Another significant impact that can accrue is the problem of eutrophication in the reservoir. This occurs mainly due to the disposal of nutrient rich effluents from the agricultural fields. As in the catchment of Daudhan dam the proportion of total agricultural lands is relatively low, especially under irrigation, it is expected that not much use of agro-chemical and fertilizers shall be in practice. Thus, the problems arising due to eutrophication shall be of the minimal order.

8.5.4 Impact on Ground Water Quality

The present ground water level in the phreatic zone, during May 2006 was between 5 to 10 m below ground water in about 60% of the project area. In the remaining area it varied between 10 to 20 m. As the quantum of water being transferred is of the order of 1074 MCM annually through the link

canal taking off from the reservoir to the Betwa river utilizing 366 MCM in the enroute command and dropping remaining 591 MCM (excluding transmission losses of 68 MCM) into Betwa river, the water levels are not likely to rise to any significant level. Thus, the hazards of water logging and salinization are not anticipated in the region. The canal systems under the proposed project are expected to be properly lined. Therefore, there may not be much seepage loss to the ground water. Also, as the quality of surface water is within the required standards for irrigation and drinking purposes, no impacts on the ground water pollution due to seepage, if any, are anticipated.

8.5.4.1 Impact due to Change in Waste Assimilation Capacity of the River System

The minimum water flow in the Ken River in the month of April is 4.32 cumecs. As pointed out above, the wastewater from colonies and crushers shall be of the order of 0.037 cumecs. Therefore, impact due to change in waste assimilation capacity is not anticipated to any considerable extent. Besides, the reservoir is supposed to release assured supply into Ken river d/s. Even during the construction period also minimum flow of more than 1.0 cumecs shall be maintained at the site. Thus, no adverse impacts due to change in water assimilation capacity of the river system are anticipated.

8.5.4.2 Impact on Drainage System

Ken River in its course from its origin in Katni district upto the Daudhan dam site is met with a number of tributaries. The submergence area of the reservoir is expected to encroach into most of these tributaries. Due to the water spread area of the reservoir, the length of tributaries joining the river will get shortened which may cause widening of the channels close to the periphery of the reservoir. This widening is expected to cause more silt deposition at the reservoir site. Several streams cross the proposed link canal and provision of cross drainage works is being contemplated in the project area. These cross drainage works will be so designed that they do not hamper the width and course of the river streams and therefore, minimized the siltation problem which may arise at the crossings. Thus, little impacts on the drainage aspects are anticipated.

The canals irrigating the command area originate from the high altitudes. Necessary provisions are being made in the project area for suitable cross drainage structures with adequate capacities. Suitable diversion arrangements are being made for small streams to the nearby structures. This shall take care of any adverse impacts in the command area.

8.5.4.3 Impact due to Contamination by Agro-chemicals and Fertilizers

The introduction of irrigation shall result in the use of optimum doses of fertilizers and other agro-chemicals for raising the agricultural production in the region. It becomes essential to study the impact of use of fertilizers and agro-chemicals on the quality of ground water. It may be pointed out here that the soils in the project area are deficient in respect of essential nutrients like nitrogen, phosphorus and potassium. It is therefore, expected that use of optimum levels of fertilizers may not cause any significant pollution to the ground water. Nevertheless, it would be worthwhile a precautionary measure to test the quality of ground water periodically and suitable corrective measures adopted from time to time.

8.5.5 Impact on Land Environment

Impacts on land environment are both during the pre-project and post-project activities. During the construction phase, secondary impacts relating to pollution due to dust and other construction materials, soil erosion, increased inflow of traffic resulting in generation of aerosols and noise pollution due to machines and movement of heavy vehicles may come into existence. During the post impoundment period, i.e. operation stage, the aforesaid secondary impacts would gradually be reduced while the impacts due to impoundment would set in. These post project impacts are two types. The first is immediate submergence of area resulting in total loss of eco-system and effect on socio-economic system. The second will be gradual one relating to the surrounding areas in the immediate vicinity of the project coming under submergence. Virtually, these impacts include degradation of soil due to excessive irrigation, soil and water pollution due to excessive use of fertilizers and agro-chemicals, soil erosion, seismic impacts etc.

8.5.5.1 Impact on Land Use

Excavation for the construction of dam will produce depression and will naturally change the micro topography of the area to a limited extent. Most of the quarries on the either side of the river are situated within a distance of 2 to 3 km and are shallow to medium in depth. Therefore, only a little erosion from the excavation pits is expected. Also, the rocks are hard and compact. Therefore, the erosion intensity will also be expected to be low. During this phase, tunnel and link canal excavation will also be carried out which will also generate spoils and waste. These need to be managed properly so that land degradation due to siltation is prevented.

Moderate dust generation containing silica is expected at sand quarries. Transportation of earth material to earthen dam site and its compaction will be done mostly by rollers and dumpers and to some extent by trucks having hydraulic dumping system whereas manual labour will be employed in the compaction work. Water spray during compaction process

will reduce disbursal of dust. Therefore, adverse effects on workers engaged for these purposes will be negligible. Most of the quarries will be partly or completely under submergence. Hence, adverse impacts shall be to a minimum. Only one rock quarry is outside the submergence zone which can be used either as ground water recharge pit or for irrigation purposes. If that is used as ground water recharge pit, care should be taken to prevent them from becoming breeding ground for mosquitoes.

8.5.5.2 Roads

Roads are the only main mode of communication in the area. Chhatarpur-Panna National Highway (NH- 75) passes on the northern side. In addition, there is a wide network of state highway roads, village roads and cart tracks. The status of village roads and cart tracks will have to be improved and new approach roads to quarries, labour colony, stores and construction sites will have to be constructed. As pointed out earlier, frequent movement of heavy vehicle loaded with construction material will cause air pollution in terms of SPM, noise and gases. To mitigate the pollution effects, preventive measures such as sprinkling of water, plantation of trees etc. have to be taken in right earnest. One of the important positive impacts of road development will be improvement to the world heritage centre, Khajuraho, which is about 30 km away from the dam site.

8.5.5.3 Muck Generation

Ken-Betwa Link Project Phase-I envisages construction of a dam across Ken River near Daudhan Village and two Power Houses, two tunnels, link canal, Ken LBC and command area canal system. These activities shall invariably lead to generation of huge muck causing degradation of land and loss of biomass. Therefore, appropriate action shall have to be taken for muck disposal to avoid unnecessary hazards

8.5.5.4 Submergence of Land

The formation of the reservoir by construction of dam across the Ken river near Daudhan Village shall involve huge submergence of land and consequent change in land use and land cover besides adverse impacts on social environment. The total area under submergence at FRL will be 9000 ha as per analysis done by M/s AFC Ltd., Hyderabad covering parts of 10 villages. The classification of land use as per AFC is presented in the Table 8.10.

Table 8.10
Land use in the submerged area of the reservoir

S. No.	Land Use	Area (ha)	% of Total Area
1	Built up land	89	0.99
2.	Agricultural land (crop land)	2171	24.12
3.	Tanks/Rivers/Streams	1571	17.45
4.	Open scrub	150	1.67
5.	Dense Forest	590	6.56
6.	Open Forest	261	2.90
7.	Scrub Forest	4168	46.31
	Total:	9000	100.00

Out of the total forest area of 5258 ha, 4141 ha is coming under Panna Tiger Reserve Forest and remaining 1117 ha out side the Panna Tiger Reserve. About 58.43% of the submergence area will be under forest, 24.12% under agriculture land and 17.45% will be under the water bodies.

8.5.5.5 Increase in food grain production

Since large tract of land will be brought under assured irrigation through 6.35 lakh ha of proposed annual irrigation, there will be huge increase in food grain production, making farmers self dependent and economically better off. This will be high positive impact from the project.

8.5.5.6 Land degradation

Normally land degradation on the introduction of irrigation occurs due to excessive irrigation and corresponding use of fertilizers and agro-chemicals. However this situation is not likely to happen in this project, as most of the command areas are water scarce and even intensity of irrigation proposed is not much. However, excessive use of chemical fertilizers and other agro-chemicals may result in ground water pollution, which may be hazardous for general public health. Also, ample precautionary measures have to be taken in providing supports, linings etc. to the tunnels to avoid any risk of subsidence.

8.5.5.7 Reservoir Induced seismicity

Reservoir induced earthquakes are usually associated with large dams of height more than 100 m and volume over 1 km^3 . However, reservoir induced seismicity in case of low height dams cannot simply be ruled out. The factors influencing earthquake frequency and magnitude include the rate of increase of water level, duration of loading, maximum water level reach and duration for which high level of water is retained. As the impoundment behind the dam at Daudhan would be on dense quartz, arenite and sandstone of very hard and compact nature, the reservoir-induced seismicity is of remote chance in this particular case. However, a seismic surveillance plan needs to

be made for follow up prior to construction of dam. It would be better if permanent seismological stations around the project site are installed.

8.5.5.8 Recharge of ground water

Due to assured irrigation in the command, ground water recharge will take place. This will help farmers in drawing ground water during summer months for their crop and thus practising conjunctive use of surface water. This will also be high positive impact.

8.5.5.9 Water Logging and Salinization

The Ken-Betwa Link Project Phase-I is mainly intended to provide irrigation water to the command area in Madhya Pradesh and Uttar Pradesh. Unless, the river waters are free from harmful salts, the reservoir water may likely induce salinity in the command area especially with high ground water table. Also, due to impounding of water in the reservoir, the ground water table in the vicinity will be affected. In other words, water table may rise and cause salinity unless it is kept at adequate depth below ground level. As pointed out above, the quality of ground water in the vicinity of link canal are well within permissible limits, therefore, there is no likelihood of either water logging or salinization in the region. Nevertheless, proper drainage plan and conjunctive use of surface and ground water shall have to be resorted to reduce the ill effects of water logging and salinity, if any that may take place in the area.

8.5.5.10 Impact on Soil Erosion

The soils in the command area are formed from parent materials such as quartzite, granite and sandstone and are generally associated with alfisols and vertisols. The texture of these soils varies from sandy loam to clay loam. The command area of the Ken project is undulating with gentle slopes. The soils of this area, therefore, are prone to slight to moderate erosion and few areas with severe erosion. Appropriate soil erosion measures, therefore, are needed to be taken in right earnest.

8.5.6 Impact on Bio-diversity

The submergence area of the proposed Daudhan dam shall include forests land, wildlife habitats, agricultural lands and a number of habitations. The impacts shall be both positive as well as negative. Among the positive impacts, the proposed reservoir will provide a congenial habitat conditions for several native species and also for new species to come up. Thus, the creation of reservoir will enhance the possibility of biological diversity in the area. Plantation along the drainage and irrigation channels will contribute to revival of the vegetal cover of the area. Also, the tree cover, which is almost negligible at present shall get conducive environment to grow more. Improved irrigation facilities will also support agro-forestry system that may be a constructive input for the local people in term of fuel wood, small timber

and fodder production. The proposed project will support the native diversity of the area as far as fauna is concerned.

8.5.6.1 Impact on Biota

There are many rare and threatened species of wild animals in the Panna National Park and its surroundings. Nearly 4141 ha. of the park land will come under submergence. However, this may not drastically bring down the habitat of the wild animals. Hence, an effective Management Plan is required to be evolved to ensure the safety and security of the rare wildlife of the park in consultation with the authorities of wildlife department. Necessary clearances are being taken from the concerned authorities.

8.5.6.2 Impact on Habitat Loss

In view of the submergence by the creation of the reservoir, there shall be a loss of wild habitat for some of the Rare Endangered Endemic Threatened (REET) and some rare species. Loss of key species brings out major changes in wild habitat. Therefore, an effective Management Plan needs to be evolved to take care of these hazards.

8.5.6.3 Impact due to Habitat Change

The reservoir submergence fortunately is neither a home nor an important habitat for wildlife and therefore the impacts of the project on species may not be too severe to prevent any recovery. Indeed, there shall be a loss of forage grounds due to submergence but there may not be any loss of corridor or migratory path for wildlife including birds. The change in habitat is not very significant. There are no known migratory routes for birds including the occasional visitors.

8.5.6.4 Impact on the Breeding Grounds

There are no known breeding grounds for any of the threatened fishes within the project area. Some of the fishes may migrate to the u/s or d/s of the reservoirs for breeding through the fish ladders etc., proposed in the body of the structures. Loss of habitat for wild life may reduce the breeding and feeding areas leading to competition for food and shelter. However, it is expected that the access for food and shelter may not be severely affected due to the coming up of project. Besides, the creation of reservoir may provide conducive environment for the wildlife by the provision of water especially during summer months. As far as the birds are concerned, they are either residents or local migrants and their breeding grounds may extend beyond the project area.

8.5.6.5 Impact on Animals

The Ken river is passing through the Panna National Tiger Park bisecting it into two parts. In case, if the Wildlife viz., tigers are present on

both sides of the river, in the event of coming up of a reservoir and its getting filled, the migration of tigers from left to right and vice-versa might have been affected, necessitating provision of migratory path across the river. But the situation is not same. Tigers are reported to have made their shelters only on right bank of the river. As such, there is no adverse effect on animals due to this project.

8.5.6.6 Impact on Aquatic Environment

None of the species of aquatic plants comes either under endangered or REET categories. The Betwa river was observed to suffer from eutrophication during summer months when the river flows get drastically reduced and the rates of dilution of sewage and other trade effluents are low. As a result of interlinking, the conditions in Betwa river are expected to improve. Besides, interlinking may facilitate migration of fish. The link canal does not intersect any perennial water body and, therefore, there shall be no submergence along the canal. The loss of trees and shrubs during the construction phase of canal shall be made good by canal bank plantations in due course of time. Irrigation facilities created may enhance tree cover that can provide a suitable habitat to the local territorial fauna including birds. Creation of reservoirs shall provide additional room for aqua culture. Interlinking of the rivers will facilitate rapid migration of fishes to the new channel for inter breeding. The Daudhan dam reservoir can be used for development of fisheries.

8.5.6.7 Impact on Sensitive Eco-system

Other than the Panna National Park and the forests in the reservoir areas there are no other sensitive eco-systems being adversely affected. However, all terrestrial communities of plants occurring in the reservoir area shall be lost due to submergence. But the project is not going to cause any permanent damage to the aquatic communities.

8.5.6.8 Impact due to Bioaccumulation and Biomagnification

Bioaccumulation and biomagnifications of all substances that can neither be digested nor excreted is a well established biological and ecological phenomenon. It is expected that the proposed project may not influence the problem of bioaccumulation and biomagnifications to any considerable extent. In order to minimize the problems of bioaccumulation and biomagnifications, efforts shall be made to promote integrated pest management practices all along catchment and command areas through the agriculture department as the nodal agency.

8.5.6.9 Impact due to change in ecological functioning of river system

The major change in the ecological functioning of the river systems results from the transformation of lotic to lentic badly. When the flow is impounded and the reservoir is created, the flowing water system will change to a stagnant body. Stagnant water body can get rid of pollution by sedimentation while a lotic body carries its load of pollutants downwards. Stagnant water bodies are prone to eutrophication and silting if the rates of turnover are low. However, through adoption of proper measures for control of erosion in the catchment areas, the problem can be considerably reduced.

8.5.6.10 Impact on Growth of Aquatic Weeds

As long as the flow of water is rapid, the chances of aquatic weeds are lower. When the water is impounded and the nutrient load of water triggers higher, it triggers eutrophication. Such problems are manageable through bio-manipulation of reservoirs. The special care that needs to be taken up is to prevent the accumulation of organic matter. It is expected these problems may not be encountered in the case of Ken river which is relatively less polluted.

8.5.6.11 Impacts on Fish Spawning and Migration

As there are two diversion structures across Ken river d/s of the proposed Daudhan reservoir, there is no free and direct access for u/s and d/s migrations. However, there are no known spawning grounds in the impact zones. Those species that migrate upward for breeding in shallow waters and rapids can still do it without any hindrance. D/s migration for breeding and feeding are possible as the river flows are not totally cut off in view of the inter- state obligations. However, creation of water bodies at Daudhan and Barwa Sagar will give ample benefit of practicizing pisciculture. This is a high positive impact from the project.

8.6 Environmental Management Plan (EMP)

EMP is an integral component for the sustainability of any water resources project. The development of water resources projects is always accompanied by a complex interplay of people, natural resources and the biota of the region. This induces changes in the environment. Therefore, monitoring of various critical parameters is essential in the project operation phase. From the monitoring point of view, the important parameters are air quality, water quality, land use, ecology etc.

8.6.1 Air Quality

The ambient air quality monitoring during construction phase could be carried out by an external agency, approved by State Pollution Control Board, at major construction site. Three monitoring seasons namely pre-monsoon, winter and post-monsoon should be chosen. The monitoring frequency could be twice a week for four consecutive weeks at each station for each season. The parameters to be monitored are RPM and SPM, sulphur dioxide and oxides of nitrogen. A meteorological laboratory could be set up at one of the ambient air quality monitoring stations for Daudhan project for automatically recording meteorological data such as temperature, humidity, wind speed etc. Noise emission from vehicular movement, operation of various construction equipment should be monitored during construction phase at various sites. The frequency of monitoring could be once every month.

8.6.2 Water Quality

It is proposed to monitor the effluent before and after treatment from septic tanks of staff and labour colonies. For five hundred persons one septic tank would be provided. The effluents from these tanks could be disposed off through soak pits. Drinking water facilities and waste disposal sites would be located at a distance from each other. The surface water quality of the impounded water and river Ken needs to be monitored thrice a year, The proposed parameters include pH, temperature, electrical conductivity, turbidity, total dissolved solids, calcium, magnesium, total hardness, chlorides, sulphates, nitrates , DO, COD, BOD, iron, zinc and manganese.

During project operation phase, a sewage treatment plant has been proposed to be set up to treat the effluent from the project colony. The parameters to be analyzed include pH, BOD, COD, total suspended solids and total dissolved solids. Peak labour population would be about four thousand and eight septic tanks would be required to be constructed in the labour colony. Besides, the staff colony would be provided two septic tanks. The effluents from these septic tanks would be analyzed once in a month. The surface water quality would also have to be monitored during the operation phase. It is to be monitored thrice a year in three seasons.

8.6.2.1 Surface Water

Ken-Betwa Link Project, Phase-I envisages construction of a dam on river Ken at Daudhan u/s of Gangau weir to store 2853 MCM of water to supply 1405 MCM to Madhya Pradesh and 1600 MCM to Uttar Pradesh to provide for irrigation in the districts of Panna, Chhatarpur, Tikamgarh in Madhya Pradesh and Mahoba and Jhansi of Uttar Pradesh. The surplus water for diversion from Daudhan has to be transmitted through link canal after

meeting the enroute demands, the balance water will be transmitted to river Betwa up- stream of Parichha weir.

Monitoring aquatic ecology would be essential to achieve sustainable yield of fish. Some of the parameters to be monitored are Phytoplanktons, Benthic life and fish composition etc. The parameters could be monitored twice every year at the water sampling sites of Daudhan reservoir covering 2 km u/s and 1 km d/s. Status of afforestation programmes, green belt development, changes in migration patterns of the aquatic and terrestrial fauna species should also be considered.

8.6.2.2 Ground water

A number of Piezometers at close spacing's need to be constructed in the entire area to monitor the changes in water levels and quality. The data on water fluctuations would be needed both for pre-project and post project periods. These data would further facilitate in modelling of conjunctive use studies. The conjunctive use would be planned to mitigate effects of deficit of canal water supplies, increase dependability of existing water availability, alleviate problems of rising water levels, soil salinity and increase agricultural productivity in the command. It is expected that the groundwater development would be solely taken up by farmers at their own cost. However, tube wells would be constructed and maintained by Government organizations and farmers would be asked to meet water cess. Proper training to farmers for this purpose would have to be arranged by State Irrigation Department or CAD Authority.

8.6.3 Land Management Plan

Ken-Betwa Link Project Phase-I area comprises vast areas of forests, hilly regions, undulating plains and series of valleys. The land management consists of formulation of plans to mitigate the adverse impacts by adopting land management, CAT and command area management.

8.6.3.1 Land Management

The muck disposal shall have to be planned in such a manner as to occupy the least space and is not hazardous to the environment. The muck disposal areas need to be identified carefully. Low-level areas need to be preferred. About 1.7 MCM muck needs to be disposed at suitable locations in respect of Daudhan dam. It is planned to develop muck disposal areas along the river course in a series of terraces of boulder crater walls and masonry wells wherever needed. In between terraces, catchment water drains shall be provided. Afterwards, the terraces of the muck disposal areas shall be filled with fertile soil obtained from excavations and planted with suitable plants.

8.6.3.2 Restoration Plan for Quarry sites

A part of the aggregate required for the construction of dam, powerhouses and other head works would be obtained from the muck generated during foundation exploration and tunnels since the rock has been found to be suitable as coarse aggregate in CC and other works. Additional quantities of coarse aggregates for concrete works would be obtained from Daudhan village rock quarry and Palkohan road rock quarry. The quarry for fine aggregate would be obtained from Banne river sand quarry and Barne sand quarry which are situated at about 25 and 30 km from the dam axis, respectively, on the left side of the approach road on the Banne and Barne river shores. Problem of taking coarse aggregate from quarry sites can be considerably minimized if material excavated from approach channel to spillway & tunnels are used in concrete portion of dam.

Borrow area quarries have been identified at locations near Gangau, Palkohan, Kharyani and Daudhan villages. The coarse aggregate quarries require restoration measures whereas fine aggregate quarries do not need as they will be extracted from the river bank. The quarries shall be stabilised after extraction of required construction materials by adopting engineering and biological measures.

8.6.3.3 Silt Transfer

The yield received from rains in the catchment area would be stored in reservoir and then let out into the link canal through the upper level tunnel. Normally, the silt transported from the catchment area would settle down into the lower layers and finally to the bottom and the top silt free water would be admitted into the link canal. However, during monsoon season the flood waters due to heavy rain fall would be laden with more suspended silt which would require mitigative measures. Silt excluders need to be built at the head regulator of main canal and branch canals. The silt excluders shall extract silt from the water and lead it to the river or other natural drainage through a tail race. Similarly, a silt excluder shall also be provided at the regulator near Barwa Sagar.

Silt escape or bed escapes, provided with vents and gates, need to be provided on the link canal nearer to the streams or rivers at suitable location. Even after providing silt excluders and silt escapes, some quantity of suspended silt still shall get deposited on the bed of link canal. Every year during the closure period of the canal, the deposited silt would have to be removed from the bed of the canal in order to avoid growth of weeds. Since the bed of the canal shall be entirely lined, desilting can be done with ease.

8.6.3.4 Land scaping of Project Sites

The area around the proposed project need to be developed as a tourist resort in view of its proximity to the world heritage centre at

"Khujaraho" which is about 31 km away. The landscaping plan should include gardens, viewpoints etc. The necessary approach roads shall also have to be constructed keeping the landscaping in view. Aquaculture would be developed and facilities for angling and fishing would be created. The main attraction points around the project within a radius of 100 km include Rehne falls, Pandav falls, Rangawan dam, Dhubela museum, Rajgarh place, Jatasankar, Bhimkund caves, Panna National Park and Crocodile park.

8.6.3.5 Catchment Area Treatment

The total catchment area of Ken river at the site of Daudhan dam has been worked out to be 19,799 sq km based on remote sensing and GIS data whereas as per toposheet, it has been worked out as 19,633 sq km. The catchment area lies in the districts of Panna, Chhatarpur, Damoh, Sagar, Satna, Katni, Narasinhapur and Raisen districts of Madhya Pradesh. It is a well established fact that reservoirs formed by dams on rivers are subjected to sedimentation. The eroded sediment from catchment areas when deposited on streambeds and banks cause braiding of river reach. The removal of top fertile soil from catchment adversely affects the agricultural production. Thus, a well designed CAT plan is essential to prevent the hazards of soil erosion. The various steps involved in planning an effective CAT shall involve data acquisition, estimation of soil loss and silt yield index at prioritization of various watersheds. The characteristics of catchment areas that need to be considered are land use and land cover, slopes and soils characteristics. Areas prioritized in the different sub basins for CAT has been presented in Table 8.11

Table 8.11
Prioritized sub-watersheds for Catchment Area Treatment

Sl. No.	Sub-basin	Total number of sub water-sheds	Total Area (ha)	No. of Watersheds prioritized as high and very high	Area prioritized as high and very high	Percentage
1.	Upper Ken sub-basin	50	564063	9	47557	8.43
2.	Sonar sub-basin	75	768533	12	94609	12.32
3.	Bearma sub-basin	41	621697	4	61671	9.92
4.	Reservoir	-	9000	-	-	-
5.	Total	166	1963293	25	203837	10.38
	Source: AFCL					

From the table, it is inferred that about 12.32% of the area of Sonar sub basin is prioritized for treatment whereas only 8.43% of the area is prioritized under Ken sub basin. Out of the total catchment area, 21.60 % has been given high and very high priority. It is proposed to treat the catchment area in 25 sub watersheds, which are prioritized as high and very high.

8.6.3.6 Conservation and Management Measures

The forests and vegetation play the crucial role in protecting river catchments in hilly regions. The area under dense forest (above 40% crown density) varied between 0.03% and 4.6% in different sub basins. The rest of the forest is under different categories namely open forest (0.3 to 11%), scrub forest (13.7 to 40%) in different sub basins which is indicative of the degradation status. An area of 49031 ha would be treated by forestry and silvi-pastoral measures in the open and scrub forest areas. The choice of plantation would depend on the altitude of the site and environmental needs. Also, properly managed pastures might be the best use of land that can not support trees etc. in association with leguminous plans.

As an integral part of future forestry management plan, a fairly big seven year plan of afforestation of 49188 ha has been proposed. Staggered trenches would be constructed for silvi-horticultural plantation for detention and conservation of rainwater and eroded soils.

Engineering and Mechanical measures needed for treatment of excessively erosive and vulnerable area include gully control structures, contour and staggered trenches along with development of pasture and fodder grasses, check dams and percolation tanks. The reservoir peripheries may have different slope in view of undulating topography. The proposed width for the reservoir rim treatment with plantation shall differ according to the slopes. Slopes above 15% are not recommended for plantation.

Out of the submergence area of 9000 ha, the extent of forest area going under submergence (5258 ha), would have to be compensated suitably under the provisions of the Forest Conservation Act-1980. This would be accomplished by afforesting twice the area of forest coming under submergence.

8.6.3.7 Command Area Management

With the introduction of irrigation in a region, new areas would be brought under irrigation for the first time. The Ken command area falling in Uttar Pradesh is well developed whereas the area of Madhya Pradesh requires land development in selected reaches. The difference of level between the first and last contour of the command area is 76m which is distributed over vast areas of the command. The CAD would include land levelling, shaping, construction of field channels and drainage systems. Land levelling is essential in undulating area of the command for equitable distribution of water and prevention of soil loss due to erosion. The total land requiring land levelling is estimated to be about 104221 ha.

Considering the topography of land, it has been estimated that nearly 74% of the command has slope range between 0 to 2%. Area requiring drains has been estimated to be90655 ha. To prevent stagnation of

water in the command, field drains would drain into subsidiary drains to be constructed at right angle to natural drains. The field boundaries could be made use of in digging these subsidiary drains. Field drains should be at least 30 cm deep with side slope ranging between 4:1 and 8:1. Drains should be as straight as possible with cross section of trapezoidal shape.

8.6.4 Public Health

The construction of Ken-Betwa Link project might contribute to increased incidence and occurrence of water borne diseases. It might also increase the incidence of sexually transmitted diseases due to congregation of labour during the construction phase. The respiratory diseases may also, show an upward trend. During the post construction phase also, water borne diseases might increase due to impoundment of water as also, large scale irrigation. Therefore, it would be essential to strengthen and supplement the existing health delivery system.

8.6.4.1 Preventive and Curative Measures

Well maintained labour camps need to be provided for the project workers with all basic sanitary facilities. Providing safe drinking water and proper underground drainage facilities would help in preventing the incidence of diseases. Regular health checkups should be organized in the labour camps and provide required medical treatments of the diseases. One primary health centre at each block may be adequate to take care of the affected people. Also, regular surveillance activities should be organized in the area. The water quality also needs to be monitored in terms of electrical conductivity, total dissolved salts, fluorides, chlorides, nitrates, pH and sodium adsorption ratio besides pathological and bacteriological parameters.

Water for drinking and other purposes would be provided through bores in the labour camps. Two bores in each camp would be adequate and necessary temporary pipelines, water tubes for washing purposes and other accessories would have to be provided. Chlorination of the drinking water should be done frequently. Appropriate sanitary facilities and space for cooking have to be provided to each labour family.

8.6.4.2 Sewage Waste Disposal

There shall be urgent need to adopt sewage waste disposal under total sanitation programme in the region. It is estimated that peak labour population of 6000 would be accommodated during construction phase in case of Daudhan dam at scattered places for which necessary sewage disposal provisions have to be planned.

8.6.4.3 AIDS Control

With the congregation of labour from the local areas as also from outside, there are chances for the spread of sexually transmitted diseases. Therefore, serious efforts would be needed for prevention as well as slowing down of the spread of the diseases through creation of awareness and bringing out behavioural changes in the society. It is expected that the district level AIDS control centre would take care of the requisite measures. The NGOs in the neighbouring area may also assist in these efforts.

8.6.5 Bio Diversity Management Plan

Conservation of nature and natural resources involves proper management of natural wealth, biological wealth and the habitats that sustain these resources. In the present project, hazards may arise as a result of construction of Daudhan dam on river Ken. Also, extensive human activities during different phases of the project would add to these hazards. Therefore, it is essential to evolve a detailed bio diversity conservation and management plan for the proposed link project.

8.6.5.1 Identification of Areas and Habitats that Need Conservation

The following area requires special attention with reference to conservation and management of flora and fauna.

1. Dam site on River Ken at Daudhan (Submergence area - 9000 ha)

The affected areas would be limited mainly to the dam site. As a result of submergence, all terrestrial organisms would be severely affected. All mesophytes and xerophytes would be destroyed. The animals would be forced to migrate. Therefore, the flora and fauna of reservoir would require special attention.

8.6.5.2 Management Plan

The existing natural ecosystems of u/s and the down stream areas of the project need protection and further strengthening of conservation efforts. Since most of these areas are administered by State Forest Department, it would be desirable to strengthen the existing set up of the Forest and Wildlife Department of the State with clear mandate of ensuring safety and conservation of wildlife in the region. Poaching has been one of the major causes for destruction of wildlife. This has to be checked by regular patrolling and deployment of anti-poaching parties and enforcement of the Wildlife Protection Act – 1972 as amended from time to time.

The reserved forests need to be declared as non interference areas for any human activities. Strict monitoring of labour activities would be carried out to prevent any harm to local wild animals and birds. All precautions would have to be taken in right earnest to avoid any interference with the wildlife. The main activity for the implementation of the conservation and management plan would be to monitor and enforce regulatory provisions in the existing conservation areas in the vicinity of the project and ensure that the natural ecosystem structure and functions are not impaired. The proposed conservation efforts would endeavour to conduct works related to documentation of the existing biological diversity in the area and published check lists of flora and fauna and accounts of ecology and biodiversity from time to time.

4141 ha Forest area of Panna Tiger Reserve would be submerged due to construction of Daudhan dam. The necessary clearance would have to be obtained from the State Forest Department and Supreme Court for diversion of this area. In addition to compensatory afforestation in lieu of this diversion, the project authorities would have to put concerted efforts to improve the balance area of Panna Tiger Reserve Forest.

The Daudhan reservoir may provide an opportunity to develop carp based fisheries with an anticipated production of 470 MT/ year that may provide livelihood to 500 fishermen families. Attempts should be made to form fishermen cooperative society of the tribal oustees. As the tribal's of the project area are not habitual to deep water fishing, the oustees would be imparted proper training in this regard. The womenfolk would also be trained on sorting, grading, sun drying and smoking. Infrastructural facilities for fishing, such as fishing nets, boats etc. would also have to be provided to the society.

8.6.6 Disaster Management

The emergency planning for dam break scenario consists of "hardware" aspects such as provision of evacuation pathways, setting up of alarms and warning systems, establishing communication systems besides the "software" aspects concerning human behaviour, procedures to be followed, roles and responsibilities, leadership, guidance and provision of information.

The emergency response organization must have a Chief Emergency Coordinator (CEC), who will be overall in charge of planning, execution and coordination of activities of Disaster Management Plan. The CEC would be assisted by an Emergency Planning Group (EPG), constituted for purpose of decision making and planning the emergency effort under the plan. This group would involve all the Heads of Departments of Irrigation, Revenue, Health, Police and public representatives. To assist this group with technical information and advice, an Advisory Team consisting of various experts on dam safety and related issues would need to be constituted. At local level i.e. a taluk/settlement level, Emergency Action Groups need to be constituted for pooling, mobilizing and responding to the inundation

situations. These groups should consist of local volunteers, engineering support group, medical team and police representatives. The Disaster Management Plan can not be effective unless accompanied by training programmes that include periodic exercises and drills. Also, effective emergency communication systems need to be installed for rapid communication within identified hazard zones. The participation of local people in the Disaster Management Plan is an integral component of any emergency preparedness plan. For this purpose, necessary awareness programmes have also to be organized at regular intervals.

8.6.7 The EMP Costs

The EMP proposed in the present study covers air and noise pollution management, land and water management plan including catchment area treatment, public health management plan and biological conservation plan. For each component, attempts have been made to work out the estimated costs. The Abstract of costs for the environmental plan is presented in Annexure 8.1. The total financial provision required for implementation of EMP under the project has been estimated to be of the order of Rs. 3495.16 crore.

CHAPTER-IX
SOCIO-ECONOMIC ASPECTS AND R & R

CHAPTER-IX

SOCIO-ECONOMIC ASPECTS AND R & R

The development of Water Resources Projects is always a boon for the people of command area but at the same time, there are some problems associated with displacement of people in the event of creation of a reservoir. Therefore, it entails to study in detail the socio-economic profile of the concerned region and offer probable solutions to either mitigate or remove the adverse impacts of development. Also, a detailed R&R plan has to be evolved to ameliorate the ill effects of displacement of people on account of creation of a reservoir. The MoEF being the nodal agency for clearing development projects, has to oversee that adverse impacts of any development project be minimum and appropriate ameliorative measures are adopted to mitigate the adverse impacts. M/s AFC Ltd, Hyderabad was entrusted with the task of carrying out necessary socio-economic surveys and to prepare a R&R plan for the Ken-Betwa Link project Phase-I. In this chapter, the socio-economic status both for pre and post project scenarios and a R&R plan based on the findings of M/s AFC Ltd., Hyderabad has been presented.

9.1 Socio-Economic Aspects

The total catchment area of Ken river upto Daudhan dam site is 19,633 sq km. The submergence area of the proposed project is spread over two districts of Madhya Pradesh viz. Chhatarpur & Panna. However, villages coming under submergence fall in Chhatarpur district only. The Ken-Betwa Link Project Phase-I constitutes two main divisions of command areas viz. Ken command area with an annual irrigation of 3.23 lakh ha and CCA of 2.41 lakh ha and En-route link canal command area of 0.60 lakh ha. As mentioned earlier, command area of the project falls in Chhatarpur, Tikamgarh districts of Madhya Pradesh and Jhansi & Mahoba of Uttar Pradesh.

9.1.1 Demography

The total population of the districts in the catchment as well as command area of Ken-Betwa Link Project Phase-I is presented in Table 9.1

Table 9.1

District wise total population, population density and sex ratio in the catchment and command areas (2001 Census)

Sl. No.	District	Total Population	Male Population		Female population		Sex ratio	Popu-lation density	SC	ST
		No	No	%	No	%	per 1000 males	per sq km	%	%
1.	Chhattarpur	14,74,723	7,88,933	53.5	6,85,790	46.5	869	170	23.3	3.5
2.	Panna	8,56,558	4,50,549	52.6	4,06,009	47.4	901	120	20.0	15.4
3.	Tikamgarh	12.02,998	6,37,913	53.0	5,65,085	47.0	886	238	24.3	4.3
4.	Jhansi	17,44,930	9,32,820	53.4	8,12,110	46.6	871	347	28.8	0.1
5.	Mahoba	7,58,380	4,06,790	53.6	3,51,590	46.4	864	262	25.9	-

From the table, it is clear that the male population varies from 52.6% to 53.6% and that of female from 46.4% to 47.4%. The data indicates a skewed population in favour of males. Also, the maximum population of scheduled caste (SC) was in Jhansi district where as Panna district had the maximum scheduled tribe (ST) population.

9.1.2 Agriculture

Agriculture is the mainstay of the population inhabiting the area. Among the important cereals, wheat, maize and jowar are grown in the region. The important oilseeds grown in the area are sesame, soyabean, groundnut and mustard. Bengal gram, red gram and green gram are the major pulses grown in the area. Whatever little irrigation is practised in the area, it is mostly through wells, followed by tanks. The net area irrigated at present is 600405 ha. Most of the farmers in the area are marginal owning, less than 1 ha of land.

9.1.3 Literacy

Education is receiving due impetus in the region. State Governments are putting their respective best efforts to promote literacy, especially, among the rural masses. The district wise percentage literacy is presented in Table 9.2.

Table 9.2

District wise percentage literacy in Ken-Betwa Link Project

Phase-I (2001)

Sl. No.	District	Male literacy	Female literacy	Total literacy
		(%)	(%)	(%)
1.	Chhatarpur	65.3	39.3	53.3
2.	Panna	58.9	38.2	49.1
3.	Tikamgarh	68.7	41.0	55.7
4.	Jhansi	66.2	42.0	54.9
5.	Mahoba	N.A	N.A	N.A

This shows that literacy rate in male is considerably higher than that in female.

9.1.4 Public Health Facilities

The public health facilities in the district falling under the Ken-Betwa Link project Phase-I are average to below average. The medical and health facilities in the districts are being catered through the Government and Private Hospitals while at the Tehsil/block level, the primary health centres take care of the medical facilities. Private allopathic doctors and registered medical practitioners are also available. The medical and health facilities available in the districts are presented in Table 9.3.

Table 9.3

Medical and Health facilities in the Ken-Betwa Link Project Phase-I (2005-06)

Sl. No.	District	Hospitals (Allo-phathic)	Public Health Centres	Sub-Centres	Dispensaries (other than allopathic)	Allo-pathic doctors	Others
1.	Chhatarpur	2	45	186	29	62	37
2.	Panna	8	19	139	16	41	-
3.	Tikamgarh	7	24	156	31	47	33
4.	Jhansi	33	60	-	-	425	840
5.	Mahoba	18	28	42	-	121	212

In many of the districts, efforts are being made to supply protective drinking water to as many villages as possible. Owing to illiteracy prevalent in the area, water is being contaminated due to unhygienic storage, domestic practices and lack of awareness on cleanliness aspects. The sanitary facilities, especially, available in the rural area are extremely poor. Even in the semi urban areas, open drainage canals without cover are found thereby exposing the sewage to the disease transmitting organisms like flies, mosquitoes, insects etc. Open air defecation is still prevalent in the rural area which causes many health hazards.

9.1.5 Submergence Area

Due to construction of the Daudhan dam, 2171 ha of village land spread over 10 villages shall come under submergence. It has been estimated that about 1585 families will be affected in these villages. A small population of peripheral villages would also be affected as lands of the people belonging of these villages will also be adversely affected. It is significant to note that no railway lines, telephone lines, main power lines, mineral deposits, historical and archaeological monuments are coming under submergence.

9.2 Project Affected Villages

The project-affected villages are those villages, where either Government lands or Private lands or both shall be acquired for the construction of Ken-Betwa Link Project. As a result, a part of culturable land and some of the households living in these villages would be affected by loss of land or house or both. It is estimated that a total geographical area of 9000 ha spread over 10 villages would be adversely affected. The total population of these 10 villages, shall be 7224. The literacy rate of the study area is about 42.3%. The percent of SC and ST population of the area at present is 13.26 and 36.09 respectively.

The occupational distribution of the workers indicated that the prominent occupation is agricultural labour (56.4% of total workers) followed by cultivators (38%). All other services account for 2.1% followed by animal husbandry (0.7%), trade and commerce (0.6%) and industry (0.04%). About 63% of the female workers are engaged in agricultural labour while 52% of male workers are dependent on it.

The total geographical area of the 10 villages affected due to Daudhan reservoir is 9000 ha (worked out by M/s AFC Ltd, based on satellite data). About 24.12% of the area is sown with agricultural crops, dense forests cover about 6.77% and open and scrub forest cover 3.06 and 48.60% respectively.

9.2.1 Livestock

The livestock population in the project area is dominated by cows and goats with 4.87 and 6.25 animals per household respectively. This is followed by buffaloes and sheep. The livestock details of the project area are shown in the Table 9.4.

Table 9.4

Livestock population of the project area

Sl.No.	Type of livestock	Daudhan	Average per household
1.	Cattle	1586	1.00
2.	Cows	7712	4.87
3.	He-buffalo	207	0.13
4.	She-buffalo	2805	1.77
5.	Sheep	281	0.18
6.	Goats	9909	6.25
7.	Poultry	1137	0.72

9.2.2 Agricultural Implements

Agricultural implements available with the farmers inhabiting the project area mainly consist of yokes, electric pumps and diesel pumps. The total of units along with computed number per household is furnished in Table 9.5.

Table 9.5
Agricultural implements with the farmers in project area

Sl. No.	Type of implement	Numbers	Average per household
1.	Tractors	24	0.01
2.	Power Tillers	4	0.00
3.	Sprayer	44	0.01
4.	Yoke	602	0.17
5.	Decorticator	28	0.01
6.	Duster	16	0.00
7.	Bullock cart	169	0.05
8.	Electric pump	590	0.17
9.	Diesel pump	434	0.13

9.2.3 Income and Expenditure

The major source of the income for the project families is from the agriculture-based activities, which accounts for nearly 90% of the overall income, followed by selling up of minor forest produce. Similarly, the major part of the expenditure is spent on food and some sort of recurring cost on agriculture and livestock. Also, a significant amount (10%) was being spent on health. The income and expenditure patterns of the project area is shown in Table 9.6

Table 9.6

Income and expenditure patterns of the project area

Sl. No.	Income		Expenditure	
	Particulars	%	Particulars	%
1.	Agriculture	59.78	Food	36.64
2.	Agri. Labour	20.16	Fuel	0.83
3.	Non-Agriculture	0.87	Clothes	7.93
4.	Livestock	8.47	Housing	2.26
5.	Business	0.58	Education	3.90
6.	Sericulture	0.08	Health	9.77
7.	Minor forest produce	7.99	Social ceremony	7.03
8.	Govt./Pvt. Service	1.40	Agriculture & Livestock	24.63
9.	Others	0.66	Others	7.01

9.2.4 Housing

The major part of the submergence area contains semi pucca houses occupying 65.43% whereas Kutcha houses constitute nearly 33%. The details are presented in Table 9.7.

Table 9.7

Housing details of Daudhan project area

Sl.No.	Type of housing	No.	%
1.	Semi Pucca	1037	65.43
2.	Kutcha	528	33.31
3.	Pucca	20	1.26

9.3 Project Affected Community

There are 1585 households in 10 villages which are going to be affected by the construction of Daudhan dam. The affected households may loose their lands or houses or both under submergence when the dam is created. In the normal course, all the affected households would be compensated for the loss of their lands and houses. In case of those whose houses get submerged would have to be resettled in a new habitation. They would also have to be helped to take up some alternative occupation in the new surrounding.

The affected households would be classified under two categories viz. PAF and other affected families (OAF). A land holding of 2 ha dry land and 1

ha of wet land has been considered as a Minimum Economic Holding (MEH). PAF would be one who looses 50 % or more of his /her land and left with less than MEH after the loss of his / her land slips Below the Poverty Line (BPL) after acquisition of his / her land. All the persons who loose their houses due to submergence would also be considered as PAF's. Using this criteria, about 1585 PAF's in the study area have been identified. They are eligible for assistance under the Economic Rehabilitation Programme (ERP).

The total population of the affected households is 7224 as per door to door survey done by M/s AFC Ltd. The number of males is 3872 whereas females are 3352 thereby indicating a sex ratio of 865 females per 1000 males. The total number of affected households due to submergence of Daudhan dam is 1585. The largest numbers of PAF houses are in Kuppi village (438) in submergence area of Daudhan reservoir. On an average, there are about four members per household in the affected villages.

There are 92% male headed household and the remaining 8% female headed ones. The affected households mostly belong to backward castes (37.72%). The scheduled castes and tribes constitute about 13.26% and 36.09% of total population, respectively, whereas the remaining 12.93% belong to higher castes. There are 1380 scheduled tribe and 485 scheduled caste houses that would get submerged. The age wise distribution of household population of the 7224 affected households is presented in Table 9.8.

Table-9.8
Age-wise distribution of Project Affected Persons (PAP's)

S.No.	Village	Age Group (Years)					
		0-6	7-17	18-35	36-60	Above 60	Total
1.	Daudhan	871	2042	1996	1965	350	7224
	% to Total	12.06	28.27	27.63	27.20	4.84	100.00

Children up to 6 years of age formed 12.06% of the total population whereas persons above 60 years of age constituted only 4.84%.

9.4 Resettlement and Economic Rehabilitation Plan

The Department of Land Resources, MRD, GoI, formulated a policy entitled "National Rehabilitation and Resettlement Policy – 2007" (NRRP- 2007). Further, the Department of Rehabilitation, Govt. of Madhya Pradesh, also formulated a policy known as "Ideal Rehabilitation Policy of Madhya Pradesh– 2002" (IRPMP- 2002) for R&R of PAF's. Since, the National R&R – 2007 stipulates

that best R&R Policy needs to be adopted for providing R&R assistance to the project affected families, a comparison of NRRP-2007 and IRPMP- 2002 revealed that the NRRP-2007 provided for better assistance to PAFs except for the following two aspects.

- All major sons in a joint family are to be treated as separate families and would be entitled for all R&R benefits
- All major unmarried daughters in a family are to be treated as separate families for provision of R&R benefit

9.4.1 Identified PAF's

The total number of affected families due to the construction of Daudhan dam has been assessed to be 1585 spread over 10 villages. Since the rehabilitation of 779 households spread over in four villages located inside Panna Tiger Reserve viz. Mainari, Kharyaru, Palkoha and Daudhan has been taken up by the National Tiger Conservation Authority(NTCA), no socio-economic survey of these households have been carried out for preparation of R&R Plan for these affected households. Thus, only 806 households from the remaining six villages have been considered for R&R Plan. The caste wise distribution of the PAF in the reservoir area is given in Table 9.9.

Table-9.9
Caste-wise distribution of project affected families in the Daudhan reservoir area

No. of PAF's					% to total				
SC	ST	BC	OC	Total	SC	ST	BC	OC	Total
109	339	279	79	806	13.5	42.1	34.6	9.8	100

As stated above, the economic rehabilitation of the PAF's has been made as per the National R&R Policy-2007 and IRMP -2002.

i. Housing grant of Rs. 40,000 for each displaced BPL, PAF household
ii. Each affected family that is displaced and has cattle shall get financial assistance of Rs. 15,000
iii. Each affected family that is displaced shall get one time financial assistance of Rs. 15,000 for construction of cattle shed.
iv. Each affected family that is displaced shall get one time financing assistance of Rs. 10,000 for shifting of the family, building materials, belongings and cattle.

v. Financial assistance of Rs. 25,000 per each PAF household who is a rural artisan, small trader and self employed person and Rs. 40,000 to agricultural or non-agricultural labour.
vi. Displacement grant of Rs. 15,360 for each PAF and major sons who has lost his house or house site.
vii. Provision of land to land to the extent of land acquired, to the ST and SC PAFs.(Not considered since the displaced persons will be settled in colonies near the areas where the affected persons are staying)
viii. Financial assistance to the extent of
    a) Rs. 48,000 whose total holding is acquired or
    b) Rs. 32,000 if he becomes a marginal farmer (<1.0 ha) after land acquisition or
    c) Rs. 24,000 if he became a small farmer (> 1.00 ha and < 2.0 ha) after land acquisition.

9.4.2 The Cost

The cost of relief, R&R of the affected households under the Ken-Betwa Link Project Phase-I has been worked out in accordance with the R&R Policy of Government of India and Government of Madhya Pradesh. Broadly, three major components have been considered viz. land acquisition, resettlement and economic rehabilitation of displaced persons and economic rehabilitation of PAFs who have lost only land but no house.

9.4.2.1 Land Acquisition

According to the socio-economic survey conducted by M/s AFC Ltd, Hyderabad, 2171 ha of patta land has to be acquired for Daudhan reservoir from 1585 families residing in 10 villages. In addition, 4066.37 ha of patta land would be required for the Canal and distributary system. The estimated land requirement towards land to land compensation to ST and SC PAFs would be about 358 ha. However, since the displaced persons will be settled in colonies near the areas where the affected persons are staying, no land acquisition is proposed on this account. Thus, the total land acquisition required for the project has been estimated to be about 6237.37 ha. The total compensation for land acquisition has been estimated to be Rs. 314.28 crore.

9.4.2.2 Resettlement and Economic Rehabilitation of Displaced Persons

The resettlement plan provides for the construction of new colonies for the resettlement of 806 families to be located in the vicinity of the villages coming under submergence comprising free house site and free infrastructure facilities including roads, schools, health resettlement centres, workshop and farm service centre, training centre etc. While computing the land

requirement for construction of houses is taken to be of the order of 42.37 ha. The establishment of colonies including assistance for house construction, schools, roads and other infrastructures facilities has been estimated to cost Rs. 3.45 Crore. The economic rehabilitation package for 806 PAFs identified has been estimated to cost Rs. 8.11 crore. Further, keeping a margin of 5% for meeting additional claims that might arise, the total cost of economic rehabilitation programme would be about Rs. 8.52 crore.

9.4.2.3 Compensation in lieu of Properties

The compensation for loss of properties like houses and cattle sheds has also been computed. In addition to the loss of 806 houses, an additional 5% budget has been included in the indicative budget. Budgetary provisions for loss of 419 cattle sheds, 967 productive trees and 40 farm houses has also been made. The total cost worked out to be Rs. 5.88 crore.

9.5 Training

Training is a very crucial component for successful implementation of the EMP having varied components related to different disciplines. The training is also important for the project-affected persons for up-gradation of their skills and also for imparting new skills to undertake different avocations of their interest. The training for implementation of components of ERP is at two levels viz. Departmental Level and PAP's.

9.5.1 Training at Departmental Level

Training of personnel belonging to Departments of Water Resources, Forests, Agriculture, Fisheries and Rehabilitation and Resettlement would be an important component of any training programme under EMP. The essential components of a given training programme would be awareness about environment and its impacts, EMP, R&R Policies, Soil and Water Conservation measures, Afforestation, On Farm Development, Reservoir, Fisheries, Animal Husbandry, Knowledge of Law etc.

9.5.2 Training the Project Affected Persons(PAP's)

The identified PAP's shall be the ultimate beneficiaries of any R&R Plan. The strategy of training to PAPs, especially the women, should comprise the following:

- Awareness of aims and objectives of R&R Policy and Action Plans
- Cooperating and Coordinating with NGOs for identifying the PAPs for vocational training

- Imparting training to PAP's for proper utilization of productive assessment grants for purchase of assets.
- Women should be trained to acquire special skills to generate income and inculcate thrift culture.
- Tribal's should be encouraged to take up bee keeping, collection of gum and its processing, collection of forest produce etc.

9.6 Organisation and Management

The EMP for Ken-Betwa Link Project has the components related to CAT, CAD, flora and fauna, compensatory afforestation, public health, R&R, etc. involving various departments like Irrigation, Agriculture, Forest, Public Health, Panchayat Raj and Rural Development etc. for its implementation. Institutional set up are required to be constituted at the Government Level, at the Department Level, at District Level and at Project Level. The Chief Engineer, Irrigation Department, located at the site would be the Principal Executive for Implementation of the EMP & ERP. He would be responsible for allocation of funds for various components of EMP & ERP. He would also be responsible for smoothening the process for easy disbursal of compensation for acquisition of land, houses, etc.

The Revenue Department would be responsible for identification of the affected persons as per the land records and disbursal of the compensation amounts for the assets acquired from the affected households after careful assessment. The Revenue Department would also be responsible for provision of alternative sites for resettlement of the affected households and the identified sites nearer to the projects would be handed over to the Irrigation Department prior to implementation of the project. Other Departments like Forests, Fisheries, Agriculture, Tribal Affairs, Public Health, Housing, etc. also need to be involved while implementing the various components of EMP & ERP.

9.7 Monitoring and Evaluation

The successful implementation of R&R Plan of PAP's requires continuous monitoring of the programme at different levels viz. Project, District and State. Therefore, it will be essential to constitute Project, District and State Level Committees for Monitoring and Evaluation of Implementation of various components of EMP & ERP. As per NRRP 2007, the Central Government shall constitute National Monitoring Committee to be chaired by the Secretary, Department of Land Resources, MRD, for Reviewing and Monitoring the Progress of Implementation of R&R Plans relating to all cases to which this policy applies.

9.8 Project Cost

A major impact of the construction of Ken-Betwa Link Project Phase – I relates to the submergence of about 9000 ha under Daudhan dam. This includes river course, forest area and agricultural land belonging to the farmers of 10 affected villages. The land acquisition would be necessary for resettlement colony, green belt and other facilities. The total land acquisition for the project has been estimated to be in the vicinity of 6237.37 ha. The package of assistance would include sanction of productive asset grant to each head of project affected household as also to each of the major children of such households, besides provision of maintenance allowance for your family, cattle maintenance allowance, vocational training grant, and women thrift grant. Also, costs for resettlement of displaced persons include sanction of housing grant for construction of a new house and infrastructure facilities like electricity, drinking water, school, health centre, resettlement centre, etc. The total cost for resettlement and economic rehabilitation has been estimated as about Rs. 333.77 crore.

It has also been proposed to impart training to the staff dealing with economic rehabilitation programme since it would involve an inter-disciplinary approach and coordination with different agencies. It has also been proposed to train the PAF's to make them aware of their entitlements and to enable them to take appropriate decisions in choosing the type of economic activity suitable to their skills and family background. The training schedule has been so designed as to help the PAF's in efficient use of the productive asset grants sanctioned to them and in the efficient upkeep and maintenance of the equipment. The cost of training the R&R staff and PAF's has been estimated to be about Rs. 0.05 Crore.

It has also been proposed to involve NGO's in the implementation of programmes particularly those involving PAF's with a view to ensuring transparency in the disbursement and utilization of assistance on a large scale. The NGOs would help a great deal in mollifying the feeling of the affected people, dispelling their misgiving and making them understand about the benefits of various programmes that would be undertaken to resettle and rehabilitate them. The total outlay proposed for the implementation of Project Affected Persons Economic Rehabilitation Plan (PAPERP) for the Ken-Betwa Link Project would amount to about Rs. 333.77 crore. The component –wise distribution of PAPERP outlay has been presented in Table-9.10. Detailed computations are furnished in Annexure 9.1.

Table 9.10

Cost of Project Affected Persons Economic Rehabilitation Plan (PAPERP)

(Rs. in crore)

S.No	Particulars	Dau-dhan reser-voir	KBL canal	Ken LBC syste m	PH-I	PH-I I	Total
1	Land compensation	57.97	152.65	103.54	0.08	0.04	314.28
2	Cost of resettlement colony for displaced persons	3.45	0.00	0.00	0.00	0.00	3.45
3	Economic Rehabilitation of Project Affected Households	8.52	0.00	0.00	0.00	0.00	8.52
4	Compensation in lieu of properties	5.88	0.00	0.00	0.00	0.00	5.88
5	Land for colonies during dam construction	1.60	0.00	0.00	0.00	0.00	1.60
6	Training of R&R Staff and PAFs	0.05	-	-	-	-	0.05
	Total	77.47	152.65	103.54	0.08	0.04	333.78

Grand Total: Rs. 333.78 crore

Members of Expert Committee getting views of affected people of Daudhan village, which is likely to be submerged in the proposed Daudhan dam

Visit of Members of Committee of experts on interlinking of rivers

A spectacular view of deers at Panna Tiger Reserve near Daudhan dam

CHAPTER-X
COST ESTIMATE, B C RATIO & FINANCIAL ASPECTS

CHAPTER-X

COST ESTIMATE, BENEFIT COST RATIO AND FINANCIAL ASPECTS

10.0 General

The Ken-Betwa Link Project envisages construction of a dam at Daudhan on Ken river, two weirs i.e. Bariyarpur on Ken river & Parichha on Betwa river, Ken-Betwa link canal, two tunnels, two power houses, Ken LBC and their canals along with developments in command areas of the project.

The Working Group Report of erstwhile Ministry of Irrigation, Govt. of India had issued broad guidelines for preparation of Detailed Project Reports for major irrigation and multipurpose projects in 1980. These were based on the IS : 4877-1968 which have subsequently been updated with explanatory notes for each unit / minor head / sub-head. For preparing the cost estimates of Ken-Betwa link project, these guidelines of CWC have been followed.

The cost estimates have been worked out by calculating the quantities of different items of the works involved for the execution of the project components. The rates for principal items of various works have been adopted from “Unified Schedule of Rates-2007-08” of Govt. of Madhya Pradesh.

10.1 Classification of units

The Ken-Betwa Link Project broadly comprises of the following three components :

(i) Main component comprising of Daudhan dam, Upper level tunnel, Dam toe Power house (PH-I), K-B link canal and enroute command

(ii) Ken LBC System comprising of Lower level tunnel, Power house (PH-II), Canals and their commands

(iii) Bariyarpur PUW and Parichha weir

The cost estimate of Ken – Betwa Link Project, has been grouped into the following units. Table 10.1 shows unit wise cost estimate of project.

Table-10.1
Cost Estimate of the Project

(Rs. Crore)

Component	Unit-I Head works	Unit-II Canals	Unit-III Power	Unit-VI Command area Development	Total
Daudhan dam	5530.11	-	-	-	5530.11
Bariyarpur PUW	503.53	-	-	-	503.53
Parichha weir	202.24	-	-	-	202.24
K-B link canal	-	1789.67	-	33.15	1822.82
Ken LBC System	-	838.30	-	154.45	992.75
Power House-I	-	-	245.86	-	245.86
Power House-II	-	-	95.68	-	95.68
Total	6235.88	2627.97	341.54	187.60	9392.99

Thus, the total cost of the link project works out to be Rs. 9393 crore at 2007-08 price level, which includes Environmental Implementation Plan (EMP) and Socio-economic Survey and Resettlement & Economic Rehabilitation Plan studied by AFC, Hyderabad. The general abstract of cost of the project is given in Annexure:10. The details under various heads are described in the following paragraphs.

10.1.1 Unit – I : Head Works

Unit-I Head works mainly includes cost of the following structures of the project:

- Daudhan dam including Earth dam, Non-over flow section with irrigation sluices, Over flow section with spillway & energy dissipation arrangements and intake structure of dam toe power House (PH-I) etc.

- Reconstruction and Remodeling of Bariyarpur PUW & Parichha weir

The total cost of Unit-I : Head Works is estimated to be Rs. 6235.88 crore. Details are given in Annexures-10.1, 10.2 & 10.3 and their sub-annexures. The sub-headwise details are given below:

10.1.1.1 A - Direct charges

In general, Direct charges cover minor heads like I-Works, II-Establishment, III- Tools & Plants, IV- Suspense and V- Receipts & recoveries.

I-Works

A. Preliminary **Rs. 10511.48 lakh**

Provision under this sub-head has been made to cover the actual expenditure incurred on detailed survey & investigation works mentioned below for preparation of Detailed Project Report of this project.

- Topographical surveys & investigations
- Hydrological & meteorological surveys
- Geological & Geotechnical surveys
- Construction material survey
- Seismic studies
- Construction of access Roads to facilitate site investigations
- Charges for consultancy works for various studies and
- Preparation of Detailed Project Report

However, for detailed survey & investigations for establishing the final locations of different project components at pre construction stage, a lumpsum provision of 2% of I-Works has been considered under this sub-head. The details are given in Annexures- 10.1.1, 10.2 & 10.3.

B. Land **Rs. 8979.00 lakh**

Under this sub-head, provision for acquisition of land for construction of the project, colonies, offices, stores, stock yards, working area and approach roads etc. , compensation for houses, solatium charges, standing crops and other immovable properties, cost of resettlement colonies for displaced persons, economic rehabilitation of PAFs, training of R&R staff and PAFs etc. have been considered. The details are given in Annexures- 10.1.2, 10.2 & 10.3.

C. Works **Rs. 135630.33 lakh**

This sub head includes cost of construction of following components:

- Daudhan Earth dam, coffer dam, concrete dam (OF & NOF), intake structure for dam toe power house (PH-I), Irrigation sluices etc.
- Bariyarpur PUW & Parichha weir (cost estimate submitted by the Govt. of UP)

The quantities and the cost of the components have been evaluated as per the designed drawings supplied by the Specialised Directorates of Central Water Commission, New Delhi. Necessary provisions have been made for Spillway radial gates with embedded parts, stop logs and hoisting arrangements etc. The details of works under this sub-head are given in Annexures- 10.1.3, 10.2 & 10.3.

D. Regulators Rs. 579.43 lakh

Provision has been made under this sub-head for construction of one head regulator at Bariyarpur Barrage proposed by Govt. of UP.

K. Buildings Rs. 8671.14 lakh

Provision has been made under this sub-head for construction of temporary & permanent buildings for both residential & non-residential buildings and hostel accommodation for various categories of staff, offices, inspection bungalow, circuit house, workshops, stores, sheds as well as other service buildings like hospital, schools, police station, post office & welfare center etc. The details under this sub-head are given in Annexures- 10.1.4, 10.2 & 10.3.

L. Earth work Rs. 70539.00 lakh

Under this sub-head, the cost of earth work and lining involved in the upstream diversion channel and down stream spillway channel at Daudhan dam has been considered. The details under this sub-head are given in Annexures- 10.1.5, 10.2 & 10.3.

M. Plantation Rs. 573.06 lakh

Under this sub-head, cost of proposed plantation in the colony, parks in the d/s of Daudhan Earth dam and along the approach roads to the dam sites have been considered. The details under this sub-head are given in Annexures- 10.1.6, 10.2 & 10.3.

O. Miscellaneous Rs.2660.07 lakh

Under this sub head provision has been made to cover the cost of the following works

- Capital cost of electrification, water supply purification and distribution system, sewage disposal, medical equipment, fire fighting equipment, furniture and crockeries for inspection bungalow and circuit houses, initial camp equipment for hospital, primary & secondary schools, community centre etc.

- R & M of above equipments/infrastructural facilities etc.

- R & M of inspection vehicles, market complex, police station, post office, pump house , telephone lines etc.

Provision has also been made for other miscellaneous items such as inaugural foundation laying ceremony, compensation to work men, visit of VIP dignitaries, anti malaria measures, security arrangements for dam sites, flood lighting, model studies, data processing machines etc. The details are given in Annexures- 10.1.7, 10.2 & 10.3.

P. Maintenance Rs. 3190.97 lakh

Under this sub-head provision has been made to cover the cost of maintenance of all works during the construction. A provision of 0.25% on cost of concrete dams (Over flow & Non-over flow sections) and 0.5% on cost of earthen dams, 1% on the cost of permanent buildings and 1% on cost of maintenance of roads has been considered. The details are given in Annexures- 10.1.8, 10.2 & 10.3.

Q. Special Tools & plants Rs. 5112.98 lakh

Under this sub-head provision has been made at 25% of capital cost of major construction equipment and general purpose equipment. Cost of inspection/ transportation equipment has been added to the above cost in full to arrive the total cost chargeable under this sub-head. The recoveries on account of resale value of Q-Spl. T&P is considered as 75% of the capital cost of the major construction/ general purpose equipment chargeable to Q-Spl. T&P and 75% on 20% cost of inspection/transport equipment chargeable to Q-Spl.T&P. which worksout to Rs. 3448.44 lakh. Details of the equipment as suggested by CMO, CWC, New Delhi and the cost that to be chargeable to the project works are given in Annexures- 10.1.9 & 10.2.

R. Communication Rs.1508.43 lakh

Necessary provision has been head under this sub-head to cover the cost of widening of existing roads in the near vicinity of the project area, formation of approach roads to project area from the existing roads, W.B.M road from quarry sites to dam/barrage sites etc. The details of length of roads and costs are given in Annexures- 10.1.10, 10.2 & 10.3.

X. Environment and ecology Rs.313234.70lakh

This sub-head includes provision for extensive management measures to sustain environment and ecology such as catchment areas treatment, forestry & salve postral management(afforestation/deforestation), soil erosion control and water conservation measures, reservoirs rim treatment/green belt development, treatment of agricultural lands, compensatory afforestation, land management plan (stabilization of muck disposal management), restoration of quarry site, tourism development plan, provision for free fuel to department engaged labourers, Bio-diversity management plan, restoration and land scapping of project sites, fisheries development plan, ground water management plan, Public Health management, Environmental monitoring programme (EMP), Dam break analysis and Disaster Management plan. The details are given in Annexure- 10.1.11.

Y. Losses on stock and unforeseen items

Rs. 1292.33 lakh

Provision has been made for losses on stock and unforeseen @ 0.25% on all sub-heads under I- works excluding sub – heads A-preliminary, B- land & Q-Spl. T&P.

II-Establishment Rs. 53855.39 lakh

The project is planned to be completed in a period of 8 years. Provision has been made @ 10% of I-Works excluding B-land towards establishment & pensionary charges.

III-Ordinary Tools & Plant Rs. 5473.63 lakh

Provision has been made under this head for ordinary Tools & Plant @ 1% of I-Works. This provision is distinct from the Q-Spl. T&P and is meant to cover the cost of survey instruments, camp equipment and other small tools & plant.

IV – Suspense

It is assumed that all the outstanding suspense would be cleared by adjustment to appropriate heads on completion of the project. As such no provision has been kept under this head.

V- Receipt & recoveries Rs. 4015.59 lakh

Under this head, estimated recoveries by way of resale or transfer of temporary buildings, special T&P and by resale or transfer of generator sets, electrical lines, telephone lines and other accessories are accounted for and provision has been made accordingly.

10.1.1.2 B - Indirect charges Rs. 5148.55 lakh

Provisions for abatement of land revenue and Audit & account charges are covered under 'Indirect charges' at the following rates

- Abatement of land revenue - 5% of cost of land
- Audit and account charges - 1% of I-Works

10.1.2 Unit – II : Canals

Unit-II Canal system covers the cost of the following structures along with their appurtenant works

- Ken-Betwa link canal
- Intake structure to the Upper level tunnel
- Upper level tunnel
- Ken LBC system
- Intake structure to the Lower level tunnel
- Lower level tunnel

The total cost of Unit-II :Canal system is estimated to be Rs. 262796.87 crore at 2007-08 price level. Details are given in Annexures 10.4, & 10.5 and their sub-annexures. The sub-head wise details are discussed in the following paragraphs.

10.1.2.1 A - Direct charges

I-Works

A. Preliminary Rs. 4536.63 lakh

Provision under this sub-head has been made to cover the actual expenditure incurred on detailed survey & investigation works

mentioned below for preparation of Detailed Project Report of this project.

- Topographical surveys & investigations
- Geological & Geotechnical surveys
- Construction material survey
- Vehicle charges for inspecting officers for site investigations
- Survey & Camp equipment
- Charges for consultation for various studies
- Actual expenditure on establishment and
- Preparation of Detailed Project Report

However, for detailed survey & investigations for establishing the final locations of different project components at pre construction stage, a lumpsum provision of 2% of I-Works has been considered under this sub-head. The details are given in Annexures 10.4.1 & 10.5.1

B. Land Rs. 25619.02 lakh

Under this sub-head, cost of acquisition of land required for canals and canal structures compensation for property & standing crops, solatium charges and diversion of communication system etc. have been taken in consideration. Under this sub-head, provision for acquisition of land for construction canals viz. K-B link canal and Ken LBC system and approach roads, colonies, canal structures etc. , solatium charges, standing crops and other immovable properties, rent for use of land prior to acquisition, economic rehabilitation measures etc. have been considered. The details are given in Annexures 10.4.2 & 10.5.2

C. Works Rs. 8316.69 lakh

Under this sub-head the cost of upper and lower level tunnels and their intake structures, surge tank at the end of lower level tunnel and bypass arrangements from surge tank to connecting canal etc. have been considered. The quantities and the cost of the components have been worked out as per the designed drawings supplied by the Specialised Directorates of Central Water Commission, New Delhi. Necessary provisions have been made in the estimate for service gates and emergency gates with embedded parts, stop logs and Rope drum hoisting arrangements etc. in the intake structures of tunnels. The details of works under this sub-head are given in Annexures 10.4.3 & 10.5.3

D. Regulators Rs. 6421.02 lakh

Under this sub-head, provision for head and cross regulators at intake / outfall of the canals and at appropriate locations where branch canals take off from main canal, desilting chamber at beginning of K-B canal, exit regulator at Barwa Sagar, service gates with embedded parts, stop logs and Rope drum hoists, monorail arrangements, etc. at regulators have been made. Provision for Cross Regulators for branch canals has also been made. Estimate of a typical cross regulator is prepared based on the detailed drawings supplied by CWC, New Delhi and the cost of other regulators are arrived based on the estimated cost of the typical regulator proportionate to discharges. The details are given in Annexures -10.4.4 & 10.5.4

E. Falls Rs. 558.62 lakh

Four falls varying from 2 m to 3.6 m have been proposed along the K-B link canal at suitable locations. Provision is kept under this sub- head for Ken LBC system and Accordingly, the cost has been worked out for construction of these falls in all the canal systems based on the cost curves prepared for Bargi diversion project, Govt. of M.P. The details are given in Annexures- 10.4.5 & 10.5.5

F. Cross drainage structures Rs.14055.91 lakh

The cross drainage works proposed across the main canals and branch canals are aqueducts, syphon aqueducts, canal syphones, super passages and culverts to facilitate the crossing of rivers/streams. Certain typical structures are estimated based on the design drawings. The cost of the structures which are not actually priced are deduced from the cost curves. The details are given in Annexures- 10.4.6 & 10.5.6

G. Bridges Rs. 1831.12 lakh

A no. of bridges (Major & Minor) are required to be constructed in the K-B canal & Ken LBC of the project to facilitate crossing of various roads. Necessary Provision has been made towards construction of these bridges. The estimates are prepared based on the cost curves. The details are given in Annexures- 10.4.7 & 10.5.7

H. Escapes Rs. 1183.77 lakh

Under this sub-head provision has been made for canal escapes at suitable locations where drainage facilities exist to take care of the discharges in the eventuality of canal breaches. The details are given in Annexures- 10.4.8 & 10.5.8

J. Power plant & Appurtenances (Civil works)

Rs 69.36 lakh

In Ken LBC, pumping of water is involved in 4 distributaries through lifts ranging from 19 to 36 m requiring 4.22 MW of power. For this purpose, 31 pumps of total capacity 23400 HP are proposed. Under this sub-head, the cost towards providing intake structures, pipes and other components is provided. The details are given in Annexures 10.5.9.

K. Buildings Rs. 7079.25 lakh

Provision has been made under this sub-head for construction of temporary & permanent buildings for both residential & non-residential buildings for various categories of staff, offices, inspection bungalow, stores, club-cum-welfare hall, laboratory & Research station etc. Rates have been adopted for these buildings based on the plinth area and prevailing market rates. The details under this sub-head are given in Annexures- 10.4.9 & 10.5.10

L. Earthwork & Lining Rs. 131519.86 lakh

The Earthwork quantities involved in cutting based on the type of soils are separately worked out. The quantity of earthwork required for embankment from borrow areas are separately worked out. The detailed estimates are prepared considering the cross sections taken at 50 m interval along the canals and detailed drawings supplied by CWC, New Delhi at various sections. Provision is also made for branch canals proportionate to the discharges of the main canal. Lining is provided for both main and branch canals at bed and side slopes in the entire length of canals as per the drawings. Provision is also made in the estimates for pressure relief and drainage arrangements under lining, expansion joints etc. The details under this sub-head are given in Annexures- 10.4.10 & 10.5.11

M. Plantation Rs. 96.32 lakh

Under this sub-head, cost of plantation in the colony areas and along the main canals & branch canals on both sides have been provided. The details are given in Annexures 10.4.11 & 10.5.12

O. Miscellaneous Rs. 2337.09 lakh

Under this sub head provision has been made to cover the cost of the following works:

- Capital cost of electrification, water supply purification and distribution arrangements, sewage disposal, fire fighting equipment, telephones, wireless sets, equipment for quality control and field labs, initial equipment and other accessories for hospitals etc.

- R & M of above equipments/infrastructural facilities etc.

- R & M of inspection vehicles, inspection bungalow etc.

Provision has also been made for other miscellaneous items such as inaugural foundation laying ceremony, compensation to work men, flood lighting, model exhibits etc. The details are given in Annexures- 10.4.12, & 10.5.13

P. Maintenance Rs. 2275.08 lakh

Under this sub head provision has been made to cover the cost of maintenance of all works during the construction of canals. A provision of 1% cost of I-works less A-Preliminary, B-Land, M-Plantation, O-Miscellaneous, Q-Spl. T&P and X-Environment & Ecology has been made. The details are given in Annexures 10.4.13 & 10.5.14

Q. Special Tools & Plants Rs. 5711.06 lakh

Under this sub-head provision has been made at 25% of capital cost of major construction equipment and general purpose equipment. Cost of inspection/ transportation equipment has been added to the above cost in full to arrive the total cost chargeable under this sub-head. The recoveries on account of resale value of Q-Spl. T&P is considered as 75% of the capital cost of the major construction/ general purpose equipment chargeable to Q-Spl. T&P and 75% on 20% cost of inspection/transport equipment chargeable to Q-Spl.T&P. which worksout to Rs. 4575.04 lakh.

Details of the equipment as suggested by CMO, CWC, New Delhi and the cost that to be chargeable to the canal works are given in Annexures 10.4.14 & 10.5.15

R. Communication Rs. 703.58 lakh

Under this sub-head, provision for construction of temporary roads and remodeling of existing roads for approach to canal and regulatory system, quarry sites and other working areas has been kept. The details are given in Annexures 10.4.15 & 10.5.16

S. Power plant and electromechanical works Rs. 447.37 lakh

In KMPP report, provision is made towards power plant and Electrical system for the proposed pumping units in the command. This has been escalated appropriately to the current price level of 2007-08 and considered in the estimate. The details under this sub-head are given in Annexure 10.5.9.

U. Distributaries & Minors Rs. 9776.99 lakh

Under this sub-head provision has been made for providing distributaries & minors considering a cost of Rs. 3800/- per ha for the total culturable command area of K-B link canal. The rates as considered in Ken LBC system are escalated to 2007-08 price level and considered for working out the cost of distributaries & minors for Ken LBC system command area. The details are given in Annexures- 10.4.16 & 10.5.17.

V. Water courses & field channels Rs. 4168.84 lakh

Under this sub-head provision has been made for providing water courses and field channels considering a cost of Rs. 4000/- per ha as worked out for a typical block of 40 ha for the total culturable command area under the project. The details are given in Annexures 10.4.17 & 10.5.18

W. Drainage Rs. 3626.20 lakh

Under this sub-head provision has been made at the rate of Rs. 4000/- per ha. for total command area for field drainage. The details are given in Annexures 10.4.18 & 10.5.19

X. Environment & Ecology Rs. 9726.23 lakh

This sub-head includes provision for extensive management measures to sustain environment and ecology such as land

management plan (stabilization of muck disposal management), measures to arrest transportation of silt across basins, provision for free fuel to department engaged labourer, Public Health management, Environmental monitoring programme (EMP). The details are given in Annexures- 10.4.19 & 10.5.20.

Y. Losses on stock and unforeseen Rs 511.77 lakh

Provision has been made for losses on stock and unforeseen @ 0.25% on all sub-heads under I- works excluding sub – heads A- preliminary, B- land & Q-Spl. T&P.

II-Establishment Rs. 21495.27 lakh

Provision has been made as per norms @ 10% of I-Works excluding B- land towards establishment & pensionary charges.

III- Tools & Plant Rs. 2405.72 lakh

Provision has been made under this head for ordinary Tools & Plant @ 1% of I-Works. This provision is distinct from the Q-Spl. T&P and is meant to cover the cost of survey instruments, camp equipment and other small tools & plant.

IV – Suspense

It is assumed that all the outstanding suspense would be cleared by adjustment to appropriate heads on completion of the project. As such no provision has been kept under this head.

IV- Receipt & recoveries Rs 4758.56 lakh

Under this head, estimated recoveries by way of resale or transfer of temporary buildings, special T&P and by resale or transfer of generator sets, electrical lines, telephone lines and other accessories are accounted for and provision has been made accordingly.

10.1.2.2 B - Indirect charges Rs. 3082.66 lakh

Provisions for abatement of land revenue and Audit & account charges are covered under 'Indirect charges' at the following rates

- Abatement of land revenue - 5% of cost of land
- Audit and account charges - 1% of I-Works

10.1.3 Unit – III : Hydroelectric installation

Ken-Betwa link project envisages construction of two power houses. Power House-I (2x30 MW) is proposed at the toe of Daudhan dam while power House-II (3x6 MW) is proposed at the exit of lower level tunnel.

Unit-III "Hydro electric installation" contains the provisions for expenditure on installation of these two power houses, penstocks, switch yards, tail race channel, various electromechanical equipments, transmission lines etc. The total cost of unit – III for PH-I & PH-II are estimated to be Rs. 245.86 crore & 95.08 crore respectively at 2007-08 price level. The details are given at Annexure 10.6 & 10.7 and its sub-annexures. The sub-head wise details are given below:

10.1.3.1 Direct charges

A. Preliminary Rs. 616.27 lakh

Under this sub-head provision for preliminary surveys & investigations to be conducted to arrive at optimum designs for the project components including consultancy charges for design works at pre construction stage at 2% of I-Works has been made. The details are given in Annexures 10.6.1 & 10.7.1.

B. Land Rs. 11.29 lakh

Under this sub-head, provision for acquisition of land for construction of power houses, Switchyards, Tailrace Channel, Penstocks, approach roads. solatium charges, etc. have been made. The details are given in Annexures 10.6.2 & 10.7.2.

J. Power plant civil works Rs. 15886.43 lakh

Under this sub head, provision has been made towards civil engineering structures comprising of pen stocks, power house complexes and tail race channel. The details are given in Annexures 10.6.3 & 10.7.3.

M. Plantation Rs. 16.80 lakh

Provision has been kept under this sub head for cost of plantation along project roads, land scapping and improvement of area around power plant and maintenance and protection of plants. The details are given in Annexures 10.6.4 & 10.7.4.

O. Miscellaneous Rs. 95.55 lakh

Under this sub head provision has been made to cover the cost of the following works

- Capital cost of electrification, fire fighting equipment, telephones & wireless sets, boundary pillars & fencing etc.

- R & M of above equipments/infrastructural facilities etc.

The details are given in Annexure 10.6.5 & 10.7.5.

P. Maintenance Rs. 295.80 lakh

Under this sub head provision has been made to cover the cost of maintenance of all works during the construction of power houses. A provision of 1% cost of I-works less A-Preliminary, B-Land, M-Plantation, O-Miscellaneous, and Q-Spl. T&P has been considered. The details are given in Annexures 10.6.6 & 10.7.6.

Q. Special T&P Rs. 494.05 lakh

Under this sub-head provision has been made at 25% of capital cost of major construction equipment and general purpose equipment. Cost of inspection/ transportation equipment has been added to the above cost in full to arrive the total cost chargeable under this sub-head for power house-II. The special T&P acquired for Daudhan dam will be utilized for Power house-I. The recoveries on account of resale value of Q-Spl. T&P is considered as 75% of the capital cost of the major construction/ general purpose equipment chargeable to Q-Spl. T&P and 75% on 20% cost of inspection/transport equipment chargeable to Q-Spl.T&P. which worksout to Rs. 346.35 lakh. Details of the equipment as suggested by CWC, New Delhi and the cost that to be chargeable to the works are given in Annexure 10.7.7.

R. Communication Rs. 50.40 lakh

Under this sub-head, provision for Construction of new roads for approach to Power plant, switch yard and other working areas has been kept. The details are given in Annexures 10.6.7 & 10.7.8.

S. Power plant & electromechanical works

Rs.13272.98 lakh

This sub-head covers the cost of power plant equipment and electrical system to be installed at both the power houses.

Provision made under this sub-head for various components are based on the drawings and costs supplied by CEA, New Delhi. The details under this sub-head are given in Annexure 10.6.8 & 10.7.9.

Y. Losses on stock and unforeseen Rs 74.27 lakh

Provision has been made for losses on stock and unforeseen @ 0.25% on all sub-heads under I- works excluding sub – heads A- preliminary, B- land & Q-Spl. T&P.

II-Establishment Rs. 3080.26 lakh

Provision has been made as per norms @ 10% of I-Works excluding B- land towards establishment & pensionary charges.

III- Tools & Plant Rs. 308.14 lakh

Provision has been made under this head for ordinary Tools & Plant @ 1% of I-Works. This provision is distinct from the Q-Spl. T&P and is meant to cover the cost of survey instruments, camp equipment and other small tools & plant.

IV – Suspense

It is assumed that all the outstanding suspense would be cleared by adjustment to appropriate heads on completion of the project. As such no provision has been kept under this head.

IV- Receipt & recoveries Rs 356.75 lakh

Under this head, estimated recoveries by way of resale or transfer of special T&P and by resale or transfer of generator sets, electrical lines, telephone lines and other accessories are accounted for and provision has been made accordingly.

10.1.3.2 Indirect charges Rs. 308.71 lakh

Provisions for abatement of land revenue and Audit & account charges are covered under 'Indirect charges'.

- Abatement of land revenue - 5% of cost of land
- Audit and account charges - 1% of I-Works

10.1.4 Unit – IV: Navigation works

Navigation is not proposed under this project. Hence, no provision is required under this sub head.

10.1.5 Unit – V : Water supply works

This project envisages providing drinking water in command areas as well as to the Urban centers adjacent to canal alignment. Water will be supplied through main canals and various branch canals, whose cost is considered under Unit -II : Canal system. However, water supply network to the local areas will be the responsibility of the local development body / local administration. Hence, no provision towards water supply works at local level has been kept under this head.

10.1.6 Unit – VI: Command Area Development

Rs. 18759.78 lakh

The total culturable command area covered under this project is 515210 ha. This area is covered by two different canal systems viz. Ken – Betwa link (60294 ha), Ken LBC system(241306 ha in M.P & 213610 ha in U.P). It is assumed that the entire existing command area in U.P portion is fully developed for irrigation. Out of 301600 ha an area of 104221 ha requires land leveling and shaping to facilitate irrigation and to prevent soil loss due to erosion in undulating areas as per the EMP study. Provision has been made at Rs. 18000/- per ha for development of Command area of 104221 ha which works out to Rs. 18759.78 lakh. The details are given in Annexure-10.8.

10.2 Revenues

10.2.1 Yearly programme of development

The link Project is scheduled to be completed in 8 years. Yearly programme of construction schedule of the project has been discussed in detail in Chapter-VII “Construction Programme, Manpower Deployment & Plant Planning”.

10.2.2 Sources of Revenue

Ken-Betwa link project has been planned to provide irrigation in water short areas directly as well as in exchange. Also, the project envisages power generation and domestic water supply in the command area and adjacent towns along the canal. Accordingly, following would be the sources of revenue from the Ken-Betwa link project as a whole.

- Irrigation water rates
- Irrigation cess
- Sale of water for domestic water supply
- Sale of power

Other than the above, tourism & fisheries development in the project areas as described in brief in the Volume- VI “Reservoir” can also be one of the major sources of revenue on account of this project.

10.2.2.1 Water rates –Irrigation cess

Water rates

A large infrastructural network such as this project being created for making water available in the proposed command areas for irrigation and drinking purposes besides power generation, needs to be self sustainable. Therefore, appropriate water pricing is quite necessary, so that cost of operation & management of project could be recovered from the beneficiaries of the project up to some extent. Water rates may be different for irrigation & non irrigation use. Water rates for irrigation use can be applied on the basis of per unit area irrigated. On the other hand, for drinking water supply, rates may be applied on the basis of per unit volume of water supplied, while power can be charged per unit basis.

The present range of water rates in Madhya Pradesh is from Rs 50 to 960 per ha for both flow and lift irrigation. In Uttar Pradesh, it ranges from Rs.30 to 474 for flow irrigation & Rs 15 to 237 per ha for lift irrigation.

These charges are in addition to the irrigation cess & betterment levy to be paid and land revenue being paid by the land holder.

Irrigation cess

As approved by the concerned State Govt., Irrigation cess would be recovered from all the land holders in the commands of the Ken-Betwa link project irrespective of whether the land holder takes irrigation water or not.

Betterment levy

When a major project is constructed, it leads to appreciation of land prices in the areas lying in the vicinity of the project. In case of an irrigation project, better yields of crops are produced. On account of this appreciation in land prices and increased yields of produce, the land owners are required to pay some share to the Govt. as betterment levy.

10.2.2.2 Auction of service, land lease, auction and navigational permits.

Vacant lands on either side of canals may be leased for plantation of fruit bearing trees. Similarly, in project colony areas, land for shops may also be leased.

10.2.2.3 Power rate

The total installed capacity of the project is 78 MW. From the simulation studies, it is worked out that average energy of 219.03 MKWh would be generated, at 90% dependability. This energy can be charged at prevailing rate of Rs. 3.00 per Kwh in the area.

10.2.2.4 Navigation

There is no navigational aspect in this project.

10.2.2.5 Other sources (Pisciculture, tourism, etc)

Revenue would accure from the project through allied benefits like pisciculture, tourism, etc. and these benefits have been considered in the benefit-cost analysis of the project.

10.2.3 Concession in water rates (irrigation), Cargo and passenger rates, etc.

As the water rates (irrigation) prescribed by the States are highly subsidized, there appears to be no rationale for further concession of these rates in the project commands.

10.2.4 Administrative charges for supply of water and collection of revenues etc.

Suitable provision has been made for running and maintenance of the canals, which include administrative charges for supply of water.

10.2.5 If the area to be irrigated is prone to scarcity, the expenditure normally incurred to redress the scarcity

The area proposed to be irrigated enroute the link canal under Ken LBC is water short and devoid of assured supply.

10.2.6 Year in which the revenue would start accruing from various sources counting from the first year of construction

The construction of project is scheduled to be completed in 8 years. The irrigation development in all the commands is also expected to be completed by then. Revenue from irrigation is expected to start accruing from beginning of 9^{th} year i.e after completion of the project. Power benefits from Power House – I can be realized after completion of head works. Benefits

from PH-II are linked with irrigation development in Ken LBC System and hence, can be realized after completion of the project.

10.2.7 Total income from various sources

The total revenue from various sources are furnished below:

1.	Agricultural produce	Rs.1369.99 crore
2.	Sale of power	Rs. 65.71 crore
3.	Domestic water supply	Rs. 1.27 crore
4.	Fisheries	Rs. 4.42 crore
5.	Tourism	Rs. 1.00 crore
	Total	Rs.1442.39 crore

10.2.8 Details of staff proposed for collection of revenues and its basis

Revenue Department of Governments of Madhya Pradesh & Uttar Pradesh would strengthen their existing system for collection of revenues.

10.2.9 Net revenue expected from different components of project

It is estimated that the net value of produce after irrigation is Rs. 144703.39 lakh and the same before irrigation is Rs. 7704.46 lakh. Thus, the net annual irrigation benefits from the total command area works out to Rs. 136998.93 lakh. The total power generation is estimated to be 219.03 Million Kwh with an installed capacity of 78 MW. The revenue from the sale of power considering Rs. 3.00 per unit works out to Rs. 6570.90 lakh. It is proposed that 49 MCM of water is to be supplied for domestic needs. It is estimated that the revenue generated from water supply will be Rs. 127.40 lakh considering Rs. 0.26 per Cum. It is also proposed to develop fisheries in the reservoirs, by which Rs. 442.00 lakh of revenue could be generated. An amount of Rs. 100 lakh can also be generated by way of tourism. Thus, the net income/benefit from various sources is estimated to be Rs. 144239.23 lakh. Details are given in Annexure-10.11.

10.2.10 Productivity of project in terms of percentage financial returns.

The details of productivity in the command area at pre and post project scenarios are as follows. Details of productivity in the command area is given in Table-10.2.

Table-10.2
Details of Productivity in the Command area

Unit: Quintals

Crop	K-B link canal		Ken LBC system	
	Pre project	Post project	Pre project	Post project
Kharif	528065	1832920	2363611	7430000
Rabi	417402	2134540	2397959	13406523
Perennial	16800	-	57400	-
Total	962267	3967460	4818970	20836523
Net increase in produce	3005193(312.30%)		16017553(332.39%)	
Total increase	19022746			

10.3 Benefit– Cost Ratio and internal Rate of Return

The BC ratio and Internal Rate of Return has been worked out as detailed below:

10.3.1 Multipurpose projects

10.3.1.1 Allocation of cost

Allocation of the cost of the project to different components is worked out based on the guidelines given in IS: 7560-1974 by adopting the "Water releases approach" under the "use of facility method". The joint cost of the dam is apportioned among irrigation(including water supply and fisheries) and power components. Out of the total cost of Rs. 939298.56 lakh of the project, the cost of irrigation component including domestic water supply and fisheries works out to Rs.879951.64 lakh and that of power component is Rs. 59346.92 lakh. Details are given in Annexure-10.10.

10.3.1.2 Estimate of annual cost

Details of annual cost of the project is given in Table-10.3.

Table-10.3
Details of annual cost of the project

Rs. in Lakh

Sl.No.	Description	Annual Cost
1.	Interest @ 10% on Capital cost of the project including cost of land development	74015.52
2.	Depreciation of the project @ 1% cost of the project for 100 years of life (Irrigation component)	6872.41
3.	Depreciation of the project @ 1.20% cost of the power component for 75 years of life	409.85
4.	Annual O&M charges @ Rs. 600/- per ha of CCA	3091.26
5.	Annual O&M charges for power houses @ 5% cost of E&M works of power houses	663.65
6.	Maintenance of head works @ 1% of the cost of head works	5342.57
7.	Depreciation of the pumping system @ 8.33 % of the estimated cost of pumping system in Ken LBC system assuming life of the pumping system is 12 years (lift irrigation)	43.07
8.	Power Charges for lifting in Ken LBC for 76.77 MKhw. @ Rs. 3/- per unit	2303.10
	Total annual Cost	92741.43

10.3.1.3 Benefit Cost Ratio

As described in the above paras, the net annual benefits from various components of the project works out to Rs.144239.23 lakh and the annual costs works out to Rs. 92741.43 lakh. Thus the Benefit-Cost Ratio of the project works out to 1.56 (considering cost of Daudhan dam+Bariyarpur Barrage+Parichha dam). Detailed calculation is placed at Annexure-10.11.

Further, as detailed in Annexure-10.11, the B.C.Ratio is also computed considering (1) Daudhan dam project only and (2)considering Daudhan dam project and Bariyarpur Barrage and the same are worked out to be 1.71 and 1.60 respectively.

10.3.1.4 Internal Rate of Return (IRR)

The project has been planed to be completed in a period of 8 years including pre construction year. The phasing of the expenditure has been planned accordingly. The details of yearly expenditure chargeable to link

project have been given in Annexure 7.9. Considering life of the project as 100 years, the IRR of the Ken-Betwa link project has been computed as 12.00%. Considering all three structures viz. Daudhan dam, Bariyarpur and Parichha dam. Detailed calculation is placed at Annexure-10.12.

10.3.1.5 BC ratio for flood control component of the projects.

No cushion in the reservoir storage is provided exclusively for flood control. Flood control is only an incidental benefit from Daudhan dam. Hence, no B.C. ratio for flood control component of the project is worked out.

10.3.2 Benefits other than those considered in the BC ratio and IRR.

While calculating BC ratio, benefits from irrigation, power, water supply, fisheries and tourism have been considered. However, project will also provide other benefits such as employment generation, industrial development, infrastructure development, socio-economic condition of people in project area. These benefits have not been accounted for.

CHAPTER-XI
PROJECT OPERATION PHILOSOPHY

CHAPTER- XI

PROJECT OPERATION PHILOSOPHY

11.1 Concept of Interlinking of River

Ken-Betwa Link Project including Phase-I & Phase-II is an Interlinking of River Project with multipurpose benefits out of which irrigation is major benefit followed by benefits of drinking water, power etc. Concept of interlinking of Ken river with Betwa river came as Ken river was found to be surplus at Gangau weir whereas Betwa river was found to be deficit in Upper Betwa as well as lower Betwa basin. Preliminary Water Balance Studies carried out by NWDA vide Technical Study No. WB 31 (Jun 1993) and WB-70 (May 1993) indicate that upper Betwa basin as well as lower Betwa basin are deficit by 1567 MCM and 1147 MCM respectively. Since entire catchment of Ken river upto Gangau weir falls in MP and even otherwise as per existing agreement and proposed MOU, UP desires to utilize allocated share of water in Ken command of Banda district as well as enroute command, transfer of surplus Ken water to Upper Betwa basin by way of substitution was visualized in this project. The very first basic principle behind formulation of this Interlinking of River Project is to make surplus Ken water available to Upper Betwa basin falling in Madhya Pradesh through three identified category 'B' projects Makodia (in place of Neemkheda), Kesari and Barari which were earlier individually not found feasible for various reasons. Upper Betwa portion will be covered separately in DPR of Ken-Betwa Link project, Phase-II.

11.2 Some unfounded concerns about the project

The criticism of Inter Basin Water transfer by its opponents on the plea that NWDA is transferring water from one surplus basin to another surplus basin is unfounded because in this project, transfer of water has been proposed from surplus Ken basin to deficit Betwa basin. As such, their apprehension is not correct.

Secondly, some critics have raised concern that transfer to adjacent basin may not be viable as when Betwa is in drought, the Ken basin will also be deficit which is regreeted by the hydrological events which took place in the year 2005 and 2006 where in Ken river witnessed unprecedented flood in the year 2005 as a result of which, a part of age old Gangau weir was washed away and later its repair could be done with the permission of Hon'ble Supreme Court. In fact, this unprecedented flood compelled UP to consider think about this Ken-Betwa link project seriously and therefore MOU was signed in same year. Further, during the year 2005, Betwa was not at all in flood. Next year i.e. in

2006, Betwa experienced heavy flood and there was no flood in Ken river, rather there was a drought in the whole basin.

There have also been apprehensions that transfer of Ken water to Betwa will have adverse impacts on existing irrigation in Ken command of Banda. Since, after construction of Daudhan dam, assured and enhanced supply of irrigation water from 850 MCM to 1600 MCM will be available to Ken command in UP therefore, no adverse impact is expected in existing downstream command.

Apprehensions have also been expressed about projects in upstream of Daudhan dam having impact on the water availability. A provision of 2266 MCM of water has been kept for all the major/medium/minor irrigation projects which are either existing/ongoing or will come in future. Therefore, the upstream projects requirement has already been taken into account. Hence, the concern raised in this regard is also not sustainable.

11.3 The Project

As mentioned earlier in different chapters, the project envisages construction of following important structures:-

1. Daudhan Dam across Ken
2. Link canal joining Ken to Barwa Sagar reservoir
3. Two Power Houses having total installed capacity of 78 MW (one at the toe of Daudhan dam PH-I and the other at the end of lower level tunnel emerging from Daudhan dam PH-II)

Apart from above, canals will also offtake from left bank of Daudhan dam (after lower level tunnel & PH-II). There are two canal systems which take off from Bariarpur headworks. Left Bank Canal where construction is going on will feed part command of Madhya Pradesh. identified in Ken Multi Purpose Project, whereas Right Bank Canal, an existing one will take care of existing Ken command in Banda of Uttar Pradesh. Thus the projects will have following commands/aspects for which operation will be required:-

(i)	Ken command in MP	For irrigation
(ii)	Ken command in UP	
(iii)	Enroute command in UP & MP	
(iv)	Power Generation	
(v)	(a) PH-I – 2x30 MW	
	(b) PH-II – 3x6 MW	
(vi)	Drinking water supply	
	(a) Enroute canal – 49 MCM	

In order to meet the various demands, operation of the project has to be planned. Since the project will undergo three phases, i.e. construction, operation and maintenance, each stage of the project has been discussed in the following paragraphs.

11.4 Project in Construction Stage

Though Ken-Betwa Link Project, Phase-I is an inter state project involving UP & MP the most of the project components lie in MP except small stretch of link canal in UP. Since this project has been declared as a national project therefore 90% of finance needed for the project is expected from the Centre. For construction of the project, either of following mechanism could be followed:-

(i) Project to be constructed by MP and UP to give MP its cost share on the pattern of Bansagar Project

or

(ii) Project to be constructed by a Board comprising of Engineers from both the States on the pattern of Betwa Board for construction of Rajghat & Matatila Project

or

(iii) Project to be constructed by a Board/Authority comprising of Engineers from both the States as well as Centre.

Decision in this regard will be taken by the Centre in consultation with both the States after clearance of the project from CWC, MOEF & Planning Commission.

11.5 Project in Operation Stage

Since the project envisages construction of one reservoirs through which major share of water will have to be released to meet various demands of irrigation, power and drinking water, a Reservoir Regulation Committee will have to be formed. This Reservoir Regulation Committee will ensure release of water through Daudhan Dam in such a fashion that irrigation demands of various commands are met in optimal manner and at the same time power is also generated during peak hour and drinking water is made available to the projected beneficiaries. For this, appropriate rule curves and release patterns would have to be agreed by both the States which would be updated subsequently.

11.5.1 Irrigation to get priority over power generation

Since this project envisages to provide annual irrigation of 3.84 lakh ha to MP and UP in new command apart from stabilization of 2.13 lakh ha. existing command in Banda district of UP and thus being major benefit, irrigation is required to be accorded priority over power generation in this project.

11.5.1.1 Ken Command to be given First Priority

Before making any proposal for diversion of surplus water from Ken basin to another basin, the inbasin needs of the Ken basin upto the ultimate stage of development should be considered first. Accordingly, the requirement of existing/ ongoing/proposed projects located in Ken basin is to be accorded the first priority under the project. Accordingly, provision of 2266 MCM has been kept for existing/ongoing/proposed projects in Ken basin upstream of Daudhan dam. Further in downstream, the existing Ken command in U P is presently getting 850 MCM water from Bariarpur Pick-up Weir through its RBC located in the downstream of proposed Daudhan dam across Ken river for irrigation of about 2.13 lakh ha area in Banda district. It is proposed to provide 1600 MCM of water in post project scenario to stabilize irrigation in this area. Govt. of MP had earlier proposed KMPP for irrigation in Ken command of MP through LBC off-taking from Bariarpur Pick-up Weir and LBC taking off from the dam for irrigating 0.68 lakh ha & 1.73 lakh ha respectively. Govt. of MP had later dropped this proposal. Now this command has been taken over by Ken-Betwa Link Project Phase-I. In order to keep the irrigation in Ken command of MP unchanged, it is proposed to provide 1007 MCM & 398 MCM of water from LBC taking off from the tail end of Lower Level Tunnel and from Bariarpur Pick-up Weir respectively.

11.5.1.2 Enroute command to be given Second Priority

The second priority has been accorded to enroute command of link canal. The irrigation requirement of enroute CCA of 0.60 lakh ha (0.46 lakh ha lying in MP and 0.14 lakh ha lying in UP) has been estimated as 366 MCM. The domestic water supply for the human and livestock population in the villages & towns lying along the link canal has been estimated to be 49 MCM. Since initial part of the command lie in Ken basin whereas remaining area lies outside the Ken basin, it has been accorded second priority. Since the area of Bundelkhand region being commanded through this project is water scarce area, more priority is required to be given to irrigation sector to achieve maximum food grain production.

11.5.2 Power

78 MW of power is expected to be generated through two Power Houses. PH-I has been installed at the toe of Daudhan dam in such a fashion that irrigation requirement of existing Ken command of UP (1600 MCM) and proposed Ken command of MP to be commanded through Bariarpur headworks (398 MCM) will flow through it generating upto 60 MW of power through its two units. Similarly, PH-II has been installed at the exit of Lower Level Tunnel taking off from upstream of Daudhan dam in such a fashion that irrigation requirement of proposed Ken command of MP to be commanded through LBC of KMPP (1007 MCM) will flow through it generating upto 18 MW of power through its three units. If the project would not have given topmost priority to irrigation, more generation of power would have been possible. Thus power generation in this project is linked with irrigation requirement and would thus get priority next to irrigation only. As such requirement of water for power can not be separately worked out.

11.5.3 Drinking Water

Since National Water Policy 2002 of Govt. of India accords first priority to drinking water, it is mandatory to make provision for drinking water in all storage projects. Since this project has got one reservoir i.e. Daudhan provision has been kept in the reservoir for drinking water. Drinking water to the tune of 49 MCM will be provided to enroute villages and towns of link canal through Daudhan reservoir when the reservoir will remain above 256.0 m and water will flow through link canal. Except 2-3 months during lean season, water will flow in link canal meeting drinking water requirement. Flow of water through link canal for most of the period will recharge ground water in the command area & adjoining area of canal and people living in the command & adjoining area would be able to get water through their tube wells also.

11.5.4 Flood Control

No flood cushion has been provided in Daudhan reservoir. However storage of water in reservoirs and its operation in regulated manner will help in minimizing floods in downstream area. Design flood of Ken river which will pass over spillway of Daudhan dam has been worked out as 57,202 cumecs. In order to pass design floods in Daudhan dam, 27 nos. of gates of 16 m x 18.5 m size have been proposed. Reservoir Regulating Committee will have to decide the schedule of opening of gates so that design flood passes smoothly without causing damage to the structure as well as without causing flood havoc in the downstream. Even if chances of floods are there, downstream people should get warning sufficiently in advance to evacuate the area and go to safer places.

Final Demand Tables for the reservoir at Daudhan which will be main guiding factor for Reservoir Regulating Committee are placed at Annexure- 11.1 .

11.6 Project in Maintenance Stage

The proposed board formed at the time of construction for implementation of the project will suitably be downsized and the same can continue to take care of operation & maintenance of main project, i.e. dam, main canal, branch canal, distributary, power houses etc. However, necessary steps will have to be taken to form Water Users Association (WUA) in the command area, so that they can be involved in the construction of On-Farm Development Works, i.e. field channels, field drains etc., if possible and preparation of roster for fair and equitable distribution of water among various farmers in the commands of different minor/distributary outlets. Later, these OFD Works can be handed over to WUAs for its maintenance. After formation of WUAs at minor/distributary level, a Farmers Committee for each command of the Project consisting of Representatives from each Distributary level WUAs can be formed to take care of respective command i.e. Ken command, Enroute command. Further, Project Level Committees can be formed by taking representatives of WUAs from each command, Irrigation Deptt, Agricultural Deptt. etc. Formation of WUAs and three level Committees i.e. Distributary Level, Command Level, Project Level will help in many ways as described below:-

(i) In helping in construction of On-Farm Development works, field channels, field drains and land leveling.

(ii) In ensuring proper implementation of Warabandi by making roster for fair & equitable distribution of water to farmers depending upon their land holdings.

(iii) In providing training to them for advanced agricultural technology, use of HYBRID Seeds, fertilizers & pesticides, restricted number of watering to various crops.

(iv) In ensuring conjunctive use of surface & ground water

No doubt, Reservoir Regulation Committee will decide the release of surface water for various purposes as well as for various commands at different parts of time, but it will be advisable to advocate conjunctive use of surface water and ground water among farmers through WUAs formed in each command. Since most of the commands considered in the project are water scarce having mild slope. As such, problem of water logging is not expected in initial years, but after 4-5 years when

sufficient recharge of ground water will take place, problem of water logging in some patches may crop up. So, practicizing of conjunctive use of surface water & ground water will reduce the probability of water logging. This will not be a problem as use of ground water by selected farmers in enroute command and other commands are still going on. In enroute command, use of ground water will have to be done particularly during the month of April, May & June when water is likely to be not available / available in less quantity.

(v) In creating funds for maintenance of OFD Works and subsequently taking over OFD Works by WUAs from project authorities.

(vi) In helping farmers to sell their agricultural produce in the market at reasonably good prices.

(vii) In helping farmers to take advantages of new policies of Govt. of India and State Govts.

CHAPTER-XII
OTHER ASPECTS

CHAPTER- XII

OTHER ASPECTS

12.1 Foreign exchange element

The Govt. of India has declared the Ken – Betwa link project as one of the national projects. Now, the earlier proposed Ken-Betwa link project is proposed to be taken up in two separate parts viz., Phase-I and Phase-II. As such, 90% of the cost of the present Ken-Betwa link project, Phase-I is expected to be borne by Central Government whereas the balance 10% will have to be borne by the beneficiary states viz. MP and UP. Further most of the required materials like plant and machinery, spares, instruments, etc. are proposed to be purchased/hired locally from internal resources thereby requiring no import under foreign grants/credits from other countries. Thus, prima facie, no foreign exchange element is required for the project. However if implementing Agency of the project decides at a later date to import 'Turbine' or any other item of the project from other country, foreign exchange element will come into picture.

12.2 Revenue

The source of revenue from the project is mainly from the benefits accrued from the following items.

12.2.1 Irrigation water rates

Annual O&M cost of the project works out to Rs.31.91 crore(excluding O & M of power component) whereas benefited area from irrigation is 3.83 lakh ha. The irrigation water rates will be collected from land holders to recover O & M cost of the project. The present range of water rates in Madhya Pradesh state is from Rs.50 to 960 per ha for both flow and lift irrigation. In Uttar Pradesh, it ranges from Rs.30 to 474 per ha for flow irrigation and Rs.15 to 237 per ha for lift irrigation. The land owners are free either to enter into an agreement with the Project authorities or to get irrigation on demand from time to time. However, these charges are in addition to the land revenue paid by them.

12.2.2 Betterment levy

With the introduction of irrigation and improved method of cultivation, the yield of the crops and value of the land will appreciably increase. Therefore, land owners are to pay some share to the Government for this increase in the value of their lands. Subsequently, betterment levy can be charged from beneficiaries of existing command in Banda district of UP who are not getting adequate water for their command from existing system.

12.2.3 Sale of Power

The average annual generation of power from PH-I and PH-II proposed in this link project has been worked out as 219.03 MU. The annual revenue from the power component has been worked out to be Rs.65.71 crores at the rate of Rs.3.00 per kwh as per the prevailing rates for domestic consumption in MP state. Considering a depreciation of 8.33% (for a life period of 12 years) for pumping system and a depreciation of 1.2% for raising mains, the annual cost of maintenance has been worked out to Rs.10.74 crore. As such, the cost of installation i.e. Rs.341.54 crore, can be recovered fully within 12 years in the form of the revenue even after meeting maintenance charge.

12.3 Financial resources

After getting techno-economic clearance from CWC and obtaining necessary statutory clearance from MOEF, Ministry of Tribal Affairs, etc., the DPR of the project will be put up to Planning Commission for investment clearance. The concurrence of Ministry of Finance will also be obtained. The year wise requirement of funds for the construction of the Ken-Betwa link project Phase-I is furnished in Annexure: 12.1. This project will be covered under central sector since it has already been announced as a national project and 90% of funding will be borne by central govt. Further, no foreign assistance/ aid will be required for this project since the entire cost will be met from internal resources of Government of India and State Governments. The MoU arrived between MP & UP and the Union Govt. regarding preparation of DPR suggests that “specific MoUs as required will be entered in to amongst the States of Uttar Pradesh, Madhya Pradesh and Union Govt. based on the DPR and agreements reached on scope of the link, sharing of costs and benefits and arrangements for management and control of water, etc.” So after preparation of DPR, these issues can be discussed further.

12.4 Future Utilisation of facilities (Buildings)

Two categories of buildings i.e. permanent and semi-permanent/ temporary are proposed at Daudhan dam site, Chhatarpur & Jhansi. Further, the Permanent buildings already available at Jhansi under the control of Betwa Board are also proposed to be utilized for the Ken-Betwa link project to the extent possible. Most of the permanent buildings proposed at Daudhan dam site, Chhatarpur and Jhansi will be utilized for operation and maintenance of the project, whereas the remaining buildings can be utilized for the future projects likely to come up in the vicinity or for offices of other State/Central Govt. organisations.

12.5 Legal aspects of interbasin transfers such as impact on existing Awards/Agreements/ Treaties

12.5.1 Existing Interstate agreement on sharing of Ken water

Since the Ken is an inter-state river between MP and UP, agreements were arrived at on Rangwan dam in the year 1972 on Ken canal and head works of UP, Bariarpur left bank canal of MP and Urmil Project in the year 1977. In the meeting with Secretary, Irrigation & Power, Govt. of India held at New Delhi on 10.12.1981, it was decided that an upstream use of 80 TMC should be kept for the proposed KMPP. The Table-12.1 furnishes the abstract of water use allocations as per the agreements and decision indicated above.

Table-12.1
Abstract of water allocation as per earlier agreements

Ken System	Quantity	
	MCM	TMC
Total 75% dependable yield at Ken dam	4489.94	158.56
Water use by M.P. u/s of Ken	2265.60	80.00
Water use by M.P. ex-Ken	1375.22	48.56
Water use by U.P. ex-Ken	849.60	30.00
Total 75% dependable yield at Rangawan dam	192.57	6.80
Use by M.P. for Kharif crops(Existing use by M.P.)	56.64	2.00
Use by M.P. u/s of Rangawan dam	30.87	1.09
Use by M.P. from the balance water	8.78	0.31
Use by U.P. from the balance water	96.29	3.40
Water available to U.P. from the catchment between Ken, Rangawan dam and Bariarpur barrage	101.95	3.60
Total water to be spared to U.P. from Ken system	1047.84	37.00

12.5.2 Proposed water sharing of Ken basin upto Daudhan dam as per MoU

At the time of signing of MoU for DPR of Ken-Betwa Link Project, States of UP and MP have agreed for water sharing of Ken basin upto Daudhan dam as per details is furnished in Table-12.2.

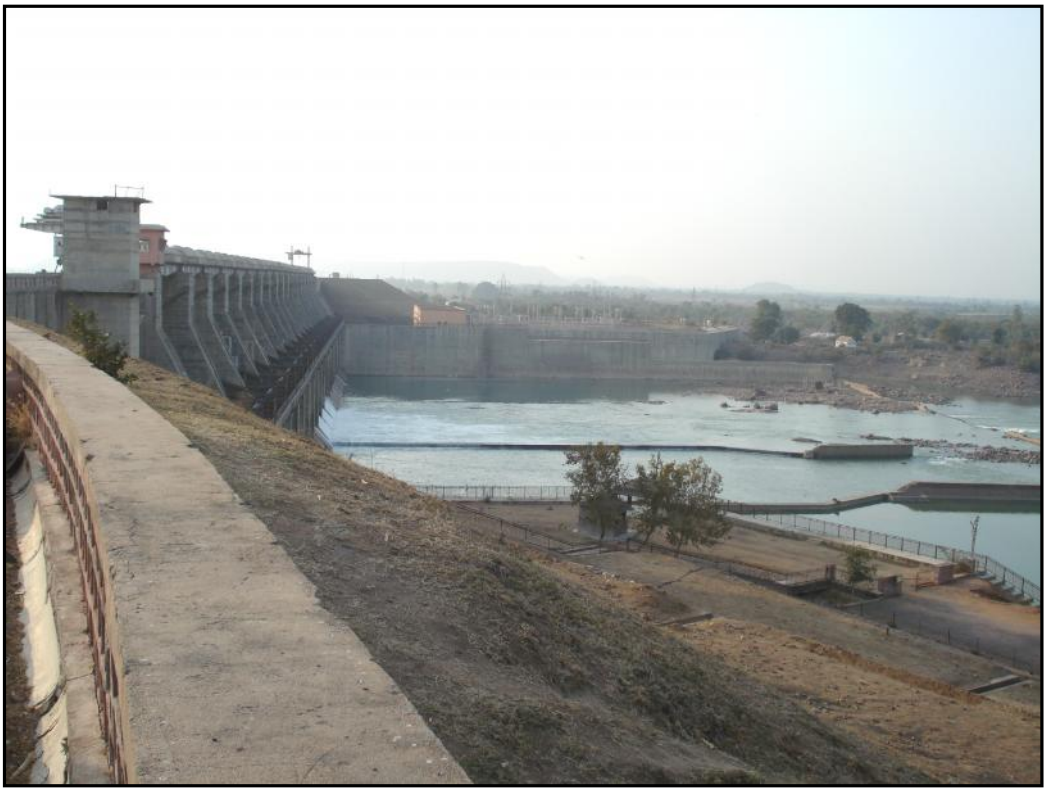
Table-12.2
Proposed water sharing of Ken basin upto Daudhan dam

Sl. no.	Particulars	Proposed water sharing	
		MCM	TMC
1.	Gross water available at proposed dam	6188	218.54
2.	Madhya Pradesh requirement in u/s of dam	2266	80.03
3.	Balance water available	3922	138.51
4.	Regeneration(+)	442	15.61
5.	Net water balance available	4364	154.12
6.	Total requirement of MP		
	a) D/s of Ex.Daudhan	1375	48.56
	b) Enroute use	263	9.29
	c) Domestic enroute utilization & transmission losses	49	1.73
	Total	1687	59.58
7.	Total Requirement of Uttar Pradesh		
	D/s of Daudhan including enroute command	1700	60.04
8.	Proposed water transfer to Betwa basin	659	23.27
9.	Requirement for D/s of Dam for ecological need	318	11.23

While preparing DPR due to change in water availability and finalization of type of crops, irrigation intensity, there is minor variation in water use from the quantities signed/agreed by states in MoU. Hence, as per the provision of MoU, this issue can be discussed further, if considered necessary.

The annual generation of power to the tune of 188.50 MU and 50.14 MU from two Power Houses in Daudhan Dam Complex will definitely improve the power shortage situation in MP.

As per the final report of hydrological studies of Ken-Betwa link project carried out by NIH, Roorkee, the 75% dependable yield available at Daudhan dam site is 6590 MCM showing an increase of 402 MCM when compared to earlier availability of 6188 MCM. The increase in availability of water can also be taken into consideration while further planning at construction stage. While doing planning at DPR stage, attempt has been made to keep utilization of both the States nearer to their share as shown in Table-12.3.



A downstream view of the Rajghat Dam on Betwa river

A downstream view of Matatila dam on Betwa river

Table-12.3
Allocation of water

Sl.No.	Particulars	Proposed water sharing	Planned sharing as per DPR
		MCM	MCM
1.	Total requirement of MP		
	a) D/s of Ex. Daudhan	1375	1405
	b) Enroute use	263	277
	c) Domestic enroute utilization	49	38
	d) Transmission losses		68
	Total	1687	1788
2.	Total Requirement of UP		
	a) D/s of Daudhan	1600	1600
	b) Enroute use	100	89
	c) Domestic enroute utilisation		11
	Total	1700	1700
3.	Proposed water transfer to Betwa basin	659	591

Utilization of MP has increased due to change in cropping pattern. Additional quantity can be adjusted in MP's share of upstream utilization of Daudhan dam or against utilisation of Upper Betwa Projects.

12.6 Public Awareness Programme

Ken-Betwa Link Project Phase-I is the first project in which Public Awareness Programme was organized at Uldhan Village in Jhansi district lying in enroute command on 8.5.2008 to explain benefits of the project to the beneficiaries and to remove their doubts about the project. However, it was found that people in general were very much supportive of this project and they wanted its early implementation. During surveys & investigations of the project, summary of the project in Hindi alongwith salient features were distributed among the villagers for their awareness about the project.

Address by Shri M.K.Sinha, CE(N), NWDA during public awareness campaign organised by NWDA at Uldhan village, Jhansi district, on 08-05-2008

Public awareness campaign organised by NWDA at Uldhan village, Jhansi district, on 08-05-2008

ABBREVIATIONS

ABBREVIATIONS USED

Abbreviation		Full Name
AFC	_	Agricultural Finance Corporation
As	-	Arsenic
BCD	-	Biochemical Oxygen Demand
BH	-	Bore Hole
BIS	_	Bureau of Indian Standard
BM	-	Bench Mark
BOD	-	Bio Oxygen Demand
BPL	-	Below Poverty Line
CA	_	Catchment Area
Ca	-	Calcium
$CaCo_3$		Calcium Carbonate
CAD	_	Command Area Development
CAT	-	Catchment Area Treatment
CBIP	_	Central Board of Irrigation & Power
cc	-	Cement Concrete
CCA	_	Culturable Command Area
CD	_	Cross Drainage
Cd	-	Cadmium
^0C		Degree Centigrade
CEA	_	Central Electricity Authority
CEC	-	Chief Engineer Co-ordination
Cfm	-	Cubic feet metre
Co	-	Cobalt
CGWB	_	Central Ground Water Board
Cl	-	Chloride
cm	_	Centimetre
CMO	-	Construction Management Organisation
CS	-	Cross Section
CMDD	-	Concrete Masonry Design Directorate
Cr	-	Chromium
CSMRS	_	Central Soil and Material Research Station
Cu	-	Copper
Cum	-	Cubicmetre
Cumec	_	Cubic metre per second
Cusec	_	Cubic feet per second

CWC	_	Central Water Commission
d/s	_	Down Stream
DH	-	Drill Hole
DBE	_	Design Basis Earthquake
DO	-	Dissolved Oxygen
DPR	_	Detailed Project Report
DSL	_	Dead Storage level
E	_	East
EEC	_	European Economic Community
EIA	_	Environmental Impact Assessment
E&M	-	Electrical & Mechanical
EL	-	Elevation level
EPG	-	Emergency Planning Group
ERP	-	Economic Rehabilitation Programme
Eto	-	Evapo-transpiration
F	-	Floride
FB	_	Fore Bearing
Fe	-	Iron
FRL	_	Full Reservoir Level
FSD	_	Full Supply Depth
g	_	Acceleration due to gravity
GD&S	-	Gauge Discharge & Silt
G&D	_	Gauge & Discharge
GCA	_	Gross Command Area
GI	_	Galvanised Iron
GIR	_	Gross Irrigation Requirement
GSI	_	Geological Survey of India
GW	_	Ground Water
H	_	Horizontal
ha	_	hectare
HP	-	Horse Power
hr	-	Hour
ham	_	hectare-metre
HCD	-	Hydel Civil Design
HE	-	Hydro Electric
HEP	-	Hydro Electric Project
HT	_	High Tension

HYV	_	High Yield Varieties
IC	-	Installed Capacity
IIT	_	Indian Institute of Technology
IMD	_	Indian Meteorological Department
IMF	_	International Monitory Fund
IMO	_	Irrigation Management Organisation
IRR	_	Internal Rate of Return
K	-	Potassium
K-B Link	_	Ken-Betwa Link
km	-	Kilometre
km/hr.	_	Kilometre per hour
KMPP	_	Ken Multi-purpose Project
KV	_	Kilo Volt
Kwh	-	Kilowatt hour
LBC	_	Left Bank Canal
LS	-	Longitudinal Section
lpm/m	_	Litres per minute per metre
LT	_	Low Tension
m	_	Metre
MoTA	_	Ministry of Tribal Affairs
mbgl	_	metres below ground level
MCE	_	Maximum Considered Earthquake
MCM	_	Million Cubic Metre
MDDL	_	Minimum Draw-down Level
Mg	-	Magnesium
Mg/L	-	Milligram per litre
MIV	-	Main Inlet Valve
Mkh/MU	_	Million Kilowatt hour/Million Units
mm	_	Millimetre
MMI	_	Modified Mercalli Intensity
Mn	-	Magnesium
MoEF	_	Ministry of Environmental & Forests
MoU	_	Memorandum of Understanding
MP	_	Madhya Pradesh
MPEB	_	Madhya Pradesh Electricity Board
MS	_	Mild Steel
MSEB	_	Maharashtra State Electricity Board

MU	-	Million Unit
MWL	_	Maximum Water Level
MW	_	Mega Watt
N	_	North
NA	_	Not Available
Na	-	Sodium
NCEAR	_	National Council of Applied Economic Research
NH	_	National Highway
NIH	_	National Institute of Hydrology
No_3	-	Nitrate
NOF	_	Non Over-Flow
NPP	_	National Perspective plan.
NRSA	_	National Remote Sensing Agency
NSL	_	Natural Surface Level
NTPC	_	National Thermal Power Corporation
NWDA	_	National Water Development Agency
OAF	-	Other Affected Families
OF	_	Over-flow
OFD	-	On Farm Development
P		Phosphate
PAPERP	-	Project Affected Persons Economic Rehabilitation Plan
PAF	_	Project Affected Families
PAP	-	Project Affected People
Pb	-	Lead
PCC	_	Plain Cement Concrete
PGA	_	Peak Ground Acceleration
PH	_	Power House
PLF	-	Power Load Factor
PMF	_	Probable Maximum Flood
PMP	_	Probable Maximum Precipitation
POL	_	Petrol Oil Lubricants
Ppt	_	Precipitation
PUW	_	Pick Up Weir
R&R	_	Resettlement & Rehabilitation
RBC	_	Right Bank Canal
RCC	_	Reinforced Cement Concrete
RD	_	Reduced Distance

RH	-	Relative Humidity
RL	_	Reduced Level
RMR	-	Rock Mass Rating
RSEB	_	Rajasthan State Electricity Board
S	_	South
SC	_	Scheduled Caste
SE	_	Superintending Engineer
Se	-	Selenium
SES	_	Socio Economic Studies
SFR	_	Sheep Foot Roller
SOR	-	Schedule of Rates
So_2	-	Sulphur dioxide
So_4	-	Sulphate
SPS	-	Standard Project Strom
sqkm	_	Square Kilometre
ST	_	Schedule Tribe
t	_	tonnes
T&P	_	Tools & Plants
TAC	_	Technical Advisory Committee
TD	-	Temporal Distribution
TMC	_	Thousand Million Cubic feet
TWL	_	Tail Water Level
UB	-	Upper Betwa
UH	-	Unit Hydrograph
u/s	_	Up-stream
UP	_	Uttar Pradesh
UPSEB	_	Uttar Pradesh State Electricity Board
USAID	_	United States Agency for International Development
USR	_	Unified Schedule of rates
V	_	Vertical
W	_	West
WBM	_	Water Bound Macadam
WR	_	Water Resources
Zn	-	Zinc