

CHAPTER – II

SURVEYS AND INVESTIGATIONS

2.0 Background

The Detailed Project Report (DPR) of Ken-Betwa Link Project was completed by NWDA in December, 2008. During the Secretary level meeting held on February 3, 2009, it was decided that DPR of Ken-Betwa Link Project will be prepared in two phases. In Phase-I, Daudhan Dam and its appurtenant works, two tunnels, two power houses and link canal will be included. The Phase-II will comprise alternative Projects proposed by Government of M.P. in Betwa Basin in lieu of Makodia dam.

The Detailed Project Report (DPR) of Ken-Betwa Link Project, Phase-I was completed by NWDA incorporating the inputs as received from Govt. of M.P. and U.P. during May, 2010 and circulated to concerned State Governments.

Further, during the meeting held under the chairmanship of Secretary (WR), Govt. of India with the representatives of Govts of M.P. and U.P. on August 4, 2010 at New Delhi, it was decided that Surveys and Investigations (S&I) works of proposed component projects in Betwa Basin including Lower Orr major dam and preparation of Detailed Project Report (DPR) of Ken-Betwa Link Project, Phase-II will be taken up by NWDA.

It was decided that NWDA will take up the S&I work of one major and five medium projects on priority after firming up the feasibility of these projects and ascertaining the feasibility of minor projects i.e. series of barrages on Betwa River and projects on tributaries of Betwa can be taken thereafter.

It was further mentioned in the said meeting that after ascertaining the feasibility of these projects within six months, NWDA will take up the detailed Surveys and Investigations and preparation of DPR of Phase-II. The Surveys & Investigations and preparation of Detailed Project Report of Phase-II was taken up by NWDA in January, 2011.

NWDA carried out the L-Section survey of Betwa river between Neemkheda and foreshore of Rajghat project (about 216 Km) to

finalize the locations of proposed barrages, on Betwa river. The FRL of Rajghat dam is 371m and bed level of Betwa river at Neemkheda site is 415 m. Therefore, only 44m head is available for construction of barrages. Two existing schemes for supply of water to Bharat-Oman Gas Refinery and J.P. Thermal Power Project near Bina also exist. Considering the available head of 44 m, topography of Betwa basin and with the help of L-section of Betwa river, five barrages were identified on main Betwa river to have a cumulative storage of 72.82 MCM. The barrages identified are Neemkheda, Parariya, Narkheraghat, Bijrotha and Kotha. After the joint inspection with the officials of Water Resources Department, Govt. of M.P. at various sites, the location of Tharr dam across Newan river (a tributary of Betwa river), Babnai dam across Babnai river (a tributary of Bina river) and Lower Orr dam across Orr river (a tributary of Betwa river) were finalized and considered for conducting the Surveys & Investigations under DPR of Ken-Betwa Link Project (Phase-II).

After firming up the feasibility of the projects with close association of the officials of Water Resources Department, Govt. of M.P., NWDA has carried out the Surveys and Investigations works of the Lower Orr major dam and Babnai, Tharr medium dam and five barrages namely Neemkheda, Parariya (Madhopur), Narkheraghat, Kotha and Bijrotha (Rajkhera) under Ken-Betwa Link Project Phase-II. In addition, the Barari and Kesari barrages proposed in Upper Betwa basin and surveyed during preparation of DPR of Phase-I of Ken-Betwa Link Project are also included in Phase-II of the project.

Further, during the November 20-22, 2013 the Central Water Commission (CWC) design team headed by Chief Engineer, Design (NW&S) and officers of NWDA inspected the proposed dams/barrages sites under Ken-Betwa Link Project, Phase-II to review these design features and feasibility of the locations of dams/barrage sites. After visiting the various proposed sites, the CWC team suggested the following recommendation for considering in the planning of the project for preparation of the DPR of Ken-Betwa Link Project, Phase-II.

(a) The Kotha Barrage project is a promising project with the new pond level of El 396/397 m. The proposal for this project needs to be further supplemented with additional investigations tests and data.

(b) The pond levels of Tharr and Babnai need to be revised to bring their storage within the confines of the river banks as submergence for these projects lies in active agricultural land. However, prima facie it was observed that bringing pond below the banks in these barrages would result in very small storage and may not be attractive. Instead, a series of check dams can be thought of.

(c) The Bijrotha and Narkheraghat Barrage may be dropped as Kotha Barrage would serve their objectives.

(d) Neemkheda Barrage project also needs to be reviewed in view of the weir already constructed downstream of it and wide submergence envisaged by it.

(e) The Parariya project can be dropped. Instead, the pond level of Barari can be raised to serve the objectives of Parariya project. However, for the present, Govt. of MP has already constructed a weir downstream of Pararia site which is taking care of the present day irrigation requirements envisaged from Pararia project. The site for Barari can be chosen depending upon the bridge requirement of local population. This would apportion part of the expenditure towards that service making the project more attractive.

A review meeting was held under chairmanship of Chairman, CWC on November 26, 2013 to discuss above recommendations and finalise the projects proposal. The officers from CWC and NWDA are participated in the meeting. After detail discussions, it was decided that following five potential projects as suggested by CWC are to be included in the DPR of Ken-Betwa Link Project, Phase-II. Therefore DPR of Ken-Betwa Link Project Phase-II has been prepared considering the following five projects.

1. Lower Orr Dam
2. Neemkheda barrage
3. Barari barrage

4. Kesari barrage
5. Kotha barrage with increased pond level i.e. 396 m

The inspection report of CWC team visit to Ken-Betwa Link, Phase-II projects on river Betwa during November 20-22, 2013 is appended at Annexure-1.2 in of Volume-II.

2.1. Topographical Surveys and Investigations

Various field surveys & investigations viz. Topographical, Geological, Construction material, Geo-technical investigations and Borrow area surveys (soils) for dam/barrages and canals, etc. in respect of Lower Orr dam and Upper Betwa projects have been carried out as per the Terms of reference for preparation of DPR of Ken-Betwa Link Project, 2006 and Guidelines for preparation of Detailed Project Report of Irrigation and Multipurpose Projects of Ministry of Water Resources (2010).

The details of various Surveys and Investigations conducted for preparation of Detailed Project Report are furnished in the following paragraphs:

2.1.1 Lower Orr dam

(i) While finalizing the location of dam axis (across Orr river, a tributary of Betwa river), various alternative locations of dam site both upstream and downstream of the proposed Lower Orr Dam axis have been considered in the light of the Project Report, of Lower Orr Project prepared by the Madhya Pradesh State Water Resources Department during June, 1987. Out of these alternative sites, the option of locating the dam about 0.6 km upstream of the existing Rajghat canal aqueduct (crossing Orr river), near Didauni village in Khaniadhana Tehsil of Shivpuri district, was finally selected for field investigations. The dam site is located at latitude $24^{\circ}50'50''\text{N}$ and longitude $78^{\circ}5'55''\text{E}$.

The various survey works like the dam axis survey, submergence area survey, river survey and the command area survey and other allied surveys were carried out by NWDA. The dam axis survey was taken up by NWDA during the month of June, 2011 and completed in November, 2011 and the submergence area survey was taken up during

October 2011 and completed in May, 2012. Besides above, the investigation works like geological & geotechnical investigations, construction material survey, borrow area survey etc. along the proposed dam axis, barrages, canals etc. were carried out by Geological Survey of India (GSI), Bhopal/CSMRS during 2011-12 and 2012-13. The Environment Impact Assessment Studies (EIA) in respect of Lower Orr dam & its canal and proposed barrages & its canals were carried out by M/s WAPCOS Ltd., Gurgaon and M/s AFC Ltd., Hyderabad respectively. The Socio-economic studies for the project has been carried out by Smt. Asha Singh, Professor, Hamidia College, Bhopal on recommendation of Water Resources Department, Govt. of Madhya Pradesh.

(ii) **Survey for transferring of GTS Bench mark levels**

The proposed Lower Orr dam site is located across Orr river near village Didauni on the border of Shivpuri and Ashok Nagar districts of MP. The dam site is located on Survey of India toposheet No. 54 L/1. For carrying out the field surveys, the levels of GTS Bench Mark available at the Rajghat canal aqueduct crossing Orr river located downstream of the Lower Orr project has been transferred to the dam site by Double leveling survey and a Permanent Bench Mark was established.

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

2.1.1.1 River

River course survey has been carried out for Orr river from the proposed dam site to its confluence with Betwa river. The cross sections of the river at every 200 m for initial 2 km length downstream of proposed dam axis and thereafter at every 1 km upto its confluence with Betwa river were taken. The L-section and X-Sections of Orr river on the upstream and downstream of Lower Orr dam site are plotted in the scale of 1:2500 H and 1:100 V and furnished in Plate 2.1.1 and 2.1.2 respectively in Volume-V (Part-1).

2.1.1.2 Reservoir

The reservoir submergence survey of Lower Orr dam has been carried out Departmentally covering an area up to Elevation of 380 m.

Reservoir survey includes fixing of base line by compassing, chaining, ranging and levels transferred by double leveling at every 50 m interval. The cross - sections have been taken at 50m or less grid interval. RCC pillars of size 15cmx15cmx60cm were erected at every 100m along the base line and at the end of each cross sections. The submergence area map of Lower Orr dam has been prepared in the scale of 1:10,0000 with 1 m contour interval and is appended as Plate 2.1.3 in Volume-V (Part-1).

2.1.1.3 Head Works

Survey work on the dam axis was taken up departmentally by NWDA. Topographical survey for a strip of 800 m width (500 m u/s and 300 m d/s upto Rajghat canal aqueduct) of the dam axis was carried upto an elevation of FRL 380m 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 RCC pillars at every 50 m interval along the main dam axis. A detailed plan of Lower Orr dam area showing locations of spillway is given in Plate 2.1.4 of Volume-V (Part-1). A detailed contour plan in the scale of 1:2500 H and 1:100 V with 1 m contour interval has been prepared for the surveyed site of Lower Orr dam and the scale of 1:5000 with 1 m contour interval prepared for dam axis and is appended as Plate 2.1.5 in Volume-V (Part-1).

At Lower Orr dam, a spillway of length 247 m has been proposed in the middle of NOF section for passing the flood discharge of 12068 cumec. The details of flood analysis is furnished in Chapter-III as computed in hydrological studies by NIH, Roorkee. Stilling basin has been proposed for energy dissipation of the out flow. The survey of the dam axis as described above also covers areas of spillway, sloping floor, stilling basin etc.

2.1.1.4 Plant and Colony layout

One colony for the staff has been proposed near village Didauni 22 km away from Chanderi town on the downstream of bund on the right flank and block survey of 25 ha for plant & colony Area was carried out. One Officer's circuit house and one inspection bungalow are also proposed near the colony. Provisions for basic amenities are also proposed

in the colony area. Alternately, there is a proposal for setting up the project colony near Chanderi township. Contour plan of plant and colony layout area are appended as plate 2.1.6 A & 2.1.6 B in Volume-V (Part-1).

2.1.1.5 Canal and Water Conductor System and Canal Structures

a) Canal and Water Conductor System

Strip contour surveys of 400 m width (200 m on either side of centre line of the canal) along the 91.260 km canal alignment of the proposed Lower Orr main canal from its off-take point near Lower Orr dam axis were carried out by Madhya Pradesh Water Resources Department during 2010. The details of surveys carried out by WRD, Govt. of MP has been adopted in the report. The condensed longitudinal section of the canal alignment is appended as Plate 2.1.7 (1/7) to 2.1.7 (7/7) & 2.1.7 F (1/5) to 2.1.7 F (5/5) in Volume-V (Part-1).

b) Canal Structures

The canal will cross 37 nos. of streams/nallas, 27 nos. of village roads, 8 nos. of district road etc., where suitable Cross Drainage/Cross Masonry structures are proposed. 12 nos. falls are also proposed in the canal. In addition to the above, detailed grid survey was also carried out by MPWRD for 9 (nine) major cross drainage sites along the canal. The details are furnished in Annexure 2.1.1. Contour plans have been prepared on the basis of grid surveys to facilitate the design work of cross drainage structures. The grid plan, L-section, Cross section etc. of the CD works are given in Plate 2.1.8 (9 Nos) of Volume-V (Part-1).

2.1.1.6 Command area

The proposed Culturable Command Area (CCA) of the Lower Orr Project is 45047 ha which lies entirely in MP. The Sample Command area survey of a typical block of 1000 ha has been carried out. The contour plan of sample command area surveyed enroute the canal is furnished as Plate 2.1.9 & 2.1.9(1/2) to 2.1.9(2/2) and appended in Volume-V (Part-1).

2.1.1.7 Catchment area treatment Soil Conservation

M/s WAPCOS Limited, New Delhi has been assigned the comprehensive Environmental Impact Assessment, Environment

Management Plan (except Social Impact Assessment and Rehabilitation & Resettlement Plan) study of Lower Orr project. The Social Impact Assessment and Rehabilitation & Resettlement Plan for the project has been entrusted to Professor Asha Singh, Hamidia College, Bhopal. In order to contain soil erosion in the catchment and reduce the silt being carried out by the rivers and streams leading to Lower Orr 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 would be under taken as per recommendations of the consultant. Necessary provision for this work has been kept in the project estimate.

2.1.2 Other allied surveys

2.1.2.1 Archaeological surveys in the reservoir area

The Archaeological Survey of India and Department of Archaeology, Madhya Pradesh have ascertained that no site of archaeological, historical and cultural importance lies within the submergence area of Lower Orr dam as well as along the canal. Copy of letter No. Chanderi/Jan/Sub division/1/13-Monument-5456/ dt 18-10-13 received from Archaeological Department, Bhopal is enclosed as Annexure 2.1.2 of Volume-II.

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

As ascertained from the Mining department, Govt. of Madhya Pradesh, no minerals of economic importance are present in the submergence of Lower Orr project and its vicinity as well as enroute of canal. Copy of letter No 601/Bhomeki/No 33/2013-14 dated 07.01.2014 received from mineral & mines department is enclosed as Annexure : 2.1.3 & 2.1.3 (a & b) of Volume-II.

2.1.2.3 Right of Way Surveys for the Reservoir

No significant road communication is existing in the proposed submergence area upto FRL of Lower Orr Dam for which right of way needs to be provided. Therefore, no such surveys have been carried out.

2.1.2.4 Communication surveys

Detailed communication survey has been carried out by NWDA. There is WBM road available upto Didauni Village. However, Telephone / Mobile Network is available in the area. The dam site is approachable through a 6km long cart track taking off at a distance of 14.8 km from Chanderi towards Pichhore. The nearest rail head is Lalitpur railway station on the Bhopal – New Delhi broad gauge line. The nearest airport is Bhopal which is about 230 km from the dam site. Communication net work of roads, railways etc. of the Upper Betwa projects area is given as Plate 2.1.10 in Volume-V (Part-1)..

2.1.2.5 Drainage Surveys

The command area under the Lower Orr Dam is drained by a network of small rivers/nallahs namely Budhna nadi, Kudrahat nadi, Bilrai nadi, Bahora nalla, Beha nalla, Nanga nalla etc. The command has good draining facilities. However, with the introduction of irrigation, as the command area develops, drainage problem may crop up in course of time. Suitable provision is therefore, made in the project estimate towards chak and collecting drains in the command area.

2.1.2.6 Soil Surveys

Soil map for command area under Lower Orr Project has been prepared using maps prepared by National Atlas of India (1982), and the information provided by the National Bureau of Soil Survey and Land Use Planning (NBSS & LUP), Nagpur/Delhi. The soils of the command area can be broadly classified into mixed Red and black soils. The mixed Red & black soils are predominantly clayey in texture while the black soils are fine textured. The mixed Red and black soils are suitable for cultivation. With good management practices, it is possible to cultivate areas under these soils both under wet and dry conditions. The lands in the command are good to very good-cultivable lands with moderate erosion. These are suitable for

irrigation with moderate limitations due to heavy texture and require drainage.

2.1.3 Geology, Geophysical & Seismic Investigations

2.1.3.1 Geology

Geological studies for Lower Orr Dam has been carried out by Geological Survey of India (GSI) Bhopal. The area around the proposed Lower Orr Project site forms a part of the Bundelkhand Craton on its western fringe occupying about 29000 sqkm area in central India. This oval shaped cratonic land mass is characterised by highly rugged and undulatory, low level plateau with clusters of isolated hills and long, narrow, linear serrated ridges ranging in height from 400 to 600m, extensive rolling plains, valleys, denudational slopes with structural depressions, older and younger flood plains with dissected bad land topography along the river course. The regional slope is towards north as revealed by the flow direction of the Sind and Betwa rivers with a number of tributaries on both the flanks forming a part of the Yamuna basin.

(i) Regional Geology

The Bundelkhand Craton is composed mainly of variegated gneisses, supracrustal metasediments and granites of multiple phases which are intruded by long, linear quartz reefs and dolerite dyke swarms. Quartz reefs exhibit NE – SW trend which were later intruded by NW – SE trending basic dykes. The gneissic-granitic suite of rocks are unconformably overlain by ENE – WSW trending, rift related, volcano-sedimentary sequence of the Bijawar Group in the south, Gwalior Group in the north and intracratonic, platformal Vindhyan Supergroup of rocks in the eastern, southern and western parts. The northern and eastern margins are covered by the great Indo-Gangetic alluvium. The lacustrine Lameta Group and the succeeding Deccan Trap basalt cover the pre-existing rocks at various levels. Soil and alluvium of the Quaternary–Recent period is mostly confined along the banks of the major rivers in the area.

Structurally, the Lower Orr Project site is free from major tectonic features such as folds, faults and lineaments. A major part of the

dam alignment is covered with alluvium anticipating the presence of buried channel on the right flank.

(ii) Local Geology

The proposed Lower Orr Project site is about 8 km upstream of the confluence of Orr river with Betwa river. The area is flat with rolling undulations displaying elevation between 340m and 400m. The Orr river flows towards east with about 60m wide channel close to the left abutment hill. The entire dam alignment is located in the basement granite/granite gneisses as the contact between the granite and the overlying sandstone (Kaimur Group of the Vindhyan Supergroup) lies much above the TBL on both the abutments.

Outcrops of granite/granite gneisses are found on the left abutment and on the Orr river bed between RD 0.00m and 240m. From 240m to 2130m, the dam axis is covered with alluvial soil. Sporadic outcrops of pink, coarse grained, foliated and massive granite are also noticed. These are traversed by the following sets of joints –

NNW – SSE/vertical

NE – SW/vertical

NW – SE/vertical

ENE – WSW /vertical

In addition to above master joints, cross random joints of limited areal and depth persistence are also present in the Orr river section. The joints are oriented askew to the dam axis. Spacing of joints varies from a few cm to more than a metre. Joints are mostly of open type and filled with clayey seams on surface which gradually gets tightened with depth. The joint planes are often stained, straight to undulatory and rough to smooth. Intersection of the joints has given rise to blocky/platy nature to the bedrocks with development of cuboidal and polygonal blocks of variable magnitude. Seepage of water through joints is anticipated under the impoundment.

(ii) Geotechnical Assessment

Pre-construction stage geotechnical investigation of Lower Orr Project in the districts of Shivpuri & Ashok Nagar, MP was carried out in December 2011 by GSI, Bhopal. The investigation is intended to evaluate the geological set up and geomorphological condition along the proposed alignment of the composite dam and also to decide the quantum of subsurface exploration by drilling to cater the preparatory needs of Detailed Project Report (DPR).

The investigation included study of initial drawings and salient features, geological/structural maps of the area, District Resource Map (DRM) of Shivpuri & Guna and 2 km geological traverse along the proposed dam axis and surrounding areas as well as technical discussions with project engineers on various geo-engineering aspects of the project. Evaluation of site specific geological condition and the need for requisite subsurface exploration by drilling to precisely assess the subsurface rock condition and seepage prospect for arriving at the depth of tentative foundation/cut off grades for various main and appurtenant structures and the depth of grouting for reservoir tightness was also carried out.

The Orr river is a monsoon-fed, ephemeral river having a general easterly flow direction with an open meandering course near the proposed dam site. In view of the presence of pink, coarse grained, inherently hard and compact, fresh, massive and foliated granite in the river bed and at left abutment hill and at shallow depth along the axis of the dam, the proposed dam site of Lower Orr Project appears to be geotechnically suitable for centrally located spillway. The location and alignment of the entire structure appears to be geotechnically favourable in view of the absence of significant tectonic features. Seismically also, the area has a history of least tectonic disturbances. As discussed, the bedrock is blocky with 3-4 prominent sets of joints which are oriented askew to the proposed dam axis, large scale leakage/seepage through these open and interconnected joints is anticipated necessitating the need of subsurface exploration by drilling to quantify the degree of seepage and also assess the tentative foundation grade/cut off grade and the depth of grouting required for reservoir tightness.

In order to precisely assess the subsurface condition of bedrocks, the exploratory drilling is recommended along and across the proposed dam axis, the central spillway section and earthen embankments of the Lower Orr Project. GSI has also recommended to carry out water percolation test in all the drill holes at DPR level using double packer method as per BIS code to quantify permeability characteristics of bed rocks. A geotechnical note on preconstruction stage Geotechnical investigations of Lower Orr project received from GSI Bhopal is enclosed as Appendix 2.1.1 in Volume-III.

(iii) Geophysical Investigation

Geophysical investigations in respect of Lower Orr dam site was not required as geotechnical investigations based on direct drilling for sub-surface exploration were carried out.

2.1.3.2 Seismicity

The studies for site-specific design ground motion including earthquake parameters for the proposed Lower Orr dam area have been carried out by the CWPRS, Pune. CWPRS Technical Report No. 4945, April 2012 entitled “Estimation of site-specific seismic design ground motion for Lower Orr dam, Madhya Pradesh” is enclosed as Appendix 2.1.2 in Volume-III.

According to the above studies, the proposed Lower Orr dam site lies in the Bundelkhand gneissic terrain of Archaean-Proterozoic age and is bounded by the tectonic features associated with very low level of seismicity and lies in Zone II of the Seismic zoning map of India (IS : 1893, part-1, 2002).

Conclusions and Recommendations of above study are given below:

i) For the deterministic estimate of the site-specific design ground motion for Lower Orr dam, the magnitude of the controlling MCE is estimated as 6.0 at a closest distance of 24.7 km from the site with 15.0 km as depth. The median response spectra of horizontal and vertical components for this MCE, with damping ratio of 5 % are taken as the deterministic target spectra. The DBE spectra are taken to be half of the

MCE spectra. The probabilistic estimate of the spectra are obtained with a confidence level of 0.96 and 0.50 in 100 years for MCE and DBE conditions respectively.

ii) The MCE and DBE levels of design accelerograms for horizontal and vertical components of motion are generated to be compatible with the recommended target spectra. The design accelerograms of horizontal and vertical components of motion are obtained separately using the respective target spectra and suitable phase differences. The values of the peak ground acceleration for horizontal and vertical components are found to be 0.113 g and 0.089 g for MCE; and 0.051 g and 0.041 g for DBE conditions respectively.

iii) The MCE level of accelerograms are recommended to be used for testing the safety of a dam under extreme and rare earthquake load. Damages, which do not impair the ability of the dam to hold the impounded water, are permitted under this load condition.

iv) Smoothed design response spectra are computed for damping ratios of 1 %, 3 %, 5 %, 7 %, 10 % and 15 % of critical from the MCE and DBE levels of design accelerograms. The site-specific horizontal and vertical design seismic coefficients are found to be 0.029 g and 0.023 g for the Lower Orr dam and 0.055 g and 0.051 g for the spillway of Lower Orr dam respectively. Site specific Design Parameter of Lower Orr dam is approved by National Committee on Seismic Design Parameter (NCSDP) in its 23rd meeting held on 20 November 2012. The same is enclosed as Annexure-2.1.3(C) of Volume-II.

2.1.4 Foundation Investigation

The work of foundation investigations (geotechnical) of Lower Orr dam was carried out by GSI, Bhopal in association with Central Soil and Material Research Station (CSMRS), Delhi. Geotechnical assessment of surface and subsurface data along the alignment of the Lower Orr dam gathered through geological mapping (1:2500 scale) of the project area and core logging of 15 exploratory drill holes on left, centre & right flanks (BH-1 to BH-15) aggregating to about 395 m depth of drilling to precisely assess the subsurface geological condition and water conductivity of bedrocks. Depth of drill holes ranges from 15 m to 30 m. The summarized details of sub-surface exploration is furnished in Annexure 2.1.4 of Volume-II. A

report on sub-surface exploration of Lower Orr dam is enclosed as Appendix 2.1.3 in Volume-III.

The rock samples collected from the 15 bore holes were got tested from CSMRS, Delhi and the parameters are appropriately used by CWC in the design of the structure. The test results of rock samples are furnished as Appendix 2.1.4 in Volume-III.

The work for soil investigation of Lower Orr dam was carried out by CSMRS. A total of 6 No. undisturbed soil samples was collected from 8 foundation pits. A report on the foundation soil investigation are furnished as Appendix 2.1.5 in Volume-III.

2.1.4.1 Earth Dam

Sub surface exploration for the 1730.5 m long earthen dam proposed on the right flank of the lower orr dam has been done by drilling 6 bore holes.

Based on interpretation of surface exploratory data, it is inferred by GSI that the foundation of the Lower Orr dam is composed of hard rock with very good geotechnical features. Geo-technically, such rock mass is considered to be suitable and very competent for the earth Dam as well as for composite dam with adequate treatment measures for ensuring full reservoir competency.

2.1.4.2 Concrete Dam in Spill Way Portion

The sub surface exploration of the 487.0 m long over flow and non over flow section of the Lower Orr dam has been done by drilling 9 No. drill holes.

As inferred by GSI, the foundation grade rock has sufficient area and depth continuity to house the concrete/masonry structure. The configuration of the bedrock profile along the axis of the dam is such that it is available on much higher elevations on both the flanks than the river bed. GSI therefore, suggested the location for the central spillway. However, the location of the central spillway has been finalized by the CMDD (NW&S) design directorate of CWC considering all other aspects.

2.1.4.3 Canal and canal Structures

Subsurface exploration has not been carried out for canal and canal structures across the Lower Orr main canal. However, the work for soil investigations of Lower Orr main canal was carried out by CSMRS New Delhi. A total of 8 No. representative disturbed soil samples were collected from various locations. A report on the soil investigation is appended as Appendix 2.1.6 in Volume-III.

2.1.4.4 Power House and Tunnels

No Power House and Tunnels are proposed in Lower Orr dam.

2.1.5 Geo-technical Investigations and Borrow Area (soil) Surveys and Construction Material Survey

2.1.5.1 Borrow Area Survey - Soils

The work of borrow area soil investigations for the proposed Lower Orr dam was carried out by CSMRS. Representative bulk soil samples from potential borrow areas in the vicinity of dam site were collected during July 2012 as per the suggestions of CSMRS team during their field visit on 6th and 7th May, 2012. Investigations were carried out in its laboratory to characterise the collected borrow area materials for their suitability in the construction of the earthen portion of the dam. In all, 35 soil samples were collected from borrow pits near the Lower Orr dam site. Selected samples were tested by CSMRS. These pits were excavated to 2.0 m depth approximately. Representative samples were taken from 0.2m below the excavated depth. The location of borrow areas in the vicinity of the Lower Orr dam is appended as Plate: 2.1.11 in Volume-V (Part-1).

Laboratory tests such as Mechanical analysis and Atterberg Limits, Specific gravity, Standard Proctor Compaction, Triaxial Shear Test, One Dimensional Consolidation, Laboratory Permeability, Free Swell test, Chemical Analysis, Soil Dispersivity Tests (Pin Hole, Crumb, SCS double Hydrometer, 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 have predominance of silt and clay sizes little and medium sand. The soils in general have medium plasticity characteristics. The soil samples are capable of developing

reasonable value of maximum dry density. They possess low shear strength characteristics and intermediate compressibility characteristics. The soil samples have impermeable characteristics and are non dispersive in general. The Borrow area report received from CSMRS is furnished as Appendix 2.1.7 in Volume-III.

2.1.5.2 Construction Material Survey

(i) Sand

Sand is not available in the Orr river on either side of dam site. The sand can be brought from the Marhai Nalla, Kudrahat Nadi, Budhana Nadi and Bugdhan Nalla with an average lead of 9 km, 15 km, 38 km and 31 km respectively. About 4 lakh cum of sand is available in the above nallas which can be used for the project construction. Alternately, Fine Aggregate can be obtained by crushing quarried rock also. Two sand samples were collected by CSMRS, New Delhi from the Budhana river near Chanderi-Pichhore road bridge for ascertaining their suitability for construction purpose. The test results and report are enclosed as Appendix 2.1.7 in Volume-III.

(ii) Rock and Aggregates

The CSMRS, New Delhi has carried out construction material survey and laboratory investigations of rock samples for their use as coarse aggregate in concrete during investigation of the proposed Lower Orr dam project. 20 coarse aggregate samples were collected from 10 quarries for ascertaining their suitability and the test results of the same are enclosed as Appendix 2.1.8 in the Volume-III. Map showing location of quarries in the vicinity of lower orr dam is appended as Plate: 2.1.12 in Volume-V (Part-1).

2.1.5.3 Brick & Tiles

Soil of suitable quality is available near the proposed colony sites for manufacture of bricks and tiles for use in building construction. Also, brick kilns are available in the vicinity of project area at Khaniyadhana, Shivpuri district & Ashok Nagar & Jhansi towns. Bricks can be transported from the nearest kilns to the colony sites for construction.

2.1.5.4 Pozzolona

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

2.1.5.5 Cement /Lime Stone

Deposits of lime stone in small quantities are found in Raisen(near Sanchi) and Vidisha districts in Upper Betwa sub-basin.

2.1.5.6 Cement and Steel

The requirement of cement for the construction of the project can be brought from nearest cement plants located at Narasinghgarh (Damoh) and Banmore (Gwalior) of MP state to the nearest railhead i.e. Lalitpur and Mungaoli. Similarly, the steel requirement of the project can be brought from steel plant located at Mandideep near Bhopal, Banmore near Gwalior and Bhilai steel plant located in Chhattisgarh state.

2.1.5.7 Scarce Materials

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

2.1.5.8 Any Other Material

There has been adequate material 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 stocked at the nearest rail head points in the proposed stores/stack yards all along the canal and from there, these will be conveyed to the site with minimum lead.

2.1.6 Hydrological and Meteorological Investigations

2.1.6.1 Rainfall and Runoff

Three rain gauge stations i.e., Pichhore, Ashok Nagar and Chanderi located in and around the Lower Orr sub-basin have been considered for hydrological studies at Lower Orr dam site. List of rain gauge station located in the Upper Betwa basin and respective period of availability of data considered for hydrological studies is given at Annexure 2.1.5 of Volume-II. The nearest IMD observatory is located at Guna. The

normal monthly rainfall data shows that this station receives 90% of its total rainfall during the south-west monsoon period (June to September).

The average annual rainfall in the sub-basin varies between 1000mm to 1400 mm and the sub-basin lies in the medium rainfall zone. The normal annual rainfall for the Guna IMD station for the period 1961 to 1990 is 1009.8 mm and are furnished in Annexure 2.1.6 of Volume-II.

2.1.6.2 Sunshine, Cloud Cover and Visibility

Mean values of the cloud cover in the sub-basin varies from 1.3 oktas to 6.8 oktas. Mean monthly cloud cover data observed at Guna IMD observatory is furnished in Annexure 2.1.6 of Volume-II.

2.1.6.3 Wind and Cyclones

The mean wind velocity values varies between 4.3 km/hr to 13.3 km/hr. Mean monthly wind velocity values observed at Guna IMD observatory are furnished in Annexure 2.1.6 of Volume-II.

2.1.6.4 Humidity

The mean monthly relative humidity in the sub-basin varies from 16% to 89%. The relative humidity values observed at Guna IMD observatory are furnished in Annexure 2.1.6 of Volume-II.

2.1.6.5 Temperature

The monthly temperature in the sub-basin varies from 7.9°C to 41.1°C as observed at Guna IMD observatory. The monthwise average maximum and minimum temperature values are furnished in Annexure 2.1.6 of Volume-II.

2.1.6.6 Discharge

There is no G&D site situated on the Orr river at present. Recently, NWDA opened a new G&D site at Betwa aquaduct just d/s of the proposed Lower Orr dam site. As the data of the G&D site is not available for longer period, the long period data available at the nearest Basoda G&D site established by CWC on main Betwa river has been considered for the hydrological study.

2.1.6.7 Sedimentation

There is no silt observatory site on the Lower Orr river. In absence of sufficient sediment data, the sedimentation volume of the project site in 50 and 100 years has been computed from the available sedimentation rate used for the Rajghat dam for determining sedimentation profile. A sedimentation rate of $367.872 \text{ m}^3/\text{sq.km}/\text{year}$ has been considered for Lower Orr dam site as computed for Rajghat project.

2.1.6.8 Water quality

The water quality samples taken from the Orr river near the proposed dam site were tested at water quality testing laboratory of CWC, New Delhi. The result are enclosed in Annexure - 2.1.7 of Volume-II.

2.1.6.9 Evaporation

There is no pan evaporimeter installed near the dam site. Hence, evaporation values computed for Guna IMD observatory has been considered in the study. The same are furnished in the Table 2.1 below:-

Table- 2.1

Monthly Evaporation at Guna IMD observatory

Month	Evaporation
	(m)
January	0.0856
February.	0.1050
March	0.1727
April	0.2253
May	0.2840
June	0.2265
July	0.1200
August	0.0967
September	0.1248
October	0.1373
November	0.1005
December	0.0818
Total	1.7602

2.2.1 Neemkheda Barrage

The Neemkheda barrage site is proposed across Betwa River near village Neemkheda in Goharganj Tehsil of Raisen district. The barrage site is located on toposheet No. 55 E/11. The GTS Bench mark established by Survey of India situated in western compound of Maulana Azad Central Library building at Bhopal, M.P. was transferred by double leveling survey to the site by NWDA and permanent bench mark was established near Neemkheda site proposed earlier across Betwa River. The same values has been adopted in the report.

2.2.1.1 River

No separate river survey has been carried out for river Betwa. However, reservoir survey carried out for Neemkheda/Makodia dam sites earlier was used to find out river cross sections at desired intervals. The L-section and X sections of Betwa river at u/s and d/s of Neemkheda barrage are plotted in scale 1:5000 H and 1:200 V, in Scale 1:1000 furnished in Plate 2.2.1 and 2.2.2 respectively in Volume-V (Part-1).

2.2.1.2 Reservoir

The reservoir survey of Neemkheda barrage was carried out earlier by the M/s CADD Systems, Indore as per the guidelines in the TOR of DPR of Ken-Betwa Link Project has been adopted in the report. Reservoir survey includes fixing of base line by compassing, chaining, ranging and levels transferred by double leveling at 50 m interval. The cross - sections have been taken at 50m or less grid interval by Total station. RCC pillars of size 15cmx15cmx60cm were fixed at every 200m along the base line and at the end of cross sections. TBM RCC pillars of size 40cmx40cmx110cm were also constructed at every 1Km intervals wherever possible and levels were transferred on them by DT leveling and were also transferred on prominent structures located in the submergence area. This survey has been utilized for finalization of design features of Neemkheda barrage. The contour plan of the pondage/ submergence area is plotted in scale 1:10000 and given in Plate 2.2.3 of Volume-V (Part-1).

2.2.1.3 Head works

The Neemkheda barrage site is proposed across Betwa river near village Neemkheda in Goharganj Tehsil of Raisen district. Neemkheda dam/barrage axis survey was already done by NWDA as per earlier proposal. The block leveling for the 1.08 km length of Neemkheda dam/barrage axis were carried out by single leveling at 10m grid interval. The cross sections survey of the axis were taken at 10m interval and extended upto 300m in the upstream and 500 m in the down stream of dam axis. According to the decisions taken by the Govt. of MP and NWDA, the Neemkheda barrage is proposed instead of Neemkheda dam. The length of Neemkheda dam proposed earlier as 1.38 km has been converted into barrage by BCD Directorate of CWC with length of 203 m. It is also decided that the reservoir survey data established earlier for Neemkheda dam can be utilised for finalization of design features of Neemkheda barrage. The plan of the head works showing various appurtenants of the barrage is plotted in a scale of 1:2500 H and 1:100 V and shown in Plate 2.2.4 and appended in Volume-V (Part-1).

2.2.1.4 Plant & colony layout

The colony site is proposed to be located on left side of Bhopal-Raisen road (NH-86) which is in the northern direction of village Rajiv Nagar in Raisen district. The survey of 52.50 ha for colony area at 50m grid interval has already been carried out during the study of DPR of Ken-Betwa Link Project in 2008. The above survey has been utilized for colony of Neemkheda barrage. Suitable Govt. land nearby the project site is not available for establishment of plant area. Private land near by the project site is proposed to be identified and acquired. The plant & colony layout is plotted in scale of 1:5000 and shown in Plate 2.2.5 of Volume-V (Part-1).

2.2.1.5 Canal and Water Conductor System and Canal Structure

The storage of Neemkheda barrage lies within gorge portion of the river and according to the conceptual plan of MPWRD, no canal is proposed for irrigation. The pondage of the barrage will be in the river gorge only and the command area as identified for the barrage would be in

the shape of strip along the pondage on both side of river banks. The water stored in the pondage of barrage shall be lifted by means of electrical pumps to irrigate 3066 ha of command area. Therefore, detailed studies of the lifting and irrigation arrangements are not carried out at this stage.

2.2.1.6 Powerhouse, Switchyards, Surge-shaft, Tailrace etc.

There is no power component proposed in Neemkheda barrage.

2.2.1.7 Tunnel, Adits and Penstocks

There is no tunnel in Neemkheda barrage.

2.2.1.8 Command Area Survey

The command area survey has not been carried out by NWDA for the project.

2.2.1.9 Soil Conservation

M/s Agricultural Finance Corporation Ltd., Hyderabad has been assigned the Rapid EIA, EMP, SIA and R&R study of Neemkheda barrage. In order to control soil erosion in the catchment and reduce the silt being accumulated by the rivers and streams leading to Neemkheda barrage, soil conservation measures would be taken as suggested by the consultant. Necessary provision for this work has been kept in the project estimate.

2.2.2 Other allied surveys

2.2.2.1 Archaeological surveys in the reservoir area

The Archaeological Survey of India and Department of Archaeology, MP has informed that no sites of archaeological, historical and cultural importance maintained by them are present within the pond area of Neemkheda barrage.

2.2.2.2 Mineral, (useful and harmful) Surveys in the Catchment and Reservoir Areas

Most of the submergence area lies in river gorge portion. As ascertained from the Mining department, Govt. of Madhya Pradesh, no minerals of economic importance are present in the pond area of Neemkheda barrage and its vicinity. Letter is enclosed at Annexure-2.1.3 of Volume-II.

2.2.2.3 Right of Way Surveys for the Reservoir

The submergence area under Neemkheda barrage would be restricted to the river portion as the barrage will be constructed within the gorge portion of river. As such, there is no requirement to provide any right of way to any structure.

2.2.2.4 Communication Surveys

The Neemkheda barrage is proposed across Betwa river near village Neemkheda in Goharganj Tehsil of Raisen district. The barrage site is about 35 km from Bhopal which is the nearest railway station and airport. The Bhopal-Raisen-Sanchi National Highway (NH-86) passes near to the project area.

The command area under Neemkheda barrage is well approachable from NH-86 and other district roads. All the villages in the vicinity of Neemkheda barrage and its command area are 100% electrified. Also, suitable provision is made for communication surveys for laying telephone lines, etc. in the project estimate. Map showing communication network of Upper Betwa project is shown in Plate 2.2.6 and is appended in Volume-V (Part-1).

2.2.2.5 Drainage Surveys

The command area under the Neemkheda barrage is drained by a network of small rivers/nallahs. The command has good draining facilities. However, with the introduction of irrigation, as the command area develops, drainage problem may crop up in course of time. Suitable provision is therefore, made in the project estimate towards chak and collecting drains in the command area.

2.2.2.6 Soil Surveys

Soil surveys for the command under Neemkheda barrage has not been carried out. However, on the basis of a map prepared for Upper Betwa sub-basin from National Atlas of India (1982), and based on the information provided by the National Bureau of Soil Survey and Land Use Planning (NBSS & LUP), Nagpur/Delhi, the soils of the command area can be broadly classified into medium to deep black soils. The deep black soils

are predominantly clayey in texture while the medium black soils are fine textured. The black soils are suitable for cultivation. With good management practices, it is possible to cultivate areas under these soils both under wet and dry conditions. The lands in the command are good to very good cultivable lands with moderate erosion. These are suitable for irrigation with moderate limitations due to heavy texture and require drainage.

2.2.3 Geology, Geophysical & Seismic Investigations

2.2.3.1 Geology

The regional geology of the proposed project site of Neemkheda constitutes a part of the Vindhyan Supergroup which is unconformably overlain by the Quaternary-Recent alluvium soils. The general slope is towards northeast as exhibited by the flow of the Betwa River and its tributaries. The geotechnical and natural hazard map by GSI has revealed that the trace of a lineament trending NNE-SSW is lying between Goharganj in Raisen district to Vidisha in Vidisha district which is nearer to the project areas of Neemkheda. All the proposed project areas of Raisen and Vidisha districts fall in seismic zone-I/II. The Betwa River flows in north northeast direction with about 100m wide channel at project site. The outcrops exposed in the river bed of Neemkheda project belongs to Bhandar Group. These sedimentary rocks comprising off white to dark grey, fine grained, hard and compact, flatly disposed, fresh to slightly weathered, massive sandstone with thin intercalatory bands of siltstone/shale. These are traversed by 3 mutually perpendicular joints, namely sub horizontal bedding joints and two right angled vertical joints trending NE-SW and NW-SE at the Neemkheda site.

2.2.3.2 Geotechnical assessment

The Betwa river is a monsoon-fed, ephemeral river having a general north-northeast (NNE) direction of flow with an open meandering course near the proposed dam site. In view of the presence of fresh, inherently hard, massive/dense sandstone in the river bed, the proposed barrage site of Neemkheda project and different variants of basalt (vesicular/amygdular, massive /dense, non-vesicular and fragmentary) in

the river bed. The location and alignment of the structure appear to be geotechnically favourable in view of the absence of significant tectonic disturbance. The bedrock is blocky with 3-4 prominent sets of open to tight and interconnected joints. Joints are oriented both parallel and across to the barrage axis. Large scale leakage through joints is anticipated necessitating the need of sub-surface exploration to quantify the intensity of seepage and also to assess the tentative foundation grade and the depth of grouting for reservoir tightness. A pre-construction note on geotechnical investigations of Neemkheda dam/barrage is given in Appendix 2.2.1 of Volume-III.

2.2.3.3 Geophysical Investigation

Geophysical investigation in respect of Neemkheda barrage site was not needed as geotechnical investigations based on direct drilling on the barrage axis for sub-surface exploration were carried out.

2.2.3.4 Seismicity

Seismo-tectonically, the Bundelkhand –Malwa area is a stable land mass with a history of least tectonic disturbances. The area of the Upper Betwa basin is practically devoid of active lineament, fault or shear. As per the seismic zoning map of India (1990), the proposed layout of the Ken-Betwa link scheme including storage dams/barrages in Upper Betwa falls under seismic zone-II which signifies low seismic events not exceeding magnitude 3 and hence seismo-tectonic hazards would be considered as minimum.

2.2.4 Foundation Investigation

The work of foundation investigations (geotechnical) was carried out through GSI, Bhopal in association with CSMRS Delhi. Geotechnical assessment of surface and subsurface data along the alignment of the Neemkheda barrage gathered through geological mapping (1:2500 scale) of the project area and core logging of 5 exploratory drill holes on left, centre & right flanks (BH-1 to Bh-5) aggregating to about 127.50 m depth of drilling to precisely assess the subsurface geological condition and water conductivity of bedrocks. Depth of drill holes ranges from 13.80 m to 42.00 m. The summarized details of sub-surface exploration is furnished in

Annexure-2.2.1 of Volume-II. A geotechnical note on sub-surface exploration of Neemkheda barrage is enclosed as Appendix -2.2.2 in Volume-III.

The rock core samples were got tested from CSMRS, Delhi and the parameters are appropriately used by CWC in the design of the structure. The test results of rock samples are furnished as Appendix -2.2.3 in Volume-III.

2.2.4.1 Earth and Rock Fill Dam

Since barrage is proposed, no investigation is required under this sub-head.

2.2.4.2 Barrage

The foundation investigations carried out at the barrage site is already furnished in above para 2.2.4.

2.2.4.3 Canal and Canal Structures

Canal is not proposed under Neemkheda barrage as the irrigation is proposed by lifting the water directly from pondage of barrage.

2.2.4.4 Power House and Tunnels

No Power House and Tunnels are proposed under Neemkheda barrage.

2.2.5 Geo-technical Investigations and Borrow Area (soil) Surveys and Construction Material Investigations

2.2.5.1 Soils

Since, Neemkheda barrage is a masonry/concrete structure, no investigation for borrow areas (soils) were conducted.

2.2.5.2 Sand

CSMRS, New Delhi carried out construction material survey and laboratory investigations of sand samples for their use as fine aggregate in concrete during preparation of DPR of Ken-Betwa Link (2008) for the Makodia dam (now dropped) which is 7 km upstream of proposed Neemkheda barrage is considered same for this project also. 14 sand samples were collected from different sand quarries and the physical tests

viz. specific gravity, grading and fineness modulus, silt and clay content, 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. It was found that the sand samples collected from the following quarries were suitable for use in concrete either directly or mixed with finer sand to improve their fineness modulus.

1. Barari barrage sand quarry
2. Khambu Khedi sand quarry
3. Keotan sand quarry
4. Neemkheda(Rong Pura)sand quarry
5. Betwa Navidiya sand quarry

The report on the construction material surveys and laboratory investigations of sand samples is enclosed as Appendix 2.2.4 in Volume-III. It has been considered that the sand from above quarries can be used for Neemkheda barrage.

2.2.5.3 Rock and Aggregates

The 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 for proposed Makodia dam (now dropped) which is 7 km upstream of the project is proposed to be used for this project also. 18 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 Bureau of Indian Standards (IS:2386-latest version) for assessing their suitability as per IS:383-2002 for use in concrete. Accordingly, the following rock quarries were found suitable for use in wearing as well as non-wearing surfaces.

1. Sumer Rock Quarry
2. Betwa Barri Ghat Rock Quarry
3. Kanajna Rock Quarry

4. Ruber Yai village Rock Quarry
5. Nateran Kherra Rock Quarry

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 report on the construction material surveys and laboratory investigations of rock samples is enclosed as Appendix: 2.2.4 in Volume-III. It has been considered that the rock from above quarries can be used for construction of Neemkheda barrage also.

2.2.5.4 Bricks, Tiles

Soil of suitable quality is available near the proposed colony sites for manufacture of bricks and tiles for use in building construction. Also, brick kilns are available in the vicinity of project area at Raisen, Vidisha and other towns. Bricks can be transported from the nearest kilns to the colony sites for construction.

2.2.5.5 Pozzolona

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

2.2.5.6 Cement /Lime Stone

Deposits of lime stone in small quantities are found in Raisen (near Sanchi) and Vidisha districts in Upper Betwa sub-basin.

2.2.5.7 Cement and Steel

The requirement of cement for the construction of the project can be brought from nearest cement plants located at Narasinghgarh

(Damoh), Banmore (Gwalior) of M.P state to the nearest railhead i.e., Bhopal. Similarly, the steel requirement of the project can be brought from steel plant located at Mandideep near Bhopal and Bhilai steel plant located in Chhattisgarh state.

2.2.5.8 Scarce Materials

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

2.2.5.9 Any Other Material

There has been adequate material 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 stores/stack yards all along the canal and from there these will be conveyed to the site with minimum lead.

2.2.6 Hydrological and Meteorological Investigations

2.2.6.1 Rainfall and Runoff

9 rain gauge stations located in and around the Upper Betwa basin have been considered for hydrological studies at Neemkheda barrage site. The nearest rain gauge station is located at Raisen. The normal monthly rainfall data shows that this station receives 92% of its total rainfall during the south west monsoon period (June to September). The maximum rainfall occurs during August (493.9 mm) and the minimum rainfall occurs during April (1.2 mm). The annual normal rainfall is 1208.8 mm and are furnished in Annexure: 2.2.2 of Volume-II.

2.2.6.2 Sunshine, Cloud Cover and Visibility

The cloud cover is varying from 0.9 oktas to 6.1 oktas in the Neemkheda barrage area. The highest cloud cover is experienced in the month of August. The monthwise cloud cover at Raisen IMD observatory is furnished in Annexure 2.2.2 of Volume-II.

2.2.6.3 Wind and Cyclones

The wind velocities in Neemkheda barrage area varies from 2.3 km/hr to 10.4 km/hr. The monthly wind velocities of Raisen IMD observatory are furnished in Annexure 2.2.2 of Volume-II.

2.2.6.4 Humidity

The maximum and minimum mean monthly relative humidity varies from 23% (April) to 88% (August). The values of monthly relative humidity of Raisen IMD observatory are furnished in Annexure 2.2.2 of Volume-II.

2.2.6.5 Temperature

The climate of the Betwa basin is characterized by hot summer and mild winter. The daily maximum and minimum temperature varies from 7°C to 41.9 °C. The monthwise daily maximum and minimum temperatures of Raisen IMD observatory are furnished in Annexure 2.2.2 of Volume-II.

2.2.6.6 Discharge

No gauge and discharge site is available in the vicinity of Neemkheda barrage site. One Gauge & Discharge site was established by NWDA at Neemkheda barrage site on Betwa River and observations were started from July, 2006. This site is closed now.

In addition to the above, Gauge and Discharge data being observed by CWC at Basoda on river Betwa have been collected and the same have been utilized in hydrological study carried out for this project.

2.2.6.7 Sedimentation

There is no sedimentation observatory site in the Betwa river near the Neemkheda barrage site. In absence of sufficient sediment data, the sedimentation volume of the project site in 50 and 100 years has been computed from the available sedimentation rate used for the Rajghat dam for determining sedimentation profile. A sedimentation rate of 367.872 m³/sq.km/year has been considered for Neemkheda dam site as computed for Rajghat project.

However, a silt observatory site, has been established by NWDA at Neemkheda G&D site, located 7 km d/s of Makodia dam (now dropped) site on Betwa river and observation started w.e.f. 25.07.2007. This site is closed now.

2.2.6.8 Water quality

The water quality samples taken at the above site were tested at water quality testing laboratory of CWC, Bhopal. The results are enclosed in Annexure: 2.2.3 (a & b) of Volume-II.

2.2.6.9 Evaporation

There is no IMD observatory site near the Neemkheda barrage site. Therefore, monthly evaporation values computed at Raisen IMD observatory has been used for the hydrological study and the same are furnished in Table 2.2 below.

Table- 2.2

Monthly Evaporation values at Raisen IMD station

Month	Evaporation
	(m)
January	0.0753
February.	0.0918
March	0.1507
April	0.2046
May	0.2638
June	0.1995
July	0.1156
August	0.0992
September	0.1230
October	0.1287
November	0.0930
December	0.0738
Total	1.6190

2.3.1 Barari Barrage

The Barari barrage is proposed across Betwa river near Barrighat village of Gyaspur tehsil in Vidisha district, about 62 Km downstream of Neemkheda barrage site. In order to initiate the

topographical surveys for the barrage, the value of SoI Benchmark located on south- east centre of platform of South of two Mahadev temples on island called “Charan terath” in Betwa river in Vidisha, was transferred by double levelling to the site by NWDA for establishing permanent bench mark near Barari barrage axis at the time of preparation of DPR of Ken-Betwa Link Project (2008). The same has been considered.

2.3.1.1 River

The following topographical surveys have been carried out along/across the river course.

a) L section u/s

Levels of the Betwa river were taken at an interval of 50 m by single levelling up to pond level + 1 m i.e. 409 m (408+1m) for back water effect. The total length of the L-section including tributaries, nalla etc. comes out to 120.983 km.

b) L-section d/s

The levels were taken upto 10.168 km from the axis of barrage at 50 m interval. The Betwa river L-section, 3 km u/s and d/s of Barari barrage is plotted in a scale of 1:5000 H and 1:200 V and given as Plate: 2.3.1 in Volume-V (Part-1).

c) X-section u/s

The x-section of Betwa river were taken at every 200 m interval for a distance of 2 km from the axis of the barrage and thereafter at 500m interval upto a distance corresponding to the level of 414 m (MWL) covering all topographical features in between of each cross section. The total length of the X-section comes to 114.743 km.

d) X-section d/s

The Betwa river x-section at every 200 m interval upto HFL + 1 m on either side of the river from bank and upto the 5 km from the axis of the barrage were taken. The total length of the X-section comes to 53.850 km. The cross sections of the Betwa river is plotted in the scale of 1:5000 H and 1:500 V and given as Plate:2.3.2 in Volume-V (Part-1).

2.3.1.2 Reservoir/Pond

The submergence survey of Barari barrage has been carried out on the line of river survey as the barrage will be constructed within the gorge portion of river and accordingly the cross-section of the river will be restricted up to pond level + 1 m or 1 km on either side of the firm bank of river whichever is less. As detailed above, X-sections were taken at 200 m interval for a distance of 2 km and thereafter at 500m interval corresponding to the length of L-section in the upstream of axis of the structure. In the downstream, X-sections were taken at 200 m intervals upto HFL +1 m on either side of river bank for a distance of 5 km from the axis of the structure. The levels are taken at 50 m or less interval. L-section has also been carried out for small tributaries and nalla joining the pond.

The above surveyed data has been utilized for preparing submergence area plan in the scale of 1:2500 H at 1 m contour interval based on which, the reservoir/pond capacity of the barrage has been assessed and adopted in the studies. The submergence/pondage area map of Barari barrage is given at Plate: 2.3.3 in Volume-V (Part-1).

2.3.1.3 Headworks

The Barari barrage is situated on Betwa river near Barrighat village of Gyaraspur tehsil of Vidisha district. 2.273 km length of Barari barrage axis including 0.883 km extension has been surveyed by NWDA. Block levelling for the Barari barrage axis has been carried out by single levelling at 50 m or less grid interval. The cross section along the barrage axis were taken at 50 m interval by taking levels and extended upto 300 m on the upstream side and 500 m on the downstream side of barrage axis. The contour plan of barrage site was prepared on 1: 5000 H and 1:200 V scale with contours at 1 m interval. The same has been utilized for preparing the layout plan, L-section along the barrage axis, etc. The Contour plan of the headworks is given as Plate: 2.3.4 in Volume-V (Part-1).

2.3.1.4 Plant and Colony layout

In the vicinity of Barari barrage, suitable Govt. land is not available for plant and colony and hence, survey was carried out. Private land is proposed to be identified and acquired to construct the above

colonies. For pumping station, sites can be located in the upstream of the barrage. Colony area is also proposed near towns Raisen & Vidisha for main canal construction. The plant & colony Layout is shown in Plate 2.3.5 and appended in Volume-V (Part-1).

2.3.1.5 Canal and Water Conductor System and Canal Structures

Water is proposed to be lifted by 21 m from RL.403.90 m to RL 425 m through a 4 km long pipeline into a small existing tank located near Gulabganj village, Gulabganj tehsil in Vidisha district. Thereafter, one ridge canal of 4.50 km long with FSL at 424 m is proposed to run in the south-west direction to irrigate the proposed command area. The existing tank is to be remodelled according to requirement of project. The survey of alignment and double levelling for the lift portion is completed. The contour plan and L-section of the alignment have been prepared in 1:5000 H & 1:200 V scale with 1m contour interval and the same are shown in Plate:2.3.6 in Volume-V (Part-1).

Since the canal is proposed as a ridge canal, no rivers/streams will come across and hence no canal structures would be required.

2.3.1.6 Powerhouse, Switchyards, Surge-shaft, Tailrace, etc.

There is no power component proposed in Barari barrage.

2.3.1.7 Command Area Survey

The CCA proposed under the Barari barrage is 4444.45 ha with an irrigation intensity of 100%. Sample command area survey has been carried out for about 10% of the CCA. The command area survey was done along the base line with cross-section at an interval of 50 m grid.

The purpose of the sample command area survey is to assess the rate per hectare on development of command area of the project. The command area map has been plotted in the scale of 1:5000 at a contour interval of 1.0 m and for OFD works, the same is plotted in the scale of 1:5000 at a contour interval of 0.25 m. The OFD map of Barari barrage is given in Plate: 2.3.7 in Volume-V (Part-1).

2.3.1.8 Soil conservation

M/s Agricultural Finance Corporation Ltd., Hyderabad has been assigned the Rapid EIA, EMP, SIA and R&R study of Barari barrage. In order to contain soil erosion in the catchment and reduce the silt being carried out by the rivers and streams leading to Barari barrage, soil conservation measures would be taken as suggested by the consultant. Like wise, in the command area of Barari canal, 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 recommendations of the consultant. Necessary provision for this work has been kept in the project estimate.

2.3.1.9 Any other

Nil

2.3.2 Other Allied Surveys

2.3.2.1 Archaeological surveys in the reservoir area

The Archaeological Survey of India and Department of Archaeology, MP have informed that no sites of archaeological, historical and cultural importance maintained by them are present within the pond area of Barari barrage.

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

As ascertained from the Mining department, Govt. of Madhya Pradesh, no minerals of economic importance are present in the pond area of Barari barrage and its vicinity as well as enroute its canal. Letter is enclosed at Annexure-2.1.3 of Volume-II.

2.3.2.3 Right of Way Survey for the Reservoir

The submergence area under Barari barrage will be mostly restricted to the river portion as the barrage will be constructed within the gorge portion of river. As such, there is no requirement to provide any right of way to any structure.

2.3.2.4 Communication Surveys

The Barari barrage is proposed near Barrighat village of Gyaraspur tehsil in Vidisha district. The barrage site is about 28 km from Vidisha which is the nearest railway station. The Bhopal-Raisen-Sanchi National Highway (NH-86) and the railway line connecting Bhopal and Delhi pass nearer to the project area. The nearest airport is at Bhopal situated, about 80 km from the barrage site.

The command area under Barari ridge canal is well approachable from NH-86 and other district roads. All the villages in the vicinity of Barari barrage, its canal and command area are 100% electrified. Also, suitable provision is made for communication surveys for laying telephone lines etc. in the project estimate. Map showing communication network of project is enclosed Plate: 2.2.6 in Volume-V (Part-1).

2.3.2.5 Drainage Surveys

The command area under the Barari ridge canal is drained by a network of small rivers/nallas. The command has good draining facilities. However, with the introduction of irrigation, as the command area develops, drainage problem may crop up in course of time. Suitable provision is, therefore, made in the project estimate towards chak and collecting drains in the command area.

2.3.2.6 Soil Surveys

Soil survey has not been carried for the command under Barari ridge canal. However, on the basis of a map prepared for Upper Betwa sub-basin from National Atlas of India (1982), and based on the information provided by the National Bureau of Soil Survey and Land Use Planning (NBSS & LUP), Nagpur/Delhi the soils of the command area can be broadly classified into medium to deep black soils. The deep black soils are predominantly clayey in texture while the medium black soils are fine textured. The black soils are suitable for cultivation. With good management practices, it is possible to cultivate areas under these soils both under wet and dry conditions. The lands in the command are good to very good cultivable lands with moderate erosion. These are suitable for

irrigation with moderate limitations due to heavy texture and require drainage.

2.3.3 Geology, Geophysical, & Seismic Investigations

2.3.3.1 Geology

i) Local Geology

The Barari barrage site is located in the upper reaches of Betwa river which is characterized by typical pineplained topography comprising extensive plains, shallow valleys with gentle bank slopes and low lying hills. The river mostly flows south to north with dendritic to subdendritic pattern. The barrage site area is more or less flat with rolling undulations on both the flanks of the Betwa river displaying elevations roughly between 412 m and 397 m. The barrage alignment (FB 122⁰) area has soil/alluvial cover consisting of silty-clayey soil, sandy-silty loam, concretionary yellow soil and regolith. Bed rock is not exposed along the alignment of the barrage. However, outcrops of fragmentary basalts are seen in the Betwa river section about 500 m downstream of the proposed Barari barrage.

ii) Geotechnical Assessment

Pre-construction stage geotechnical investigation to evaluate the geological set up and site conditions of the proposed location barrage in Upper Betwa was carried out by GSI, Bhopal in 2006. According to GSI, the location of proposed barrage near Barari is suitable and geotechnically favourable as the site is devoid of active lineament, fault or shear. Seismically also, the area has not experienced any major geological event in the recent past.

At barrage site, the bedrock is anticipated to be at deeper levels in view of the presence of thick soil/alluvium cover and permanent ponding of water, which may pose construction problems. GSI therefore, suggested the shifting of barrage axis in either direction having bed rock at or near the river bed level may be contemplated. A pre-construction stage note on geotechnical investigations of Barari barrage by GSI, Bhopal is given in Appendix 2.3.1 of Volume-III.

iii) Geophysical Investigation

In view of exploratory drilling carried out for assessment of surface and sub-surface data for foundation investigation. The Geophysical investigation has not been carried out as per the suggestion of GSI.

2.3.3.2 Seismicity

Seismo-tectonically, the Bundelkhand–Malwa area is a stable land mass with a history of least tectonic disturbances. The area of the Upper Betwa basin is practically devoid of active lineament, fault or shear. As per the seismic zoning map of India (1990), the proposed layout of the Ken-Betwa link scheme including storage dams/barrages in Upper Betwa falls under seismic zone-II which signifies low seismic events not exceeding magnitude 3 and hence seismo-tectonic hazards could be considered as minimum.

2.3.4 Foundation Investigations

The work of foundation investigations (geotechnical) was carried out through GSI, Bhopal in association with IIT, Delhi. Geotechnical assessment of surface and subsurface data along the alignment of the Barari barrage gathered through geological mapping (1:2500 scale) of the project area and core logging of 2 exploratory drill holes on left & right flanks (BH-1 & BH-2) aggregating to about 49 m depth of drilling to precisely assess the subsurface geological condition and water conductivity of bedrocks. Depth of drill holes ranges from 22.4 m to 26.5 m. The summarized details of sub-surface exploration is given in Annexure: 2.3.1 of Volume-II. A geotechnical note on sub-surface exploration of Barari barrage is enclosed as Appendix- 2.3.2 in Volume-III.

The rock samples were got tested from IIT, Delhi and the parameters are appropriately used in the design of the structure. The test results of rock samples are furnished as Appendix- 2.3.3 in Volume-III.

2.3.4.1 Earth and Rock Fill Dam

Since barrage is proposed, no investigation is required under this sub-head.

2.3.4.2 Barrage

A barrage is proposed on Betwa river at Barrighat village in Vidisha district. The extent of surveys carried out has already been mentioned in para 2.3.4 above.

2.3.4.3 Canal and Canal Structures

Since the canal is proposed as a ridge canal, no rivers/streams will come across and hence no canal structures would be required.

2.3.4.4 Power House and Tunnels

No Power House and tunnels are proposed under Barari barrage.

2.3.5 Geo-technical Investigations and Borrow Area (soil) Surveys and Construction Material Investigations

2.3.5.1 Soils

As a barrage is proposed under Barari project which will be a masonry/ concrete structure, no investigations for borrow area were carried out. The work of borrow area soil investigations for the proposed Barari canal was carried out through CSMRS. Representative bulk soil samples from potential borrow areas in the vicinity of the canal were collected by CSMRS in September, 2008 and investigations carried out in its laboratory to characterize the collected borrow area materials for their suitability in the construction of the canal. The test results of soil samples are furnished in Appendix 2.3.4 of Volume-III.

2.3.5.2 Sand

The CSMRS, New Delhi carried out construction material survey and laboratory investigations of sand samples for their use as fine aggregate in concrete during construction of the project. Fourteen sand samples were collected from different sand quarries and the physical tests viz., specific gravity, grading and fineness modulus, silt and clay content, petrographic analysis, etc. were conducted on the representative samples as per BIS (IS:2386-latest version) for assessing their suitability as per IS:383-2002 for use in concrete. It was found that the sand samples collected from

the following quarries were suitable for use in concrete either directly or mixed with finer sand to improve its Fineness Modulus.

1. Barari barrage sand quarry
2. Khambu Khedi sand quarry
3. Keotan sand quarry
4. Neemkheda(Rong Pura) sand quarry
5. Betwa Navidiya sand quarry

The test results of the above sand samples are already furnished in Appendix: 2.2.4 in Volume-III.

2.3.5.3 Rock and Aggregates

The 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. Eighteen 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. Accordingly, rock from the following rock quarries were found suitable for use in wearing & non-wearing surfaces.

1. Sumer Rock Quarry
2. Betwa Barri Ghat Rock Quarry
3. Kanajna Rock Quarry
4. Rubber Yai village Rock Quarry
5. Nateran Kherra Rock Quarry

The petro graphic examination carried out through GSI, Faridabad & Lucknow by CSMRS 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 already furnished in Appendix: 2.2.4 in Volume-III.

2.3.5.4 Bricks, Tiles

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

2.3.5.5 Pozzolona

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

2.3.5.6 Cement/Lime Stone

Deposits of lime stone in small quantities are found in Raisen (near Sanchi) and Vidisha districts in Upper Betwa sub-basin.

2.3.5.7 Cement and Steel

The requirement of cement for the construction of the project can be brought from nearest cement plants located at Narasinggarh (Damoh), Banmore (Gwalior) of M.P state to the nearest railhead i.e., Bhopal. Similarly, the steel requirement of the project can be brought from steel plant located at Mandideep near Bhopal and Bhilai steel plant located in Chhattisgarh state.

2.3.5.8 Scarce Materials

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

2.3.5.9 Any Other Material

There has been adequate material 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 stores/stack yards all along the canal and from there these will be conveyed to the site with minimum lead.

2.3.6 Hydrological and Meteorological Investigations

2.3.6.1 Rainfall and Runoff

8 (eight) rain gauge stations located in and around the Upper Betwa basin have been considered for hydrological studies at Barari barrage site. The nearest rain gauge station is located at Raisen. The normal monthly rainfall data shows that this station receives 92% of its total rainfall during the south west monsoon period (June to September). The maximum rainfall occurs during August (493.9 mm) and the minimum rainfall occurs during April (1.2 mm). The annual normal rainfall is 1208.8 mm. are furnished in Annexure: 2.1.5 and Annexure: 2.2.2 of Volume-II.

2.3.6.2 Sunshine, Cloud Cover and Visibility

The cloud cover is varying from 0.9 oktas to 6.1 oktas in the Barari barrage area. The highest cloud cover is experienced in the month of August. The monthwise cloud cover of Raisen IMD observatory is furnished in Annexure 2.2.2 of Volume-II.

2.3.6.3 Wind and Cyclones

The wind velocities in Barari barrage area varies from 2.3 km/hr to 10.4 km/hr. The monthly wind velocities of Raisen IMD observatory are furnished in Annexure 2.2.2 of Volume-II.

2.3.6.4 Humidity

The maximum and minimum mean monthly relative humidity varies from 23% (April) to 88% (August). The values of monthly relative humidity of Raisen IMD observatory are furnished in Annexure 2.2.2 of Volume-II.

2.3.6.5 Temperature

The climate of the Barari barrage area is characterized by hot summer and mild winter. The daily maximum and minimum temperature varies from 7°C to 41.9 °C. The monthwise daily maximum and minimum temperatures of Raisen IMD observatory are furnished in Annexure 2.2.2 of Volume-II.

2.3.6.6 Discharge

No gauge and discharge site is available in the vicinity of Barari barrage site. One Gauge & Discharge site was established by NWDA at Barari barrage site on Betwa river and observations were started from 07.07.2006. The site is closed now.

In addition to the above, Gauge and Discharge data being observed by CWC at Basoda on river Betwa have been collected and the same have been utilized in hydrological study carried out for this project.

2.3.6.7 Sedimentation

Being a barrage, no sediment calculation is done. However, a silt observation site, has been established by NWDA at Neemkheda G&D site, located 1 km d/s of proposed Neemkheda barrage site (now closed) on Betwa river and observation started w.e.f. 25.07.2007.

2.3.6.8 Water quality

Facility for water quality testing is not available with NWDA. So, the results of the water quality samples taken at the proposed Neemkheda barrage located u/s of the Barari barrage site & tested at water quality testing laboratory of CWC, Bhopal could be well used for this site also. The result are enclosed in Annexure: 2.2.3 of Volume-II.

2.3.6.9 Evaporation

There is no pan evaporimeter installed near the barrage site. The monthly evaporation values computed at Raisen IMD observatory has been used for the hydrological study and the same are furnished in Table 2.2 above.

2.4.1 Kotha Barrage

The Kotha barrage site is proposed across Betwa river near village Kotha in Basoda Tehsil of Vidisha district and located on toposheet No. 54 L/4. In order to initiate the topographical surveys for Kotha barrage, the value of Survey of India benchmarks located on round parapet of well near Bareth railway station was transferred by double leveling to the temporary bench mark established near barrage axis.

2.4.1.1 River

No separate river course survey has been carried out for river Betwa near the barrage site.

2.4.1.2 Reservoir

No separate reservoir survey has been carried out for Kotha barrage since initially the entire submergence lies within the gorge portion of the banks of Betwa river. However pond level of the Kotha barrage has been refixed by central water commission as 396m after their site visit during 20-22 Nov.2013. Submergence area and capacity have been increased due to increase in the pond level. Revised submergence map has been prepared based on barrage axis survey details L-Section of Betwa river carried out by NWDA and contours available on the Survey of India (SOI) toposheets. Submergence area survey, river survey and barrage axis survey of this project will be carried out in due course of time in view of change in parameters of the barrage as a fresh at next stage of project. The submergence area map of Kotha barrage is given as Plate 2.4.1 in Volume-V (Part-1). It is proposed carry out detailed submergence survey and river survey for this project at next stage of the project before taking up its implementation.

2.4.1.3 Head works

The Kotha barrage site is proposed across Betwa river near village Kotha in Basoda Tehsil of Vidisha district. Kotha barrage axis survey was carried out by NWDA. The block leveling for the 215 m length of Kotha barrage axis has been carried out by single leveling at 50 m grid interval. The cross sections survey of dam axis were taken at 50 m interval and extended upto 300m in the upstream and 500 m in the down stream of

dam axis. The grid plan of the barrage and cross section of betwa river at Kotha barrage axis is plotted and enclosed as Plate 2.4.2 and Plate 2.4.3 in Volume-V (Part-1).

2.4.1.4 Plant & Colony layout

Suitable Govt. land is not available for establishment of plants and colony, therefore plant and colony survey has not been done. Private land near to the project site is proposed to be identified and acquired. Plant & colony Layout is shown in Plate 2.4.4 in Volume-V (Part-1).

2.4.1.5 Canal and Water Conductor System and Canal Structure

Initially storage of Kotha barrage was within gorge portion of the river and according to the conceptual plan of MP Water Resources Department, the irrigation is proposed to be provided through lifting from the pondage of the barrage. Therefore, no canal was proposed for irrigation from the barrage. Now, after the visit of CWC team during November, 2013 the height of barrage has been increased from 4 m to 13.5 m as per their recommendation. The storage has been increased substantially due to increased pond level. Two main canals off taking from left and right bank of the length 39 km and 49 km respectively has now been proposed for irrigating an area about 21696 ha. Due to changes in the parameters of the barrage at later stage, the detailed survey of canal and water conductor system and canal structures could not be carried out at this stage. It is proposed to take up these surveys in due course at next stage of the project.

2.4.1.6 Command Area

The required sample command area survey of the project has not been carried out due to enhancement of CCA as per the change in parameter of the barrage. However the command area map has been prepared on the basis of Survey of India (SOI) Toposheet (1:50,000) scale and shown as Plate 2.4.5 and appended in Volume-V (Part-1).

2.4.1.7 Soil Conservation

M/s Agricultural Finance Corporation Ltd., Hyderabad has been assigned the Rapid EIA, EMP, SIA and R&R study of Kotha barrage. In order to contain soil erosion in the catchment and reduce the silt being

carried out by the rivers and streams leading to Kotha barrage, soil conservation measures would be taken up as per the studies carried out by the consultant. Necessary provision for this work has been kept in the project estimate.

2.4.1.8 Any other

Nil

2.4.2 Other allied surveys

2.4.2.1 Archaeological surveys in the reservoir area

No sites of archaeological, historical and cultural importance maintained by archaeological Survey of India and department of archaeology MP are present within the pond area of Kotha barrage as most of the reservoir area lies in river gorge portion.

2.4.2.2 Mineral, (useful and harmful) Surveys in the Catchment and Reservoir Areas

As ascertained from the Mining department, Govt. of Madhya Pradesh, no minerals of economic importance are present in the pond area of Kotha barrage and its vicinity. Letter is enclosed at Annexure-2.1.3 of Volume-II.

2.4.2.3 Right of Way Surveys for the Reservoir

The submergence area under Kotha barrage earlier restricted to the river portion as the barrage proposed to be constructed within the gorge portion of river. As such, there was no need to provide any right of way to any structure. In the present scenario due to change in the parameters of the barrage, the right of way survey is proposed to be carried out after detailed submergence area survey for assessing the right of way of the permanent structures, existing roads etc.

2.4.2.4 Communication Surveys

The Kotha barrage is proposed across Betwa river near village Kotha in Basoda Tehsil of Vidisha district. The barrage site is about 6 km from Mandi Bamora on Basoda-Bina road. Vidisha is the nearest railway station/town. The project site is well connected by road. Bhopal is the nearest airport which is about 175 km from the project site.

The command area under Kotha barrage is well approachable from district roads. All the villages in the vicinity of Kotha barrage and its command area are electrified. Suitable provision is made for communication surveys for laying telephone lines etc. in the project estimate. Map showing communication network of project is enclosed as plate: 2.2.6 in Volume-V (Part-1).

2.4.2.5 Drainage Surveys

The proposed command area under the Kotha barrage is drained by a network of small rivers/nallas. The command has good draining facilities. However, with the introduction of irrigation, as the command area develops, drainage problem may crop up in course of time. Suitable provision is, therefore, being made in the project estimate towards chak and collecting drains in the command area.

2.4.2.6 Soil Surveys

Soil survey has not been carried for the command under Kotha barrage. However, on the basis of a map prepared for Upper Betwa sub-basin from National Atlas of India (1982), and based on the information provided by the National Bureau of Soil Survey and Land Use Planning (NBSS & LUP), Nagpur/Delhi the soils of the command area can be broadly classified into medium to deep black soils. The deep black soils are predominantly clayey in texture while the medium black soils are fine textured. The black soils are suitable for cultivation. With good management practices, it is possible to cultivate areas under these soils both under wet and dry conditions. The lands in the command are good to very good cultivable lands with moderate erosion. These are suitable for irrigation with moderate limitations due to heavy texture and require drainage.

2.4.3 Geology, Geotechnical, Geophysical & Seismic Investigations

2.4.3.1 Geology

The regional geology of the proposed project site of Kotha barrage constitute a part of basaltic lava flows belonging to the Malwa group of the Deccan Trap Complex comprising low lying hills, hill

clusters, valleys and extensive plains. The general slope is towards northeast as exhibited by the flow of the Betwa river and its tributaries. The proposed project area of Vidisha district fall in seismic zone-I/II. The Betwa River flows in north - northeast direction with about 200m wide channel at project site with steeper bank slopes on either flanks. The outcrops exposed in the river bed of Kotha project site is occupied by different variants of basalt which occur under 2-5 m thick soil cover along the alignment. The basalt is medium to dark grey, vesicular to non-vesicular, fine to medium grained, massive, hard and compact, moderately to highly strong and subjected to weathering to varying depths. Some of the outcrops are suffered with spheroidal weathering with criss-cross veins of secondary silica/zeolite and calcareous material. Besides sub horizontal rolling joints, 3 prominent sets of steeply inclined to vertical joints trending (i) east-west, (ii) NNW-SSE, (iii) NNE-SSW are often present in basalt variants in the project area.

2.4.3.2 Geotechnical assessment

The Betwa river is a monsoon-fed, ephemeral river having a general north-northeast (NNE) direction of flow with an open meandering course near the proposed dam site. In view of the presence of different variants of basalt (vesicular/amygdular, massive/dense, non-vesicular and fragmentary) in the river bed, the proposed barrage site of Kotha project appear to be suitable for the proposed structure. The location and alignment of the structure appear to be geotechnical favorable in view of the absence of significant tectonic features and buried channel. Seismically also the area has a least tectonic disturbance. The bedrock is blocky with 3-4 prominent sets of open to tight and interconnected joints. Joints are oriented both parallel and across to the barrage axis. Large scale leakage through joints is anticipated necessitating the need of sub-surface exploration to quantify the intensity of seepage and also to assess the tentative foundation grade and the depth of grouting for reservoir tightness. Summarised details of sub-surface exploration is given in Annexure 2.4.1 of Volume-II. A pre-construction note on geo-technical investigations of Kotha barrage is given as Appendix: 2.2.1 in Volume-III.

2.4.3.3 Geophysical Investigation

Geophysical investigation at this site was not needed as sub-surface exploration has been carried out by deep drilling at this site as recommended by GSI.

2.4.3.4 Seismicity

Seismo-tectonically, the Bundelkhand–Malwa area is a stable land mass with a history of least tectonic disturbances. The area of the Upper Betwa basin is practically devoid of active lineament, fault or shear. As per the seismic zoning map of India (1990), the proposed layout of the Ken-Betwa link scheme including storage dams/barrages in Upper Betwa falls under seismic zone-II which signifies low seismic events not exceeding magnitude 3 and hence seismo-tectonic hazards would be considered as minimum.

2.4.4 Foundation Investigation

The work of foundation investigations (geotechnical) was carried out through GSI, Bhopal in association with CSMRS, Delhi. Geotechnical assessment of surface and sub-surface data along the alignment of the Kotha barrage gathered through geological mapping (1:2500 scale) of the project area and core logging of 3 exploratory drill holes on left, centre & right flanks (BH-1, BH-2 & BH-3) aggregating to about 64m depth of drilling to precisely assess the subsurface geological condition and water conductivity of bedrocks. Depth of drill holes ranges from 18.25 m to 26.40 m. A geotechnical note on sub-surface exploration of Kotha barrage is enclosed as Appendix: 2.2.2 in Volume-III.

The rock samples were got tested from CSMRS, Delhi and the parameters are appropriately used by CWC in the design of the structure. The test results of rock samples are furnished as Appendix: 2.4.1 in Volume-III.

2.4.4.1 Earth and Rock Fill Dam

Since barrage is proposed, no investigation was required under this sub-head.

2.4.4.2 Barrage

The extent of foundation exploration carried out for the earlier proposal of barrage as per the recommendation of GSI is described in para 2.4.4 above. However, the geotechnical investigation for modified parameters of the barrage as per the recommendations of CWC visit to site during Nov. 2013 is to be reviewed in consultation with GSI at next stage of the project.

2.4.4.3 Canal and canal Structures

In the earlier proposal of the barrage, the irrigation was proposed by lifting of water from the river gorge pondage of the barrage and no canal and canal structures was proposed. Now due to change in the parameters of the barrage as per the recommendation of CWC, two main canals of length 39 km and 44 km offtaking from left and right bank of barrage respectively have been proposed. The geological mapping and geotechnical investigations for canals and CD/CM structures will be carried out in next stage.

2.4.5 Geo-technical Investigations and Borrow Area (soil) Surveys and Construction Material Investigations

2.4.5.1 Soils

The proposed barrage which will be a masonry/concrete structure, no investigations for borrow areas were carried out. However, borrow area survey for newly proposed canals and canal structures not done at this stage is proposed to be carried out in due course of time.

2.4.5.2 Sand

The CSMRS, New Delhi carried out construction material survey and laboratory investigations of sand samples for their use as fine aggregate in concrete during construction of the project for Kotha barrage. The adequacy of fine aggregate for construction of proposed canals and CD/CM structures is to be reviewed at next stage of the project. The test results of the above sand samples are furnished as Appendix: 2.4.2 in Volume-III.

2.4.5.3 Rock and Aggregates

The 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 for Kotha barrage. The test results of the above rock samples are furnished as Appendix: 2.4.2 in Volume-III.

2.4.5.4 Bricks & Tiles

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

2.4.5.5 Pozzolona

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

2.4.5.6 Cement /Lime Stone

Deposits of lime stone in small quantities are found in Raisen (near Sanchi) and Vidisha districts in Upper Betwa sub-basin.

2.4.5.7 Cement and Steel

The requirement of cement for the construction of the project can be brought from nearest cement plants located at Narasingharh (Damoh), Banmore (Gwalior) of M.P state to the nearest railhead i.e., Ganj Basoda. Similarly, the steel requirement of the project can be brought from steel plant located at Mandideep near Bhopal and Bhilai steel plant located in Chhattisgarh state.

2.4.5.8 Scarce Materials

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

2.4.5.9 Any Other Material

There has been adequate material 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 stores/stack yards all along the canal and from there these will be conveyed to the site with minimum lead.

2.4.6 Hydrological and Meteorological Investigations

2.4.6.1 Rainfall and Runoff

9 rain gauge stations located in and around the Upper Betwa basin have been considered for hydrological studies at Kotha barrage site. The nearest rain gauge station is located at Raisen. The normal monthly rainfall data shows that this station receives 92% of its total rainfall during the south west monsoon period (June to September). The maximum rainfall occurs during August (493.9 mm) and the minimum rainfall occurs during April (1.2 mm). The annual normal rainfall is 1208.8 mm are furnished in Annexure-2.1.5 and Annexure-2.2.2 of Volume-II.

2.4.6.2 Sunshine, Cloud Cover and Visibility

The cloud cover is varying from 0.9 oktas to 6.1 oktas in the Kotha barrage area. The highest cloud cover is experienced in the month of August. The monthwise cloud cover of Raisen IMD observatory is furnished in Annexure 2.2.2 of Volume-II.

2.4.6.3 Wind and Cyclones

The wind velocities in Kotha barrage area varies from 2.3 km/hr to 10.4 km/hr. The monthly wind velocities of Raisen IMD observatory are furnished in Annexure 2.2.2 of Volume-II.

2.4.6.4 Humidity

The maximum and minimum mean monthly relative humidity varies from 23% (April) to 88% (August). The values of monthly relative humidity of Raisen IMD observatory are furnished in Annexure 2.2.2 of Volume-II.

2.4.6.5 Temperature

The climate of the Kotha barrage area is characterized by hot summer and mild winter. The daily maximum and minimum temperature varies from 7°C to 41.9 °C. The monthwise daily maximum and minimum

temperatures of Raisen IMD observatory are furnished in Annexure 2.2.2 of Volume-II.

2.4.6.6 Discharge

No gauge and discharge site is available in the vicinity of Kotha barrage site. Gauge and Discharge data being observed by CWC at Basoda on river Betwa have been collected and the same have been utilized in hydrological study carried out for this project.

2.4.6.7 Sedimentation

There is no silt observation site located at proposed Kotha barrage being a barrage.

However, a nearby silt observation site, has been established by NWDA at Neemkheda G&D site, located 7 km d/s of Makodia dam (now dropped) site on Betwa river and observation started w.e.f. 25.07.2007. This site is closed now.

2.4.6.8 Water quality

The results of the water quality samples taken at the proposed Neemkheda barrage located u/s of the Kotha barrage site & tested at water quality testing laboratory of CWC, Bhopal could be well used for this site also. The result are enclosed in Annexure :2.4.2 of Volume-II.

2.4.6.9 Evaporation

There is no pan evaporimeter installed near the Kotha barrage site. The monthly evaporation values computed at Raisen IMD observatory has been used for the hydrological study and the same are furnished in Table 2.2 above.

2.5.1 Kesari Barrage

The Kesari barrage is proposed near Ditholi village of Basoda tehsil in Vidisha district across Keotan river, a tributary of Betwa river. The value of the GTS BM located at North stone curb of a pakka well about 150 feet North of Bareth railway station, has been connected by double levelling to the Permanent Bench Mark(PBM) established by NWDA near Kesari barrage axis.

2.5.1.1 River

The following topographical surveys were carried out along/across the river course.

a) L-section u/s

Levels were taken on the Keotan river at an interval of 50 m by single levelling. The levels were taken up to pond level+1 m i.e. 407 m (406+1m) for back water effect. The total length of the L-section including tributaries, nalla etc. covers 39.90 km.

b) L-section d/s

The levels were taken upto 10 km from the axis of barrage at 50 m interval. The L-Section of Keotan river is plotted in scale 1:5000 H and 1:200 V and is given as Plate: 2.5.1 and appended in Volume-V (Part-1).X-section u/s

The x-sections of Keotan river including its tributaries were taken at every 200 m interval for a distance of 2 km from the axis of barrage and thereafter at every 500 m interval upto a distance corresponding to the level of 407 m to cover the maximum water level covering all topographical features in between of each x-section. The total length of the cross-section comes to 225.7 km.

c) X-section d/s

The river x-section at every 200 m interval up-to HFL + 1 m on either side of the firm bank and upto 5 km from the axis of the barrage were taken. The total length of the x-section comes to 45.20 km. The cross section of Keotan river is plotted in scale 1:5000 H and 1:500 V and is shown as Plate:2.5.2 and appended in Volume-V (Part-1).

2.5.1.2 Reservoir

The submergence survey of Kesari barrage has been carried out on the line of river survey as the barrage will be constructed within the gorge portion of river and accordingly the cross-section of the river will be restricted up to pond level + 1 m or 1 km on either side of the firm bank of river whichever is less. X-sections were taken at 200 m interval for a

distance of 2 km and thereafter at 500m interval corresponding to the length of L-section in the upstream of axis of the structure.

The above survey data has been utilized for preparing submergence area plan in the scale of 1:10000 at 1 m contour interval and the reservoir storage capacity has been assessed and adopted in the studies. The contour plan of the Kesari barrage/pondage area is given at Plate:2.5.3 in Volume-V (Part-1).

2.5.1.3 Headworks

The Kesari barrage is situated on Keotan river near Ditholi village of Basoda tehsil of Vidisha district. 1.775 km length of Kesari barrage axis has been surveyed by NWDA including 0.170 km extension. Block levelling for the Kesari barrage axis has been carried out by single levelling at 50 m or less grid interval. The cross-sections along the barrage axis were taken at 50 m interval by taking levels upto 1000 m on upstream side as per the topographical condition of the site and 500 m on downstream side. The contour plan of barrage axis was prepared on 1: 5000 H and 1:200 V scale with contours at 1 m interval. The same has been utilized for preparing the layout plan, L-section along the barrage axis, etc. The contour plan of the head works area of Kesari barrage is given as Plate: 2.5.4 in Volume-V (Part-1).

2.5.1.4 Plant and Colony Layout

For Kesari barrage site, the plant & colony area site has been proposed to be located on the left bank of the river near village Ditholi in the forest area. Grid survey for 60 ha. of plant and colony area at 50 m grid interval has been completed in the month of May 2008. However, in case forest land could not be procured, private land is proposed to be acquired to construct the above colonies. For pumping station, the site can be located in the upstream of barrage. Colony area is also proposed near town Raisen for main canal construction. Detailed survey has yet to be carried out for these colony areas. Locations of the identified plant & colony areas are shown at Plate:2.5.5 in Volume-V (Part-1).

2.5.1.5 Canal and Water Conductor System and Canal Structures

Water from the pond is proposed to be lifted by 9 m from RL 401 m to 410 m through a 2.90 km long pipeline into a proposed fore bay reservoir near village Amera, Basoda tehsil in Vidisha district. Thereafter, a gravity canal of 9.650 km long with FSL at 409.50 m is proposed to run towards Udaipur town in the northern direction to the terminal point at Chakra nala near village Barwasa, Basoda tehsil in Vidisha district. Marking of the alignment was done by fixing centre line pillars at about 200 m interval. Concrete 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 was carried out and the elevations of the main canal alignment at every 100 m interval were found out. The cross sections of main canal were taken at every 200 m interval by single levelling. The contour plans of the alignment have been prepared in 1:5000 H and 1:200 V scale and 1:100 V scale with 1m contour interval. Longitudinal sections and contour plans (7 Nos.) have been prepared and are shown as Plate:2.5.6 in Volume-V (Part-1).

About 22 cross drainage/masonry structures are coming across 9.650 km long canal. Among them, 2 are major structures for which surveys have been carried out. List of major canal structures are given in Annexure: 2.5.1 of Volume-II.

Grid survey at 50 m or less interval depending on the slope of land was carried out at canal structure site to cover an area up to 300 m on either side of the centre line of the canal, upto 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 the grid surveys. Cross sections of the drain have also been taken along the centre line of the canal and plotted on a scale of 1: 5000 H & 1:200 V. The grid surveys, L.S. & C.S. of canal structures across Right Bank canal of Kesari barrage is furnished as Plate: 2.5.7 in Volume-V (Part-1).

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.

2.5.1.6 Powerhouse, Switchyards, Surge-shaft, Tailrace, etc.

There is no power component proposed in Kesari barrage and its canal.

2.5.1.7 Command Area Survey

The CCA under the Kesari barrage will be 1478.50 ha with an irrigation intensity of 120%. The sample command area survey has been done for about 10% of the CCA along the base line with cross-section at an interval of 50 m grid. The map for the surveyed area is given as Plate: 2.5.8 in Volume-V (Part-1).

The purpose of the sample command area survey is to assess the rate per hectare on development of command area of the project. The command area map is plotted in the scale of 1:10000 at a contour interval of 1.0 m and for OFD works the same is plotted in the scale of 1:1000 at a contour interval of 0.25 m.

2.5.1.8 Soil Conservation

M/s Agricultural Finance Corporation Ltd., Hyderabad has been assigned the Rapid EIA, EMP, SIA and R&R study of Kesari barrage. In order to contain soil erosion in the catchment and reduce the silt being carried out by the rivers and streams leading to Kesari barrage, soil conservation measures would be taken as suggested by the consultant. Like wise, in the command area of Kesari canal, 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 suggestion of the consultant. Necessary provision for this work has been kept in the project estimate.

2.5.1.9 Any other

Nil

2.5.2 Other Allied Surveys

2.5.2.1 Archaeological surveys in the reservoir area

It has been ascertained from the list of sites of archaeological, historical and cultural importance maintained by the Archaeological Survey of India and Department of Archaeology, MP that none of them lies within the pond area of Kesari barrage as well as along the canals.

2.5.2.2 Mineral, (useful and harmful) Surveys in the Catchment and Reservoir Areas

As ascertained from the Mining department, Govt. of Madhya Pradesh, no minerals of economic importance are present in the pond area of Kesari barrage and its vicinity as well as enroute its canal. Letter is enclosed at Annexure-2.1.3 of Volume-II.

2.5.2.3 Right of Way Surveys for the Reservoir

The submergence area under Kesari barrage will be mostly restricted to the river portion as the barrage will be constructed within the gorge portion of river. As such, there is no requirement to provide any right of way to any structure.

2.5.2.4 Communication Surveys

The Kesari barrage is proposed near Ditholi village of Basoda tehsil in Vidisha district. The barrage site is about 11 km from Basoda, which is the nearest railway station. The Bhopal-Raisen-Sanchi National Highway (NH-86) and the railway line connecting Bhopal and Delhi pass near to the project area. The nearest airport is at Bhopal situated at about 110 km from the dam site. Map showing communication network of project enclosed plate 2.2.6 in Volume-V (Part-1).

The command area under Kesari canal is well approachable from NH-86 and other district roads. All the villages in the vicinity of Kesari barrage, its canal and command area are 100% electrified. Also, suitable provision is made for communication surveys for laying telephone lines etc. in the project estimate.

2.5.2.5 Drainage Surveys

The command area under the Kesari barrage canal is drained by a network of small rivers/ nallahs. The command has good draining facilities. However, with the introduction of irrigation, as the command area develops, drainage problem may crop up in course of time. Suitable provision is, therefore, made in the project estimate towards chak and collecting drains in the command area.

2.5.2.6 Soil Surveys

On the basis of a map prepared for Upper Betwa sub-basin from National Atlas of India (1982), and based on the information provided by the National Bureau of Soil Survey and Land Use Planning (NBSS & LUP), Nagpur/Delhi, the command area is covered with medium black soils. These soils are fine textured and are suitable for cultivation. With good management practices, it is possible to cultivate areas under these soils both under wet and dry conditions. The lands in the command are good to very good cultivable lands with heavy soils. These are suitable for irrigation with moderate limitations due to heavy texture and require drainage.

2.5.3 Geology, Geophysical & Seismic Investigations

2.5.3.1 Geology

i) Local Geology

The Kesari barrage site is located in the upper reaches of Betwa river which is characterized by typical pineplained topography comprising extensive plains, shallow valleys with gentle bank slopes and low lying hills. The river mostly flows south to north with dendritic to subdendritic pattern. The density of drainage is low to moderate. The barrage site area is more or less flat with rolling undulations on both the flanks of the Keotan river. The barrage alignment in general has soil/alluvial cover consisting of dark grey, silty-clayey residual soil, sandy-silty loam, concretionary yellow soil and regolith in addition to river borne unconsolidated to semi consolidated sediments of sands, kankers, boulders etc.. Sporadic outcrops of grey to light brown, fine grained, highly vesicular and amygdular basalt are observed in the Keotan river bed.

ii) Geotechnical Assessment

Pre-construction stage geotechnical investigation to evaluate the geological set up and site conditions of the proposed location of barrage in Upper Betwa was carried out by GSI, Bhopal in 2006. According to GSI, the location of proposed barrage near Kesari is suitable and geotechnically favourable as the site is devoid of active lineament, fault or shear. Seismically also, the area has not experienced any major geological event in the recent past. Further, in view of the occurrence of bed rock in the Keotan river section, the proposed barrage site appears to be geotechnically suitable for masonry/concrete structures. Abutments, however, are not firm which may otherwise restrict the length of the structure. Summarised details of sub-surface exploration of Kesari barrage is given in Annexure: 2.5.2 of Volume-II.. A preconstruction note on geotechnical investigations is given in Appendix: 2.3.1 of Volume-III.

iii) Geophysical Investigation

No Geophysical investigation could be carried out in respect of Barari barrage site at DPR stage due to delay in finalisation of the site by M.P State Govt.

2.5.3.2 Seismicity

Seismo-tectonically, the Bundelkhand –Malwa area is a stable land mass with a history of least tectonic disturbances. The area of the Upper Betwa basin is practically devoid of active lineament, fault or shear. As per the seismic zoning map of India (1990), the proposed layout of the Ken-Betwa link scheme including storage dams/barrages in Upper Betwa falls under seismic zone-II which signifies low seismic events not exceeding magnitude 3 and hence seismo-tectonic hazards would be considered as minimum.

2.5.4 Foundation Investigations

The work of foundation investigations (geotechnical) was carried out through GSI, Bhopal in association with IIT, Delhi. Geotechnical assessment of surface and subsurface data along the alignment of the Kesari barrage gathered through geological mapping (1:2500 scale) of the project area and core logging of one exploratory drill hole to a depth of 30.2 m to

precisely assess the subsurface geological condition and water conductivity of bedrocks. A geotechnical note on sub-surface exploration of Kesari barrage is enclosed as Appendix: 2.3.2 in Volume-III.

The rock samples were got tested from IIT, Delhi and the parameters are appropriately used in the design of the structure. The test results of rock samples are furnished as Appendix: 2.3.3 and Appendix 2.5.1 in Volume-III.

2.5.4.1 Earth and Rock fill Dam

Since barrage is proposed, no investigation is required under this sub-head.

2.5.4.2 Barrage

A barrage of 1.775 Km long is proposed on Keoton river near Ditholi village viz., Kesari barrage. The extent of foundation investigations carried out are mentioned in para 2.5.4 above.

2.5.4.3 Canal

Subsurface exploration of the major canal structures across Kesari right bank canal was carried out by GSI, Bhopal in association with IIT, Delhi. Two drill holes had been drilled at different chainage points along the axis of CD structures to precisely assess the subsurface geological condition. The depth of exploratory drill holes are 16.50m and 20.30m. A geotechnical note on sub-surface exploration of Kesari right bank canal is included in Appendix: 2.3.2 of Volume-III.

2.5.4.4 Power House, Tunnels, and Canal Structures

No Power House and tunnel are proposed under Kesari barrage and its canal.

2.5.5 Geo-technical Investigations and Borrow Area (soil) Surveys and Construction Material Investigations

2.5.5.1 Soils

As a barrage is proposed at Ditholi village (Kesari barrage) which will be masonry/ concrete structure, no investigations for borrow area were carried out. The work of borrow area soil investigations for the

proposed Kesari canal was carried out through CSMRS. Representative bulk soil samples from potential borrow areas in the vicinity of the canal were collected by CSMRS in September, 2008 and investigations carried out in its laboratory to characterize the collected borrow area materials for their suitability in the construction of the canal. Test results of soil samples collected from Kesari right bank canal is included in Appendix: 2.3.4 of Volume-III.

2.5.5.2 Sand

The CSMRS, New Delhi carried out construction material survey and laboratory investigations of sand samples for their use as fine aggregate in concrete during construction of the project. Fourteen sand samples were collected from different sand quarries and the physical tests viz. specific gravity, grading and fineness modulus, silt and clay content, 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. It was found that the sand samples collected from the following quarries were suitable for use in concrete either directly or mixed with finer sand to improve their Fineness Modulus.

1. Barari barrage sand quarry
2. Khambu Khedi sand quarry
3. Keotan sand quarry
4. Neemkheda(Rong Prua) sand quarry
5. Betwa Navidiya sand quarry

The test results of the above sand samples are already furnished in Appendix: 2.2.4 of Volume-III.

2.5.5.3 Rock and Aggregates

The 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. Eighteen 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. Accordingly, the following rock quarries were found suitable for use in wearing & non-wearing surfaces.

1. Sumer Rock Quarry
2. Betwa Barri Ghat Rock Quarry
3. Kanajna Rock Quarry
4. Ruber Yai village Rock Quarry
5. Nateran Kherra Rock Quarry

The petrographic examination carried out by GSI, Faridabad & Lucknow through CSMRS 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 already furnished in Appendix: 2.2.4 of Volume-III.

2.5.5.4 Bricks, Tiles

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

2.5.5.5 Pozzolona

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

2.5.5.6 Cement/Lime Stone

Deposits of lime stone in small quantities are found in Raisen (near Sanchi) and Vidisha districts in Upper Betwa sub-basin.

2.5.5.7 Cement and Steel

The requirement of cement for the construction of the project can be brought from nearest cement plant located at Narasiggarh (Damoh) and Banmore (Gwalior) in M.P state. The approximate distance works out to about 350 km to the nearest railhead i.e Bhopal. Similarly, the steel requirement of the project can be brought from Steel plant located at Mandideep near Bhopal and from Bhilai steel plant located in Chhattisgarh state. The approximate distance to the nearest rail head i.e., Bhopal is 670 km.

2.5.5.8 Scarce Materials

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

2.5.5.9 Any Other Material

There has been adequate material 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 stores/stack yards all along the canal and from there these will be conveyed to the site with minimum lead.

2.5.6 Hydrological and Meteorological Investigations

2.5.6.1 Rainfall and Runoff

9 rain gauge stations located in and around the Upper Betwa basin have been considered for hydrological studies of Kesari barrage site. The nearest rain gauge station to the dam site is Raisen. The normal monthly rainfall data shows that this station receives 91% of its total rainfall during the south west monsoon period (June to September). The maximum rainfall occurs during August (493.9 mm) and the minimum rainfall occurs during April (1.2 mm). The annual normal rainfall is 1208.8 mm are furnished in Annexure: 2.1.5 and Annexure: 2.2.2 of Volume-II.

2.5.6.2 Sunshine, Cloud Cover and Visibility

The cloud cover is varying from 0.9 oktas to 6.1 oktas in the Kesari barrage area. The highest cloud cover is experienced in the month of August. The monthwise cloud cover of Raisen IMD observatory is furnished in Annexure 2.2.2 of Volume-II.

2.5.6.3 Wind and Cyclones

The wind velocities in Kesari barrage area varies from 2.3 km/hr to 10.4 km/hr. The monthly wind velocities of Raisen IMD observatory are furnished in Annexure 2.2.2 of Volume-II.

2.5.6.4 Humidity

The mean monthly relative humidity varies from 23% (April) to 88% (August). The values of monthly relative humidity of Raisen IMD observatory are furnished in Annexure 2.2.2 of Volume-II.

2.5.6.5 Temperature

The climate of the Kesari barrage area is characterized by hot summer and mild winter. The daily maximum and minimum temperature varies from 7.0°C to 41.9°C. The monthwise daily maximum and minimum temperatures of Raisen IMD observatory are furnished in Annexure 2.2.2 of Volume-II.

2.5.6.6 Discharge

No gauge and discharge site is available in the vicinity of Kesari barrage site. One Gauge & Discharge site was opened at Kesari barrage site on Keoton and observations were started from 01.10.2006. The site is closed now.

In addition to the above, Gauge and Discharge data being observed by CWC at Basoda on river Betwa have been collected and the same have been utilized in hydrological study carried out for this project

2.5.6.7 Sedimentation

Being a barrage, no sediment calculation is done.

However, a silt observation site, has been established by NWDA at Neemkheda G&D site, located 7 km d/s of Makodia dam (now

dropped) site on Betwa river and observation started w.e.f. 25.07.2007. This site is closed now.

2.5.6.8 Water quality

Facility for water quality testing is not available with NWDA. So, the results of the water quality samples taken at the proposed Neemkheda barrage located u/s of the Kesari barrage site & tested at water quality testing laboratory of CWC, Bhopal could be well used for this site also. The result are enclosed in Annexure : 2.4.2 of Volume-II.

2.5.6.9 Evaporation

There is no pan evaporimeter installed near the Kesari barrage site. The monthly evapotranspiration values computed at Raisen IMD observatory has been used for the hydrological study and the same are furnished in Table 2.2 above.