Annexure-II (Part 1 of 2) 163

MINUTES OF 2nd MEETING OF THE EXPERT APPRAISAL COMMITTEE FOR ENVIRONMENTAL APPRAISAL OF COAL MINING PROJECTS CONSTITUTED UNDER THE EIA NOTIFICATION, 2006, HELD ON 28-29th SEPTEMBER, 2020.

DAY 1- Thursday, 28th September, 2020

Confirmation of the Minutes of 1st Meeting of the EAC (Coal) held on 17-18th August 2020: No comment was made from members of the committee on the minutes of the 1st meeting of the EAC held on during 17-18 August, 2020, therefore the Minutes of the Meeting (MoM) of 1st meeting was confirmed.

Opening Remarks of the Chairman: At the outset, the Chairman welcomed the Expert members & other participants and requested to start the proceeding as per the agenda adopted for this meeting.

Consideration of Proposals: The 2nd meeting of the Expert Appraisal Committee (EAC) for coal mining projects was held on 28-29 September, 2020 through video conferencing with support NIC team due to Covid-19 lockdown. The EAC considered proposals as per agenda adopted for the meeting. List participant attended the meeting is annexed. The details of deliberations held & decisions taken in the meeting are as under.

Agenda No. 2.1

Gare Palma Sector -II Coal mine Project of 23.60 MTPA (OC-22.0 MTPA+UG-1.6 MTPA) of M/s Maharashtra State Power Generation Company Limited (MSPGCL) in an area of 2583.48 ha in District Raigrah (Chhattisgarh) – For Environment Clearance - reg.

[IA/CG/CMIN/52019/2016; File No J-11015/72/2016-IA.II(M)]

The proposal is for Environment Clearance for Gare Palma Sector II Coal Mine Project of Open Cast 22.0 MTPA + Under Ground-1.6 MTPA capacity in mine lease area of 2583.48 ha of M/s Maharashtra State Power Generation Company Ltd (MSPGCL) located in village-Tihli Rampur, Kunjemura, Gare, Saraitola, Murogaon, Radopali, Pata, Chitwahi, Dholnara, JhinkaBahal, Dolesara, Bhalumura, Sarasmal and Libra, Tehsil-Gharghoda, District- Raigarh, (Chhattisgarh).

2.1.1 The EAC noted the followings: -

The proposal was earlier considered by the sectoral EAC in its 51st EAC meeting held on 5th December, 2019, wherein the Committee deferred the proposal for want additional information. Now, the PP has submitted the replies/compliance to observations of EAC, which is tabulated below: -

MAHARASHTRA STATE POWER GENERATION CO LTD. Executive Director (E&S) Mumbai

Sr. No.	Observations of EAC in 51st EAC meeting	Compliance / replies of Project Proponent
1	The EIA report to be revised as per the terms of reference granted for the project, and shall conform to Appendix III of the EIA Notification, 2006.	EIA report has been revised as per the terms of reference granted for the project and as per Appendix III of the EIA Notification 2006 and subsequent EAC meetings observations
2	Stage-I FC for forest land of 214.869 ha for diversion of non-forestry activity shall be submitted.	▪ Application for obtaining forest clearance submitted vide letter dt 26.07.2016, proposal no FP/CG/MIN/20495/2016. ▪ All requirements with regards to FC stage 1 application is completed, except CA land identification. ▪ All activities in processing the application for grant of FC Stage-I has been completed and the relevant documents has been submitted to DFO office on 16.05.2020. File will be recommended by DFO to CCF shortly for further onwards approval
3	Form#2 on Parivesh should be filled with all details and correct information	Form#2 on Parivesh has been filled with all details and correct information and updated in Parivesh portal.
4	Copy of Agreement for supply of power shall be uploaded on Form#2	Chhattisgarh State Power Distribution Co. Ltd., Raipur vide its Letter No. 02-02/SE (HT)/RGH-327/373 dt 29.05.20 has agreed to provide 23 MVA power supply (Annexure 2 of EIA Report)
5	Approval of Wild Life conservation from concerned statutory authorities	Wildlife conservation plan submitted (Annexure 3 of the EIA Report) to DFO on 14.11.2019. DFO recommended the WCP to CCF on 24.01.2020 CCF recommended the WCP to PCCF on 20.02.2020 (Annexure 4 of the EIA report). The WCP report is enclosed as Annexure 24 of the EIA report. The budget of Rs 488.50 Lakhs for conservation of wild life is provided during the period of 5 years (2020-21 to 2025-26).
6	One month of baseline data as the given data is almost 3 years old and validity of baseline data is about to expire as per Ministry's OM shall be collected	Additional 3 months baseline data (Nov 2019 to Jan 2020) has been collected and the same is incorporated in the revised EIA report
7	Hydrological Study and impact of mining activity on hydrology shall be	Hydrology study and embankment design was carried out by Min Mec Consultancy Pvt Ltd., New

MAHARASHTRA STATE POWER GENERATION CO. LTD. Executive Director (E&S) Mumbai

	submitted from the expert agency	Delhi The report is at Annexure 5 in the EIA report
8	Permission for extraction of groundwater from CGWA shall be obtained	NOC for ground water abstraction obtained from CGWA, New Delhi Vide Lr no. CGWA/NOC/MIN/ORIG/2020/7943 dated 03.07.2020. The sanctioned water quantity is **1454 m3/day** (Annexure 6 of EIA report)
9	Permission for usage for surface water i.e. from kelo river (as proposed for intial 3 years) for mining operation/domestic purposed shall be obtained from concerned statutory authority	➢ Application for construction of annicut for water withdrawal from Kelo River submitted to Executive Engineer on 23.01.2020 (Annexure 8 of the EIA Report) and request for water availability was submitted on 26.05.2020 ➢ Executive Engineer, Kelo Pariyogna Sarvekshan Sambhag, Raigarh, approved the same on 26.05.2020 (Annexure 9 of the EIA Report). ➢ Executive Engineer also confirmed that 6000 m^3/day water is available for MAHAGENCO.
10	Carrying capacity of the area shall be carried considering the presence of the other coal mines and mitigation measures shall be proposed accordingly.	▪ Carrying capacity study of the area has been carried out for Gare Palma Sector II coal mine and its surroundings. ▪ There are 14 coal mines and 2 Thermal Power Plants in the study area ▪ In all, 6 coal mines are in operation, 4 coal mines are not working and 4 coal mines are proposed and 2 TPPs are in operation.
11	Mining Lease or Letter of Intent for the project area shall be submitted by PP from concerned state government authorities.	➢ Mining lease application submitted on 08.12.2015 (Annexure 11 of EIA Report), ➢ Ministry of Coal has granted previous approval for mining lease vide its letter dated 20.02.2018 (Annexure 12 of the EIA Report). ➢ Further, State Government has issued Letter of Intent for mining lease vide letter dated 24th February 2020. ➢ Lease agreement will be executed after obtaining EC/FC from MOEF&CC as mentioned in letter of State Government dated 24th February 2020.
12	Compliance of issues raised during Public Hearing shall be submitted with certain timeline and allocation.	Compliance of issues raised during Public Hearing were addressed adequately.
13	Social Impact Assessment Study for	➢ Social Impact Assessment report for the

	the proposed displacement of Tribals/SC/ST.	proposed displacement of Tribals/SC/ST prepared by Greencindia Consulting Private Limited (Annexure 13 of the EIA Report) ➢ R & R plan based on SIA report is approved by Chhattisgarh Government vide letter dated 06.03.2020 (enclosed approval Letter Annexure 13a of the EIA Report). ➢ The mine lease area is falling under 14 villages and out of which 8 villages are going to be displaced and the other 6 villages/settlements/habitations are not going to be displaced (only land area is affected partially). ➢ Project Displaced population (PDP) and project affected population (only land oustees) is 7063 & 2574 respectively out of this 55.81% & 47.92% are ST and 8.15% & 4.01% are SC respectively. ➢ R&R package towards land cost payment is Rs 2435 Crores, however R&R entitlement and cost will be finalized by the District Administration
14	Impact of mine drainage and diversion of nallah based on quality and quantity (inflow of river).	Impact of mine drainage and diversion of nallah based on quality and quantity is covered in Hydrology study and embankment design report prepared by Min Mec Consultancy and enclosed as Annexure 14 of EIA ➢ Kelo river will not be diverted due to the prevailing topography, shape of the block and presence of other coal blocks all around. ➢ Flow in Kelo river, reduction is 0.8%, low impact is envisaged on downstream water balance.
15	Details of hazardous waste generation (if any) during mining operations and further handling/disposal shall be provided in details.	The major types of hazardous waste and biomedical waste generated from the proposed mining activities are as follows. ➢ Hazardous wastes like used oil barrels, waste oil barrels, used transformer oil barrels, scrapped batteries, empty oil and grease drums shall be handled and disposed off in accordance with the procedure laid down in HWM Rules. ➢ Used oil, spent oil, batteries shall be disposed-off to the recyclers having valid registration from CPCB/CECB for recycling

		or recovery. Empty oil & grease barrels shall be detoxified prior to their disposal to outside agencies
16	Impact on villages due to mining activity present in core zone (not proposed to be displaced) shall be provided.	Anticipated impacts on the surrounding villages (present in vicinity of Mine Lease Area) and mitigation measures has been submitted during presentation
17	The activities and fund provisions for CER shall be made as per the guidelines issued by the ministry regarding CER on 1st May, 2018.	Project cost is Rs. 7463 Crores CER budget proposed is Rs 45.35 Crores as per the MoEF&CC OM dt 1st May, 2018
18	Clarification from DFO/PCCF whether there is any presence of Elephant Corridor or movement of elephants in the region.	➢ DFO clarified that there is no presence of Elephant Corridor for movement of elephants in the project area (letter dated 05.03.2020.) ➢ As per DFO letter movement of elephants is approximately 6 km away from the project boundary
19	Impact of mine drainage on kelo river shall be submitted in detail.	➢ The core area (coal block) has two catchments, western side of Kelo river is catchment area of **Nala "A"** tributary to Pajhar Nadi , eastern side of Kelo river is Karnara Nala coveys storm water from hills on eastern side to Kelo river. ➢ Based on the annual flood peak series of Kelo river observed at Kelo G&D station (Latitude 21°53' 47", longitude 83°24'22") the flood peaks of Kelo with return period of 50 yrs and 100 yrs have been estimated using statistical method i.e. flood frequency method and the values of the flood peaks works out as 1357 cumecs and 1522 cumecs, respectively and peaks are increased by an order of 10% for embankment. The 50 years and 100 years return period peaks thus work out as 1493 cumecs and 1674 cumecs respectively.
20	Detailed Traffic impact assessment/ study for road transportation of coal to linked Railway Siding / Power Plant shall be conducted	➢ In case of the development of Bhalumuda station of CERL as well as extension of railway connectivity to GPII block gets delayed, the mined coal shall be transported from mine to nearest operational railway head by road and from there by rail to Koradi Thermal Power

		Station. ➢ At present the nearest operational Railway siding is Gharghoda station of CERL. Gharghoda Railway siding has been notified and opened for Rail traffic on 21.02.2020. ➢ From GP-II mine by road distance of Gharghoda siding is about 35 Kms. ➢ The access will require developing of about 4 Kms within Mine road to touch the Milupara-Tamnar ODR. ➢ The route to Gharghoda Railway siding is GP-II Mine-Gare-Hukradipa-Tamnar-Punjipatra-Bhalumuda- Gharghoda by-pass-Gharghoda siding. ➢ The entire road is two way black top road in good condition. The Coal transportation trucks already ply via this road. ➢ The traffic studies have been conducted to know the prevailing traffic volumes on the existing roads. ➢ The existing baseline scenario of NOx levels are 36 $\mu g/m^3$. After implementation of project,, the predicted contribution of NOx is 8.3$\mu g/m^3$ and future predicted baseline value of NOx is 44.3$\mu g/m^3$ which is within the prescribed standards. ➢ The existing baseline scenario of CO levels is recorded 2700 $\mu g/m^3$. After addition of predicted traffic the predicted line source values is 2.7 $\mu g/m^3$ and the future predicted baseline value is 2702.7 $\mu g/m^3$. Which is within the prescribed standards (4000 $\mu g/m^3$-One hour) . ➢ However, Incremental air emissions are limited only upto a stretch of 30 m on either side of the approach road. The transportation/evacuation of coal during initial years will be via roadways, once the railway line completed, then the 100% coal evacuation will be done through rail only

2.1.2 During deliberations on the proposal, the Committee also noted the following: -

The proposal is for Environment Clearance for Gare Palma Sector II Coal Mine Project of Open Cast 22.0 MTPA + Under Ground-1.6 MTPA capacity in mine lease area of 2583.48 ha by M/s

Maharashtra State Power Generation Company Ltd (MSPGCL), which is located in 14 villages namely Tihli Rampur, Kunjemura, Gare, Saraitola, Murogaon, Radopali, Pata, Chitwahi, Dholnara, JhinkaBahal, Dolesara, Bhalumura, Sarasmal and Libra at Tehsil Gharghoda, District-Raigarh, (Chhattisgarh).

The Public Consultation of project was conducted on 27.09.2019 at Dolesara village, Tamar Tehsil, Raigarh District Chhattisgarh at the premises of Government Primary school. The public hearing was held under the chairmanship of Shri R.A. Kuruvanshi, Additional District Magistrate Raigarh, Chhattisgarh who was nominated by District Collector, Raigarh.

The issues raised during consultation were on local employment, tree plantation, medical facility, education and providing water supply to locals, etc. Response to concerns raised by public has been addressed adequately and PP committed to provide the facilities to locals. The company committed to comply all these concerns for locals by year 2020-26. However, Committee also noted that Report of Indian Council of Medical Research (ICMR) health assessment and project of health of people living in Tamnar Block is yet to competed.

The committee also deliberated the overall impact of proposed mines with cumulative impact of surrounding mines and Thermal Power Plants. Out of total 14 coal mines in Gare Palma Sector –II, only 6 coal mines are in operation, 4 are not functional at present and 4 coal mines are proposed and 2 thermal Power Plants are in operation. The AAQ data was collected from year 2011 to 2019 from various secondary sources and additional one-month data as requested in earlier meeting of EAC. The maximum particulate matter PM10, PM2.5 SOX were found to be in range of 49.5 µg/m3 to 80 µg/m3; 54 µg/m3; 10.5 to 40 µg/m3 in that order respectively. The existing average baseline value of NOx levels is 36 $\mu g/m^3$. After implementation of project, the predicted contribution of NOx is 8.3$\mu g/m^3$ and future predicted baseline value of NOx is 44.3$\mu g/m^3$ which will be within the prescribed standards. With regard to impact of air emission due to transportation of coal to nearest railway station, the Committee, however, noted that incremental air emissions are limited only to stretch of 30 m on either side of the approach road and in this context, PP has conducted the traffic study.

The Committee also took a note of additionality of coal washery operation in the proposed project, though this was not part of TOR granted by MoEF&CC. In this regard, the Committee directs the Project Proponent to submit separate proposal for Coal Washery. However, changes occurring after separating this activity need recalculation, e.g. water requirement, etc. and PP asked to submit in due course.

As per the submission, total water required for mining project is 2785 KLD, of which fresh water requirement will be 1785 KLD and 1000 KLD will be recycled water. Out of 1785 KLD of fresh water requirement, a quantity of 1239 KLD will be for consumptive use for colony, village etc. and 546 KLD is for industrial use. The domestic waste water will be treated in STP of 1000 KLD capacity and treated water will be used for plantation and dust suppression measures and vehicle washing. For treating Industrial wastes water from mine seepage, rainwater accumulated in mine pit, two settling ponds of 5 ha each are proposed. Part of treated water will be reused for mining project (dust suppression, vehicle washing, etc.) and remaining excess treated water will

be discharged into Kelo River. Additionally, one ETP of appropriate capacity in line with approved Mining Plan shall also be established for treatment of waste water from Workshop.

In this context, the committee is of the view that project should go for advance treatment technology for STP and ETP so that treated water could be recycled and reused for different purposes including tree planation in nearby area as proposed by PP. No wastewater shall be discharged in to the river. If require, necessary arrangement shall be made to reuse the treated water from STP and ETP to nearby TPP or coal washery /or future coal washery by entering suitable agreement.

Total forest land involved in the Project is 214.869 Ha pending for diversion for non-forestry activity. Permission for Stage-I FC from MoEF&CC is yet to be granted. Application for obtaining forest clearance has been submitted vide proposal no FP/CG/MIN/20495/2016 dated 26.07.2016,

The Committee also noted that project has made adequate arrangements for embankment all along the western and eastern banks of Kelo. The height, free board, alignment and design has been prepared for the bund and given in the "Hydrology Study & embankment Design by M/s Min Mec Consultancy Pv. Ltd." The height of the bund shall vary from 3 m to 10 m. The committee recommends that the PP shall take all care about design of bunds and construction of the same.

2.1.3 *The EAC, after deliberations found responses given by PP are satisfactory and* ***recommended*** *the proposal for grant of Environment Clearance to Gare Palma Sector -II Coal mine Project of 23.60 MTPA (OC-22.0 MTPA+UG-1.6 MTPA) of M/s Maharashtra State Power Generation Company Limited (MSPGCL) in an area of 2583.48 ha in District Raigrah (Chhattisgarh), under the provisions of Environment Impact Assessment Notification, 2006 and subsequent amendments/circulars thereto subject to the compliance of the following terms & conditions / specific conditions: -*

(i) The project proponent shall obtain Consent to Establish/Operate from the State Pollution Control Boards for the proposed peak capacity of 23.60 MTPA (OC-22.0 MTPA+UG-1.6 MTPA) prior to commencement.

(ii) PP shall submit Stage-I FC for forest land involved in the project for non-forestry activity.

(iii) Third party monitoring (by NEERI/CIMFR/IIT/NITs) for air quality shall be carried out at identified locations, both ambient and the process area, to arrive at impact of the proposed expansion.

(iv) Top soil should be stored separately at marked area and necessary vegetation shall be maintained to avoid any entrainment of dust.

(v) All the recommendation of carrying capacity study shall be completed within stringent timeframe.

(vi) PP shall construct embankment leaving 100 mtrs away from HFL of kelo river and the same shall be taken prior approval from DGMS

(vii) Transportation of coal from Coal Handling Plant shall be through mechanized covered trucks for 5 years. No transportation by trucks after 5 years and proposed railway siding should be constructed without any delay.

(viii) As proposed fresh water requirement will be 1785 KLD, which shall be met from Kelo river

initially and later by groundwater. The total industrial water demand (peak) in operation phase shall be met by utilizing treated mine discharge water. If require, necessary arrangement shall be made to reuse treated water from STP & ETP to nearby TPP or coal washery /or future coal washery by entering suitable agreement. No wastewater (treated or untreated) shall be discharged into the river or any other water body

(ix) *All the villages coming under the zone of influence as in hydrology study shall be provided with suitable water supply alongwith sanitation facility.*

(x) *All the recommendation in Social Impact Assessment study shall be complied within stringent timeframe. Timeline should be submitted to District Collector for necessary action points.*

(xi) *Commitment made during public consultation process shall be adhere to. As proposed, Rs. 45.35 Crore is earmarked for CER activities, which shall be accomplished within period of 5 years.*

(xii) *Water quality and Bioassay test of kelo shall be monitored quarterly and submitted to State Pollution Control Board. No water shall be discharged in river.*

(xiii) *Quarterly monitoring of quality of water from bore hole used for drinking purpose shall be conducted and report thereof shall be submitted to SPCB.*

(xiv) *Progressive backfilling of mine and progressive reclamation of OB dump shall be done.*

(xv) *To control the production of dust at source, the crusher and in-pit belt conveyors shall be provided with mist type sprinklers.*

(xvi) *Mitigating measures shall be undertaken to control dust and other fugitive emissions all along the roads by providing sufficient fixed type water sprinklers. Adequate corrective measures shall be undertaken to control dust emissions, which would include mechanized sweeping, water sprinkling/mist spraying on haul roads and loading sites, long range misting/fogging arrangement, wind barrier wall and vertical greenery system, green belt, dust suppression arrangement at loading and unloading points, etc.*

(xvii) *Continuous monitoring of occupational safety and other health hazards, and the corrective actions need to be ensured.*

(xviii) *Permission from State Water Department for diversion of two nalas, one in the west side (Nala A) and one on the East side (Karnara nala) of Kelo river shall be taken before any diversion work. Impact of diversion in terms of availability of water in river shall be studied before diversion and submitted to State Water Department.*

(xix) *PP shall take permission of State Public Works Department before the proposed for diversion Roads from Bajamura to Ghargoda (approx. 11.6 km) and Milupara to Tamnar (app 3 km.*

(xx) *Persons of nearby villages shall be given training on livelihood and skill development to make them employable.*

(xxi) *PP shall submit Mine Closure Plan as per MoC latest 2019 guidelines to this Ministry within one year.*

(xxii) *Mining shall be carried out only by surface miners for the project and silo loading till railway siding through in-pit conveyor should be installed to avoid road transportation in 5 years.*

(xxiii) *Efforts shall be made for utilizing alternate sources of surface water, abandoned mines or else whatsoever and thus minimizing the dependability on a single source.*

(xxiv) *Active OB Dump should not be kept barren/open and should be covered by temporary grass to avoid air born of particles*

MAHAGENCO MAHARASHTRA STATE POWER GENERATION CO. LTD. Executive Director (R&D) Mumbai

(xxv) *PP shall conduct the stability study of OB dump by reputed agencies and necessary approval of DGMS.*

(xxvi) *As proposed, total plantation shall be done in 2256.60ha area of land till closure of mine. Project proponent to plant 150,000 nos. of native trees with broad leaves along the transportation route in three years to prevent the effect of air pollution. After completion of tree plantation, number of trees shall be duly endorsed from District Forest Officer.*

(xxvii) *Project Proponent shall obtain blasting permission from DGMS for conducting mining operation near villages and also explore deployment of rock breakers of suitable capacity in the project to avoid blasting very near to villages. There shall be no damages caused to habitation/structures due to blasting activity.*

(xxviii) *The Project Proponent shall complies with all the statutory requirements and judgment of Hon'ble Supreme Court dated the 2nd August 2017 in Writ Petition (Civil) No. 114 of 2014 in the matter of Common Cause versus Union of India and Ors. State Government shall ensure that the entire compensation levied, if any, for illegal mining paid by the Project Proponent through their respective Department in strict compliance of judgment of Hon'ble Supreme Court dated the 2nd August 2017 in Writ Petition (Civil) No. 114 of 2014 in the matter of Common Cause versus Union of India and Ors.*

(xxix) *Project Proponent shall obtain the necessary prior permission from the Central Ground Water Authority (CGWA) in case of intersecting the Ground water table.*

(xxx) *Proponent shall appoint an Occupational Health Specialist for Regular and Periodical medical examination of the workers engaged in the Project and maintain records accordingly; also, Occupational health check-ups for workers having some ailments like BP, diabetes, habitual smoking, etc. shall be undertaken once in six months and necessary remedial/preventive measures taken accordingly. The Recommendations of National Institute for ensuring good occupational environment for mine workers shall be implemented; The prevention measure for burns, malaria and provision of anti-snake venom including all other paramedical safeguards may be ensured before initiating the mining activities.*

(xxxi) *Project Proponent shall follow the mitigation measures provided in Office Memorandum No. Z-11013/57/2014-IA.II (M), dated 29th October, 2014, titled "Impact of mining activities on Habitations-Issues related to the mining Projects wherein Habitations and villages are the part of mine lease areas or Habitations and villages are surrounded by the mine lease area".*

(xxxii) *The illumination and sound at night at project sites disturb the villages in respect of both human and animal population. Consequent sleeping disorders and stress may affect the health in the villages located close to mining operations. Habitations have a right for darkness and minimal noise levels at night. PPs must ensure that the biological clock of the villages is not disturbed; by orienting the floodlights/ masks away from the villagers and keeping the noise levels well within the prescribed limits for day light/night hours.*

(xxxiii) *The project proponent shall take all precautionary measures during mining operation for conservation and protection of endangered fauna, if any, spotted in the study area. Action plan for conservation of flora and fauna shall be implemented in consultation with the State Forest and Wildlife Department. A copy of action plan shall be submitted to the Ministry of Environment, Forest and Climate Change and its Regional Office.*

(xxxiv) *Hon'ble Supreme Court in an Writ Petition(s) Civil No. 114/2014, Common Cause vs Union of India & Ors vide its judgement dated 8th January, 2020 has directed the Union of*

India to impose a condition in the mining lease and a similar condition in the environmental clearance and the mining plan to the effect that the mining lease holders shall, after ceasing mining operations, undertake re-grassing the mining area and any other area which may have been disturbed due to their mining activities and restore the land to a condition which is fit for growth of fodder, flora, fauna etc. Compliance of this condition after the mining activity is over at the cost of the mining lease holders/Project Proponent". The implementation report of the above said condition shall be sent to the Regional Office of the MoEFCC.

The proposal was ***recommended*** *with above specific conditions*

Agenda No. 2.2

Basantpur Tapin Coking Coal Washery of 4MTPA in an area of 32.47 ha of M/s Central Coalfields Limited, located in Kedla, District Ramgarh (Jharkhand) – Environment Clearance –reg

[IA/JH/CMIN/77450/2018; File No J-11015/97/2018-IA.II(M)

2.2.1 The proposal is for Environment Clearance for Basantpur Tapin Coking Coal Washery Project of 4 MTPA capacity in lease area of 32.03 Ha by M/s Central Coal Field Limited located in Village Basantpur, Post- Kedla, District- Ramgarh (Jharkhand).

2.2.2 Details of the proposal, as ascertained from the proposal documents and as revealed from the discussions held during the meeting, are given below:

(i) The project area is covered under Survey of India Topo Sheet No. F45B9 and is bounded by the geographical coordinates ranging from Latitude: 23° 49' 48.78" N to 23° 49' 22.16"N and Longitude: 85° 33' 44.76" E to 85° 34' 01.87" E

(ii) Coal linkage of the project is proposed for Washed Coal (Power), Clean Coal, Reject use for various destination.

(iii) No Joint venture cartel has been formed.

(iv) Project does not fall in the Critically Polluted Area (CPA), where the MoEF&CC's vide its OM dated 13thJanuary, 2010 has imposed moratorium on grant of environment clearance.

(v) Employment generation 200 employment to the persons will be provided from the project.

(vi) The project is reported to be beneficial in terms of Social, Environment, and Financial status.

(vii) Ministry granted Terms of Reference for the said project vide MoEF&CC letter No. J-11015/97/2018-IA. II(M) dated 7th January, 2019

(viii) The plan for washery has been approved by CCL board 483rd (No. 03 of 2020) meeting held on 03/02/2020 and communicated vide no. CS/BM/483/2020/153 dtd. 25/02/2020.

(ix) Baseline data for air quality (PM10, PM2.5, SO2, NOX) (6 stations), noise (day & night) (6 stations), water (surface (2 stations), drinking water (2 stations), effluent water (1 station)), have been collected from March, 2019 to June, 2019. All the points have been considered in

Annexure-I (Part 2 of 2) 174

M/S MAHARASHTRA STATE POWER GENERATION COMPANY LIMITED

HYDROLOGY STUDY AND EMBANKMENT DESIGN

OF

GARE PALMA -II COAL BLOCK, DISTRICT RAIGARH, CHHATTISGARH

JUNE, 2017
(issue 1, Rev 2)

Prepared by:

MIN MEC CONSULTANCY PVT. LTD.
A-121, Paryavaran Complex, IGNOU Road, New Delhi – 110 030
Ph : 29534777, 29532236, 29535891 ; Fax: +91-11-29532568
Email :min_mec@vsnl.com; Web site : http://www.minmec.co.in
Estb. 1983
An ISO 9001:2008 approved company

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ANNEXURES

MAHARASHTRA STATE POWER GENERATION CO. LTD. Executive Director (E&S) Mumbai

HYDROLOGY STUDY AND EMBANKMENT DESIGN FOR GARE-II COAL BLOCK, DISTRICT RAIGARH, CHHATTISGARH

1.0 BACKGROUND

The Gare Palma sector-II Coal block has been allotted to Maharashtra State Power Generation Company Limited (MAHAGENCO) vide allotment order No. 103/30/2015/NA dated August 31, 2015.

The Gare Pelma sector -II Coal block is located in the Mand Raigarh coalfield of Raigarh district, Chhattisgarh. The Mand Raigarh coalfield extends over more than 900 Sq. km. Detailed exploration of Gare Pelma sector -II Coal block has been carried out by Mineral Exploration Corporation Limited.

The Coal Block occupies an area of 2583.486 Ha & has Geological reserves of 1059.761 million tonnes. It is proposed to produce coal from this block at 23.60 MTPA (22 MT from Opencast & 1.60 MT from Underground).

There are 14 villages in the block, namely, Thilirampur, Dholnara, Muragaon, Libra, Kunjemura, Jhinkabahal, Rodopali, Dolesara, Bhalumura, Sarasmai, Pata, Chitwahi, Gare, Saraitola of Tehsil Tamnar.

The coal block has a general elevation from 242 m to 303 m above MSL. The 10 km radius around the study area is characterised by undulating and rolling topography, consisting of hills interspersed ith broad valleys. The elevation there varies from 240 m to 640 m above MSL. The general slope is towards south.

Kelo Nadi flows from north to south through the south eastern part of the coal block. A few ponds are present within the block. The southerly flowing Kelo Nadi and Pajhar Nadi, which ultimately join the Mahanadi, constitute the main drainage of the surrounding area.

2.0 OBJECTIVE

As per the scope awarded by MAHAGENCO for "Hydrology of the River During Flood & suitable diversion of drains along the project boundaries at Gare Palma Coal Block Sector-II, Raigarh, Chhattisgarh", the objectives of the study include:

MAHARASHTRA STATE POWER GENERATION CO. LTD. Executive Director (E&S) Mumbai

1. Preparation of detailed surface drainage map of core and 10 km buffer zones of M L area
2. Assessment of catchment area for the existing natural drainage network within the ML area
3. Collection of 100 years rainfall data of the nearest rain-gauge station for ML area
4. Estimation of runoff inflow into the existing drainage network during peak and lean rainfall periods
5. Demarcation of flood prone area along the major streams/rivers existing within the ML area
6. Detailed evaluation of Physiographic condition of the project site and providing at least 4 different options for diversion of major streams/rivers existing within ML area.
7. Preparation of detailed risk assessment on impact due to changing of stream / river course on surface water bodies and groundwater resource within core and buffer zones. ☐
   - Suggestive mitigation measures for the identified risk parameters ☐
   - Design details of the protection work proposed along the river ☐
   - Impact of mining on hydrology
8. Preparation of detailed risk assessment on soil conservation due to change of stream/river course on core and buffer zones. ☐
   - Suggestive mitigation measures for the Identified risk parameters
9. Preparation and submission of detailed technical report on Hydrological studies of the area by integrating all the above scope of work.
10. Source of water for use in mine , competing users in the upstream and downstream of the project site should be given.
11. Prediction of H.F.L. of different return period.
12. Design of embankment along Kelo river
13. Design of garland drain along mine area

MAHARASHTRA STATE POWER GENERATION CO. LTD. Executive Director (E&S)

3.0 METHODOLOGY OF APPROACH

For the purpose of this study, the term "study area" refers to the area within 10 km radius of the coal block. The study has been conducted as follows:

1. The surface drainage map of coal block and 10 km radius around the coal block area has been prepared based on toposheet
2. The catchment areas have been identified for the streams and rivers which are passing through the coal block area
3. Collection of long term rainfall data of the nearest rain-gauge stations and its analysis to estimate run-off inflow into the existing drainage network and identify flood frequency and magnitude.
4. (i) Estimation of flood hydrographs considering historical as well as design rainfall to suggest comprehensive drainage plan of mining block and adjoining area has been done.
   (ii) This will take into consideration pre mining and post mining scenario, affected and modified catchments.
5. Detailed evaluation of Physiographic condition of the project site has been done and options for diversion of major streams/ rivers existing within ML area has been explored.
6. Contours plotted for the mine block based on actual survey conducted by MECL have been taken.
7. Demarcation of flood prone area along the major streams/rivers existing within the ML area has been done.
8. Prediction of H.F.L. of different return period has been done.
9. Design details of the protection work (embankment) proposed along the Kelo river has been done
10. Design of garland drain along mine area, Check-dams/ Storage structures have been proposed, where needed or feasible to dilute or reduce impact on Kelo River downstream for not only reducing flood intensity or flows but silt load
11. Risk assessment on impact due to changing of stream / river course on surface water bodies and groundwater resource within core and buffer zones along with mitigation measures have been given
12. Impact of mining on hydrology has been summarised □
13. Soil conservation measures have been identified
14. Source of water for use in mine , competing users in the upstream and downstream of the project site have been given

MAHARASHTRA STATE POWER GENERATION CO. LTD. Executive Director (E&S)

4.0 LOCATION

The Gare Palma Sector – II Coal Block area lies in Mand Raigarh Coalfield in Raigarh district of Chhattisgarh state. The mine site is located in Tihli Rampur, Kunjemura, Gare, Saraitola, Murogaon, Radopali, Pata, Chitwahi, Dholnara, Jhinka Bahal, Dolesara, Bhalumura, Sarasmal and Libra villages. The area is covered in the Survey of India Toposheet No. 64 N/8 & 12 (R.F. 1:50,000) and is bound by:

As per Allotment Order no. 103/30/2015/NA dt. 31.08.2015:

Latitude : 22° 06′ 23.55″ N to 22° 10′ 37.04″ N
Longitude : 83° 26′ 22.18″ E to 83 ° 31′ 19″ E

As per CMPDI data vide letter no. CMPDI/BD/C(810)/307 dt 04-06-2012 based on modified Everest datum :

Latitude : 22° 06′ 22.33″ to 22° 10′ 48″ N
Longitude : 83° 26′ 21.85″ to 83° 31′ 19.1″ E

As per Nominated Authority letter F.No.104/28/2015/NA dt 13-10-2015, the coordinates in WGS 84 system are given below. As mentioned in the letter, the earlier coordinates were using reference system based on modified Everest datum but presently CMPDI is following WGS 84 System which is the standard reference system followed globally. It is to be noted that the respective position of any point does not change physically on the ground.

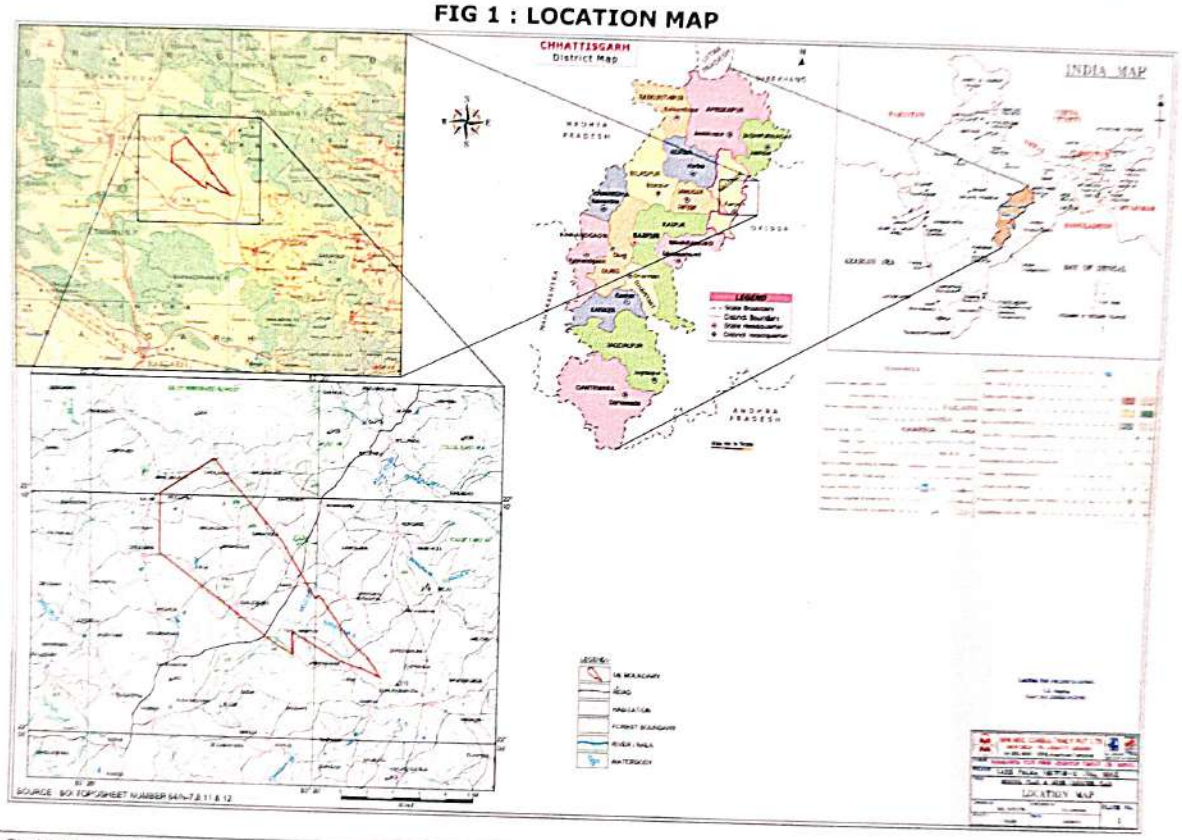
Latitude : 22° 06′ 24.215″ to 22° 30′ 49.891″ N
Longitude : 83°26′ 15.433″ to 83° 31′ 12.632″ E

The Gare Palma area is situated around 35 km towards north from Raigarh Township, which is also the nearest railway station on Mumbai-Howrah main line of SE Railway.

The block is connected by road from Raigarh via Punjipatra by State Highway. Punjipatra village is situated on Raigarh-Ghargoda main road. The distance from Raigarh to Ghargoda is around 40 km by road. The road distance between Raigarh to Punjipatra is about 20 km and Punjipatra to Ghargoda is 20 km towards north. From Punjipathara the road leads to the Gare Palma-II coal block area via Tamnar Thermal Power Plant situated at a distance of 10 km on Punjipathara- Milupara road which passes through the block. Tamnar is situated in the south-western part of the adjoining Gare Palma Sector-I area in the sub block 'F'. A network of roads is present within the block. The location map can be seen in Fig 1.

MAHARASHTRA STATE POWER GENERATION CO. LTD. Executive Director (E&S)

FIG 1 : LOCATION MAP



5.0 CLIMATE AND RAINFALL

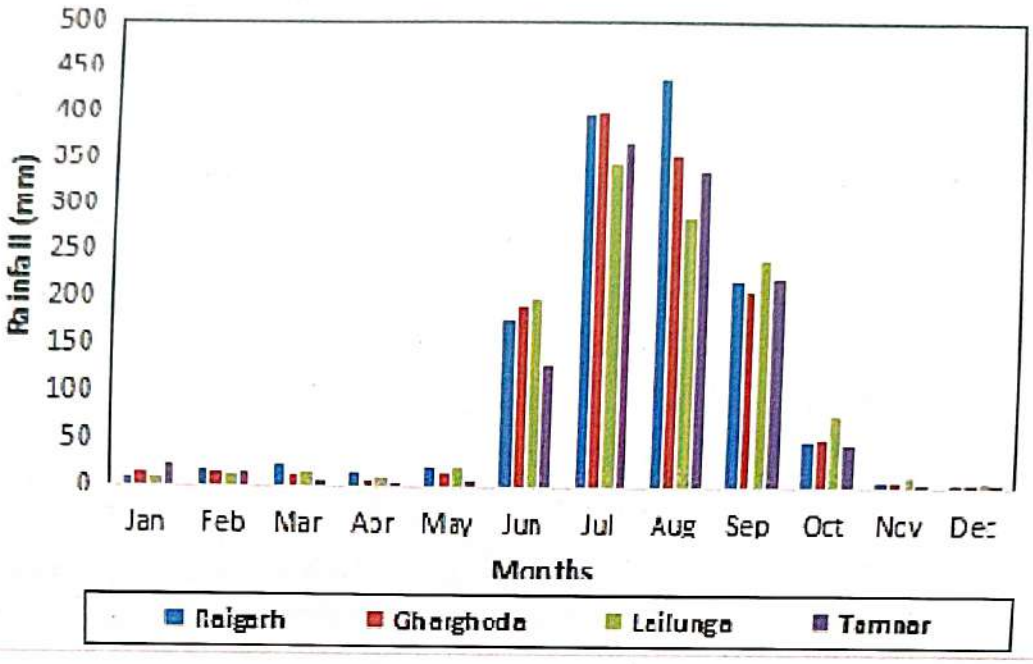
The area experiences subtropical climate with hot & dry summer well distributed rainfall during monsoon period and cold winter season. The nearest meteorological observatory of IMD is located at Raigarh at an aerial distance of approximately 35 km.

The rainfall data has been collected for the nearest IMD Station at Raigarh for 110 years (1901-2010). Similarly, the data for the Rain Gauge stations for the blocks falling in the coal block were collected. These were collected for the available period from the District Administration office for Gharghoda Block (1977-2017), Lailunga Block (1999-2016) and Tamnar Block (2009-2017). The station at Gharghoda was established in 1977, at Lailunga in 1999 and in Tamnar block in 2009,therefore the data prior to their establishment was not available. The available month wise rainfall data is appended (Annexure I). The monthly variation of rainfall has been graphically represented (Fig 2). The Rainfall data has been summarized Table 1.

TABLE 1
SUMMARISED MONTHLY RAINFALL (MM) DATA

Months	Raigarh (1901-2010)	Gharghoda Block (1977-2017)	Lailunga Block (1999-2016)	Tamnar Block (2009-2017)
January	8.3	13.9	8.8	20.7
February	16.3	12.8	12.0	13.7
March	20.5	11.6	13.1	5.9
April	14.3	6.2	9.6	2.0
May	18.5	14.6	20.2	4.8
June	177.2	191.1	199.2	129.7
July	398.7	400.0	342.9	366.9
August	435.6	353.0	284.6	335.7
September	215.6	207.0	239.7	223.0
October	47.4	49.9	73.5	45.5
November	5.3	6.7	10.3	4.6
December	4.2	4.0	2.1	1.2
Total	**1361.9**	**1240.9**	**1215.9**	**1153.7**

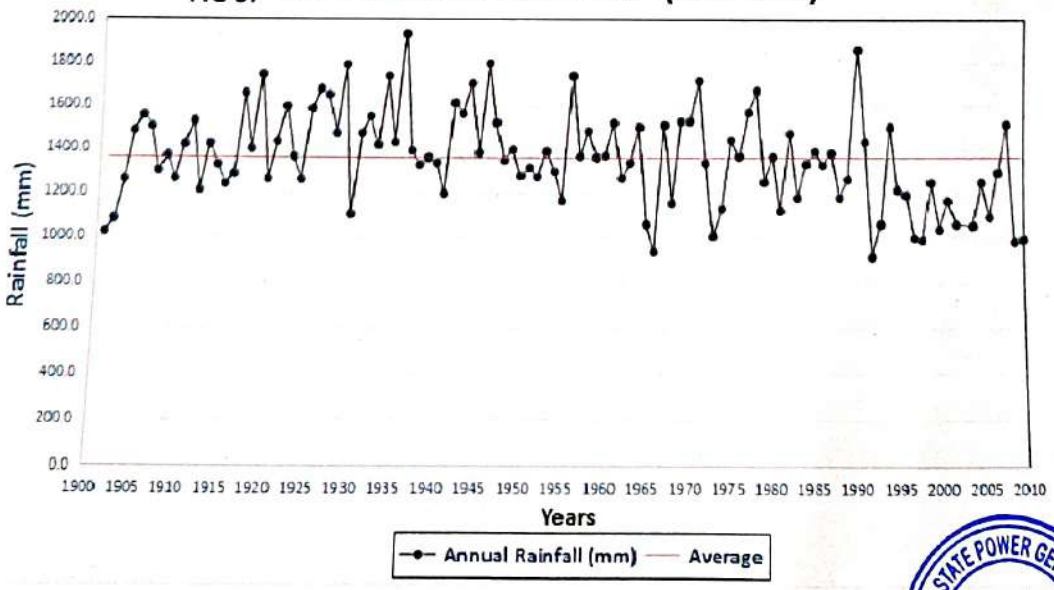
FIG 2 : MONTHLY AVERAGE RAINFALL (mm)



From the above table it is observed that annual rainfall over the study area varies between 1153.7 mm to 1361.9 mm. The larger parts of annual rainfall (87.7-92.8%) occurs between June to September every year.

The review of annual rainfall data at Raigarh indicate a large variation over the years period. The annual distribution of the rainfall has been graphically represent in Fig 3 for Raigarh, which is the maximum years data.

FIG 3: ANNUAL RAINFALL IMD RAIGARH (1901 - 2010)



6.0 DRAINAGE ANALYSIS

The topography and drainage map son the basis of toposheet, prepared for the coal block area and its surrounding 10 km radius can be seen in Fig 4 and 5 respectively.

The quantitative assessment of hydrological parameters and their use in design will be rational only when they are applied to specific area with well defined boundaries. Though the precipitation, evaporation and infiltration takes place every where but from the land surface the resultant runoff passes through one point on the stream. Therefore it is necessary to understand the character of the area upstream of discharge point from where the overland flow is generated. The catchment area is known as drainage basin / watershed.

The coal block forms a part of Kelo river watershed. The minimum and maximum elevation of core zone is 242 to 303 m above mean sea level. Kelo river and Pajhar Nadi form the main drainage of the coal block. Kelo river cuts across through south eastern "tip" of the ML area. Kelo river, along its entire length, has several nalas which are important tributaries to it. However, in context of the coal block, for drainage there is mainly nala "A" on western side of Kelo river and and Karanakaran Nala on eastern side of Kelo river. The former nala has been named "A" for the purpose of the study as no specific names have been allotted to it on the toposheet. It passes via village Kunjemura and will be also referred to as "Nala via Kunjemura". Nala "A" is a tributary to Pajhar Nadi while Karanara Nala conveys the storm water from the hills on eastern side to Kelo River.

In order to decipher the character of Nala "A", which is proposed to be diverted from its present natural course to elsewhere, to facilitate the coal mining operation in Gare-II Coal block, the watershed map of the nala, which is a left bank tributary to Pajhar Nadi, has been prepared using the survey of India toposheet of 1:50000 scale. For the purpose of this study, the catchment of the nala "A" has been taken upto the southern boundary of the coal block (Fig 6).

Similarly, the watershed of the Karanara Nala has also been identified separately as Karanara and the Nala "A" have been treated separately for the purpose of diversion. The drainage analysis of the watershed has been carried out which has been discussed subsequently.

MAHARASHTRA STATE POWER GENERATION CO. LTD. Executive Director (E&S)

FIG 4 : TOPOGRAPHY MAP OF COAL BLOCK AND STUDY AREA

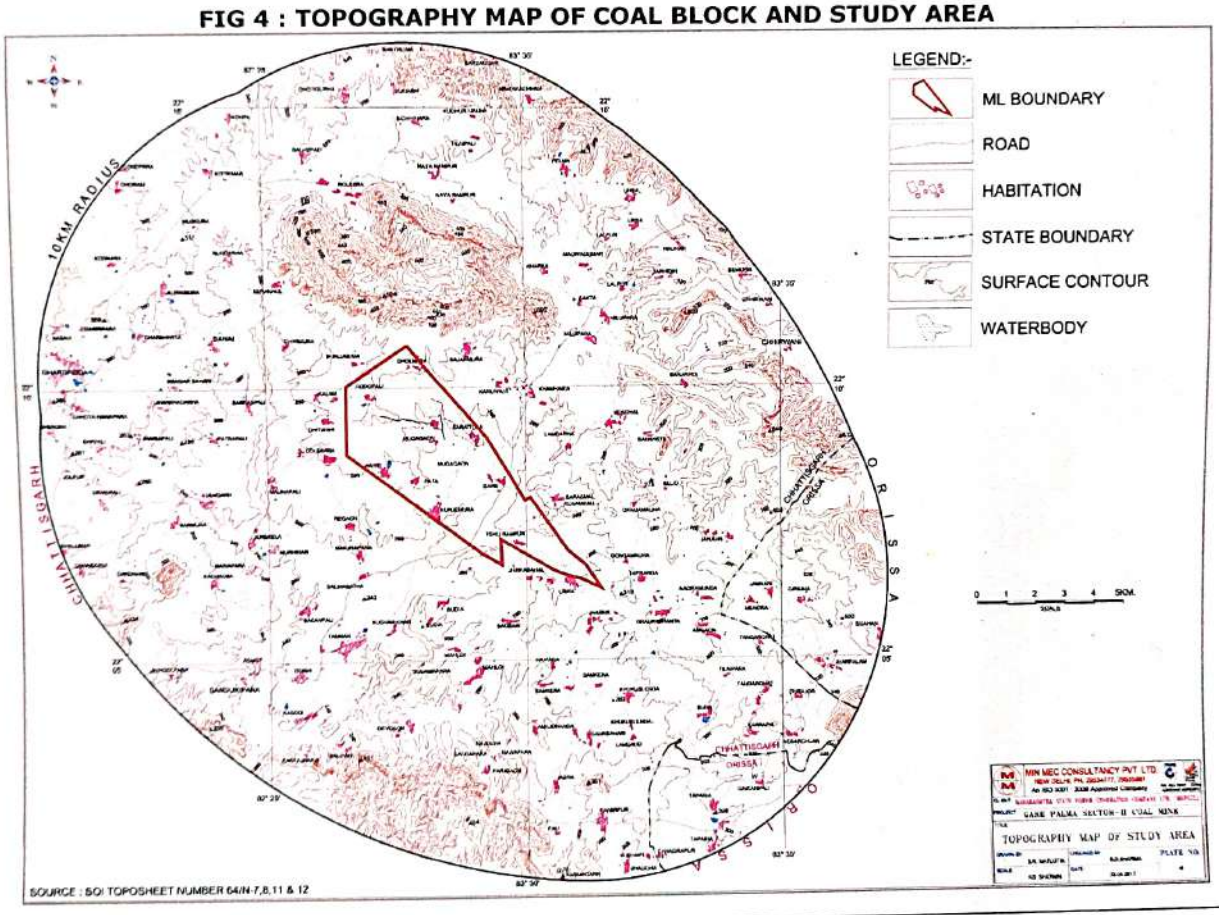


FIG 5 : DRAINAGE MAP OF COAL BLOCK AND STUDY AREA

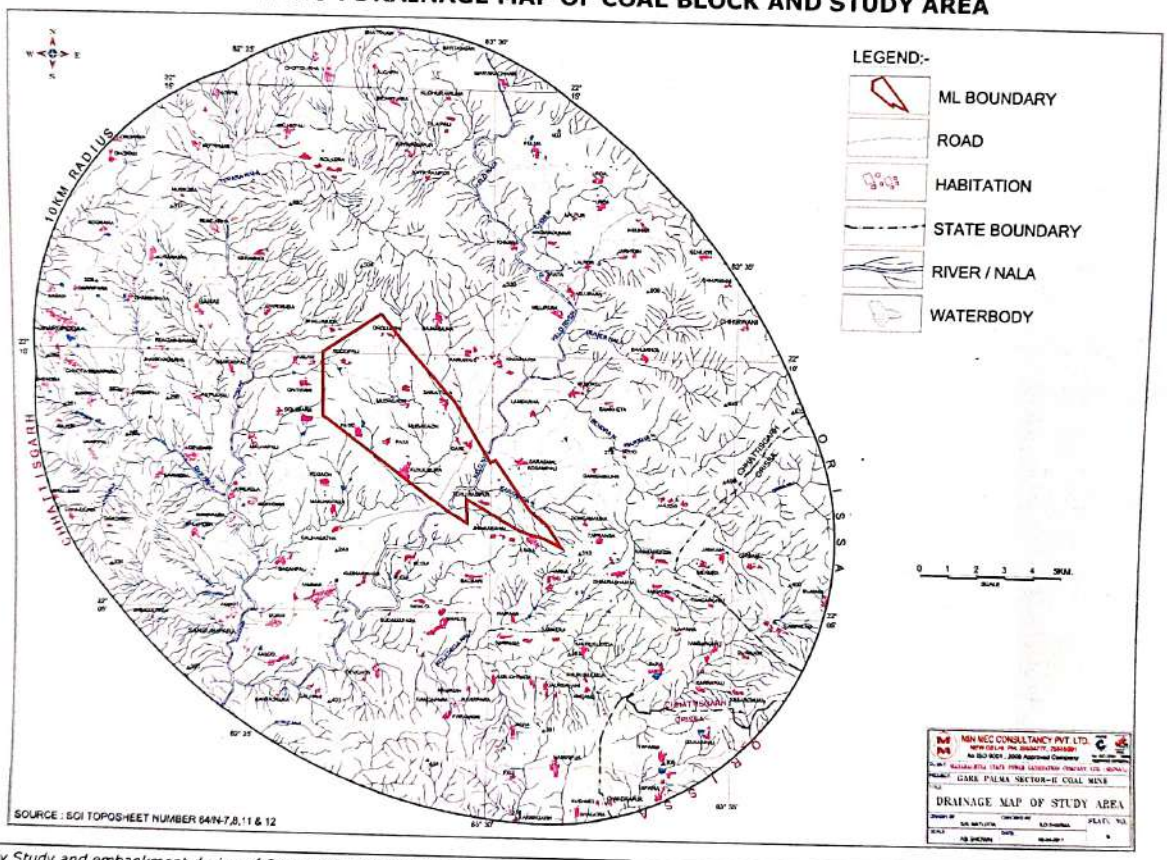
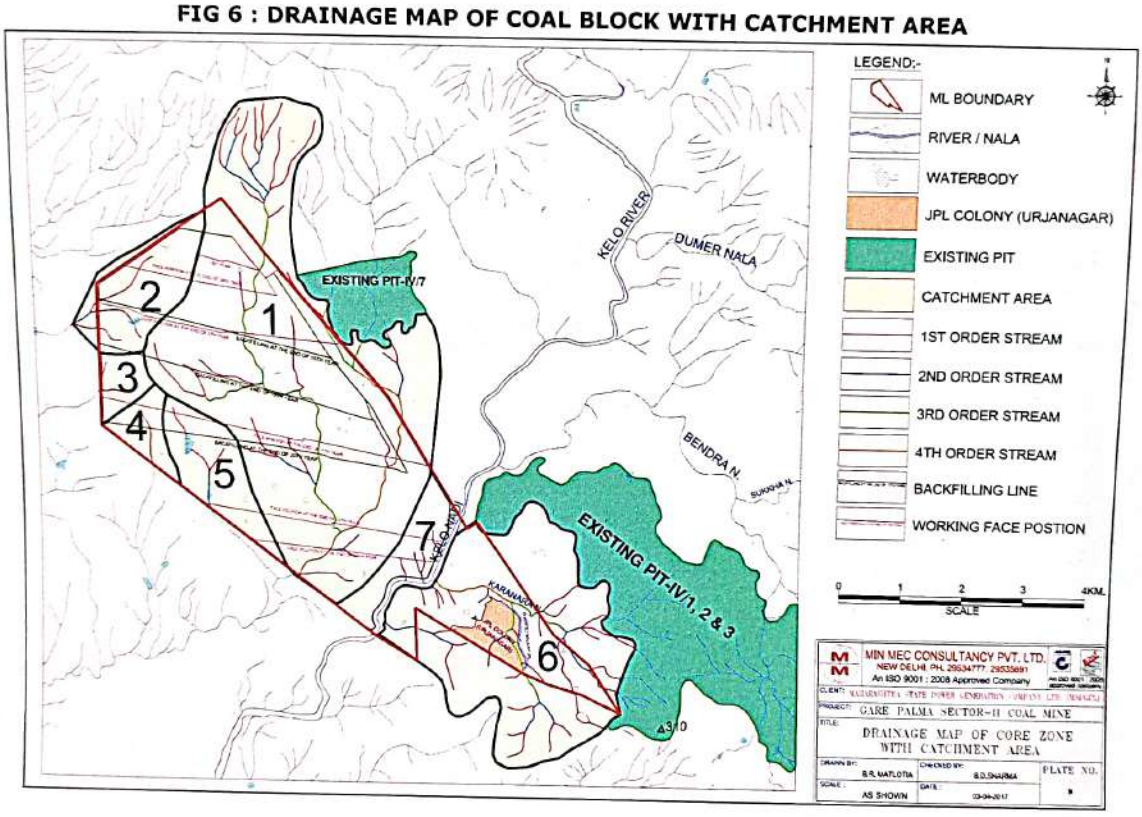


FIG 6 : DRAINAGE MAP OF COAL BLOCK WITH CATCHMENT AREA



6.1 DESCRIPTION OF DRAINAGE BASIN

6.1.1 Stream order

The stream order is a classification reflecting the degree of branching bifurcation of stream channel with in the basin. The smallest finger tip tributary is given order 1. When two order 1 tributaries join each other, order 2 stream commences. Higher order stream develop in same fashion. The trunk stream through which the entire discharges passes becomes the stream of highest order in a particular catchment. The length and number of each order of stream has been worked out and given in Table 2.

TABLE 2
LENGTH OF STREAMS AND DRAINAGE ANALYSIS

Order of stream	Length of stream (km) in catchment identified in Fig 6			
	1	**2**	**3**	**4**
1	18.806	3.367	0.893	0.86
2	4.065	0.35		
3	9.337			
4	4.688			
Total length, m	**36.896**	**3.717**	**0.893**	**0.86**
Area, km^2	19.1468	2.5457	0.6743	0.8387
Drainage density, km/km^2	1.93	1.46	1.32	1.03
	5	**6**	**7**	
1	1.736	12.57	1.6	
2	0.614	3.508	0.172	
3		3.042		
4		1.377		
Total	**2.35**	**20.497**	**1.772**	
Area, km^2	2.0934	10.3604	1.6316	
Drainage density, km/km^2	1.12	1.98	1.09	

6.1.2 Drainage density

It is the ratio of total length of stream of all orders within the basin to area of basin. The drainage density is the measure of closeness of spacing of stream channel. Low drainage density reflects poor drainage condition, gentle slope, presence of highly permeable formation in the catchment. For Nala "A" it works out as 1.93 km/sq.km and for Karanara Nala it works out as 1.98 km/sq.km. Such a density is considered as low (1-2 km/sq.km). Low drainage density of the nalas reflects presence of low erodable formation with moderate permeability. It further suggest gentle slope.

6.1.3 Length of overland flow

The average length of over land flow is taken as half of reciprocal of drainage density. It works out as follows for different sub-catchments affecting is given in Table 3.

TABLE 3
AVERAGE LENGTH OF OVERLAND FLOW

Parameter	Sub- catchment no. identified in Fig 6			
	1	2	3	4
Drainage density, km/km^2	1.93	1.46	1.32	1.03
Average length of over land flow, km	0.26	0.34	0.38	0.49
	5	6	7	
Drainage density, km/km^2	1.12	1.98	1.09	
Average length of over land flow, km	0.45	0.25	0.46	

6.1.4 Stream pattern

The combined effect of climate and geology on catchment topography yield an erosion pattern which is characterized by net work of channel or stream. The stream pattern of the 10 km radius gives an idea of characteristic of formation present in the area.

The catchment of the various nalas in the mine lease represent a dendritic or tree like drainage pattern. Such a pattern represents homogeneous character of formation over the entire catchment.

When variation in resistance to flow is more or less same then resulting stream run in all direction with no definite preference of particular direction.

6.1.5 Shape of catchment

The shape of a catchment is quantitatively measured by various factor such as form factor, circularity ratio, elongation ratio and compactness coefficient.

Form factor is the ratio of basin area to square of basin length. It works out as follows for different sub-catchments affecting the coal block and is given in Table 4.

TABLE 4
FORM FACTOR

Parameter	Sub- catchment no. identified in Fig 6			
	1	2	3	4
Area of basin, sq.km.	19.1468	2.5457	0.6743	0.8387
Length of basin, km	7.895	2.567	0.871	1.383
Form factor	0.31	0.39	0.89	0.44
	5	6	7	
Area, km^2	2.0934	10.3604	1.6316	
Length	2.15	3.713	2.595	
Form factor	0.45	0.75	0.24	

Circulatory Ratio (Rc) is the ratio of basin area to the area of circle whose perimeter is equal to perimeter of the basin.

$$R_C = \frac{4\pi A}{P^2}$$

The circulatory ratio has been calculated in Table 5.

TABLE 5
CIRCULATORY RATIO

Parameter	Sub- catchment no. identified in Fig 6			
	1	2	3	4
Basin Area "A", km^2	19.1468	2.5457	0.6743	0.8387
Perimeter of basin, km	23.148	6.862	3.544	4.496
Circulatory Ratio, Rc	0.45	0.68	0.67	0.52
	5	6	7	
Basin Area "A", km^2	2.0934	10.3604	1.6316	
Perimeter of basin, km	7.285	15.2	7.237	
Circulatory Ratio, Rc	0.5	0.56	0.39	

Elongation Ratio (R_e)

It is defined as ratio of diameter De of a circle whose area is same as the area of the basin to the length of basin

$$R_e = \frac{D_e}{L} = \frac{2}{L}\sqrt{\frac{A}{\pi}}$$

The elongation ratio has been calculated in Table 6.

TABLE 6
ELONGATION RATIO

Parameter	Sub- catchment no. identified in Fig 6			
	1	2	3	4
Basin Area "A", km^2	19.1468	2.5457	0.6743	0.8387
Length of basin "L", km	7.895	2.567	0.871	1.383
Elongation Ratio, Re	0.63	0.7	1.06	0.75
	5	6	7	
Basin Area "A", km^2	2.0934	10.3604	1.6316	
Length of basin "L", km	2.15	3.713	2.595	
Elongation Ratio, Re	0.76	0.98	0.56	

Compactness Coefficient (Cc)

It is the ratio of the perimeter of the basin to the perimeter of circle whose area is equal to the area of the basin.

MAHARASHTRA STATE POWER GENERATION CO. LTD. Executive Director (E&S) Mumbai

$$C_c = \sqrt{\frac{P}{4\pi A}}$$

The compactness coefficient has been calculated in Table 7.

TABLE 7
COMPACTNESS COEFFICIENT

Parameter	Sub- catchment no. identified in Fig 6			
	1	2	3	4
Basin Area "A", km^2	19.1468	2.5457	0.6743	0.8387
Perimeter of basin "P", km	23.148	6.862	3.544	4.496
Compactness coefficient, Cc	0.31	0.46	0.65	0.65
	5	6	7	
Basin Area "A", km^2	2.0934	10.3604	1.6316	
Perimeter of basin "P", km	7.285	15.2	7.237	
Compactness coefficient, Cc	0.53	0.34	0.59	

Relief of basin

The highest and lowest elevation in the catchment have been measured and based on the distance between the two, the slope has been calculated in m/km. Accordingly, the relief has been interpreted in Table 8.

TABLE 8
RELIEF OF BASIN

Basin no. -->	1	2	3	4	5	6	7
Highest elevation (m.amsl)	580	302	288	286	285	282	266
Lowest elevation (m.amsl)	260	273	276	270	261	246	248
Distance between both point, m	6807	2125	548	1287	3117	3551	844
Slope m/km	47.01	13.65	21.90	12.43	7.70	10.14	21.33

It is apparent that relief is moderately high in the study area. Within the basin it self there is large variation in relief. Many portions of the study area which are hill bearing have got high relief.

The result of drainage analysis of the sub-catchments within the mine lease are summarised below Table 9.

TABLE 9
FACTORS OF SHAPE OF BASIN

Sl. No.	Factors	1	2	3	4	5	6	7
1.	Area of basin, sq.km.	19.1468	2.5457	0.6743	0.8387	2.0934	10.3604	1.6316
2.	Total length of various order drains in basin, km	36.896	3.717	0.893	0.86	2.35	20.497	1.772
3.	Length of basin, km	7.895	2.567	0.871	1.383	2.15	3.713	2.595
4.	Width of basin, km	4.735	1.216	0.81	0.838	1.282	3.071	0.733
5.	Perimeter of basin, km	23.148	6.862	3.544	4.496	7.285	15.2	7.237
6.	Form factor	0.31	0.39	0.89	0.44	0.45	0.75	0.24
7.	Circulatory Ratio	0.45	0.68	0.67	0.52	0.5	0.56	0.39
8.	Elongation ratio	0.63	0.7	1.06	0.75	0.76	0.98	0.56
9.	Compactness coefficient	0.31	0.46	0.65	0.65	0.53	0.34	0.59
10.	Relief							
	Highest elevation (m.amsl)	580	302	288	286	285	282	266
	Lowest elevation (m.amsl)	260	273	276	270	261	246	248
	Distance between both point, m	6807	2125	548	1287	3117	3551	844
	Slope m/km	47.01	13.65	21.90	12.43	7.70	10.14	21.33
11	Drainage density km/sq.km	1.93	1.46	1.32	1.03	1.12	1.98	1.09
12	Average length of over land flow, km	0.26	0.34	0.38	0.49	0.45	0.25	0.46

From the above table it is observed that drainage density over the catchment is low high indicating moderate generation of storm water. Such a phenomenon occurs when land slope is moderate and terrain is not so rugged. The drainage is in intermediate. The length of 1st order stream is more as compared to higher order of stream. Therefore the system appears to be in transition from youthful nature to intermediate nature. A perusal of the various reports available about the Kelo am project shows that low to moderate velocity is anticipated in the river.

6.2 STORM WATER GENERATION

The overland flow of water generated from the rainfall depends upon several factors which are broadly grouped in two categories.

1. Climatic factor - Intensity, duration & distribution of Rainfall, evaporation & transpiration
2. Physiographic - Shape & slope of catchment, land use, soil and geology

All the factors mentioned have strong bearing on flow of water. Due to large number of variable, complexity develops resulting difficulty in quantification of runoff.

Various engineers while working for different projects in India have developed relationship between rainfall & runoff as a fraction of catchment character. These relationship, though are area specific but may be applied in similar catchments. Strange's table is widely used to evaluate daily flow based on available rainfall data.

To estimate overland monsoon flow for the the streams in and around the coal block, Strange's table has been used. The type of catchment is taken as "good" catchment. The monsoon rainfall is taken as 1151 mm (Tamnar-June to September District Administration record-1977-2017). The runoff coefficient has been taken as 42.5% (for wet ground at daily rainfall of 50 mm & 25% addition for "good" catchment). The monsoon flow for different watershed under consideration has been worked out and given in Table 10.

The peak daily runoff has been estimated using the maximum 24 hours rainfall at IMD Raigarh (315.2 mm on 25.08.1970).

TABLE 10
STORM WATER GENERATION

Basin no. -->	1 Nala "A"	2	3	4	5	6 Karanara Nala	7
Monsoon rainfall, mm	1151	1151	1151	1151	1151	1151	1151
Peak 24 hours rainfall, mm	315.2	315.2	315.2	315.2	315.2	315.2	315.2
Runoff coeffient,%*	42.5	42.5	42.5	42.5	42.5	42.5	42.5
Monsoon flow, MCM	9.37	1.25	0.33	0.41	1.02	5.07	0.8

Basin no. -->	1 Nala "A"	2	3	4	5	6 Karanara Nala	7
Peak 24 hours flow, MCM	2.56	0.34	0.09	0.11	0.28	1.39	0.22
Peak flow rate, cumec	29.69	3.95	1.05	1.3	3.25	16.06	2.53

** as per Strange's table*

7.0 DIVERSION OF RIVERS AND NALAS

Keeping in view physiography; climatic conditions; storm water generation; run off co-efficient; design parameters etc. only single solution for the diversion route have been proposed and discussed as the constraints due to (i) topography, (ii) mining sequence and (iii) other land related constraints do not permit any other diversions. It is proposed to restrict slope to avoid exorbitant cost on protection; as well as need for acquisition of land to the minimum required for proposed diversion. The considered diversions have been discussed subsequently.

7.1 DIVERSION OF RIVERS

There is one river (Kelo) which is passing through the block. The easterly flowing Kelo River constitutes the main drainage system of the block. Kelo River is flowing across the coal block towards South. Kelo river cannot be diverted due to the prevailing topography, shape of the block and presence of other coal blocks all around as follows:

- North - Bhalumura Coal Block of NTPC
- South - Gare Palma-I of GSECL
- East - Gare Palma-III of CMDC; Gare IV/7 of MIEL;
- Gare IV/6 of JSPL; IV/2&3, IV/1 of SCCL;
- West - Bhalumura Coal Block of NTPC

The mine will be protected by leaving statutory barriers and by construction of an embankment which has been discussed separately in this report.

7.1 DIVERSION OF NALAS

7.1.1 Diversion of Nalla-A (located on west side of the Kelo River)

A number of small streamlets drain the terrain in various directions giving a sub dendritic drainage pattern.

In the north side of the block over the stretch of block lying on the western side of Kelo river, Nala A is formed before entering the northern block boundary into which was earlier fed by streams of 1st and 2nd order lying over Coal Block Gare-IV/7. But as the Coal Block Gare-IV/7 has already been considerably excavated by OC operations, most of the catchment area collects in the OC pit of Coal Block Gare-IV/7. As a result, only limited catchment contributes now to the Nala A (refer Fig 7).

The water quantity calculated based on the maximum rainfall comes to 29.69cum/sec (Refer Table 10 earlier).

It is proposed to construct a garland drain along the northern boundary line (within the block area) to join the same into Kelo river located in its east side. The longitudinal cross-section of the alignment shows that the maximum cutting required to be done below surface level will be about 9 m, forming a water gradient of 1 in 79.

The section area on an average comes to 5.22 sq.m. as per Manning's equation.

$$Q = VA = \left(\frac{1.00}{n}\right) A R^{\frac{2}{3}} \sqrt{S} \quad [SI]$$

Where
Q- Flow rate, cum/s
V-Velocity, m/s
A-Flow area, sq.m.
n-Manning's roughness coefficient, dimensionless
R-Hydraulic Radius, m
S-Channel slope, dimensionless

The cross section flow area "A" of the diversion drain will be $bd + zd^2$ where b bottom width of channel in meters, d water flow depth in meters and z slope of channel side wall (dimensionless).

Additionally, a freeboard of 0.2m has been provided.

The Froude number is of interest here because its value for any particular open channel flow provides information on whether that flow is subcritical, critical or supercritical flow.

The Froude number is defined as follows:

$$Fr = \frac{V}{\sqrt{gD_m}}$$

Where
- Fr is the Froude Number, dimentionaless
- V is the average velocity of the liquid in the channel (m/s for S.I.).
- "g" is the acceleration due to gravity (9.81 m/s2 for S.I.).
- Dm is a characteristic length (hydraulic mean depth) for the particular type of open channel (m for S.I.)

For flow in a non-rectangular channel,

Fr = V/[g(A/B)]1/2,

because the hydraulic mean depth, Dm, is A/B, where A is the cross-sectional area of liquid flow, and B is the surface width.

As mentioned above, the value of the Froude number gives information about the type of flow. Details are summarized below:

- If Fr > 1, then flow regime is supercritical flow
- If Fr < 1, then flow regime is subcritical flow
- If Fr = 1, then flow regime is critical flow

The calculations have shown that value of Fr comes to 1.638, hence the flow regime will be supercritical.

It is suggested that energy dissipation may be foreseen in this drain by constructing baffles at appropriate intervals.

The diverted nala section should be lined and the banks should be fully protected by stone pitching on either side.

7.1.2 Diversion of Karnara Nala (located on east side of the Kelo River)

A small catchment area (from 1st order drainage channels), previously lying over the easternmost part of the block on east of the Kelo river, has now been reformed by construction of the Urja Nagar colony by JPL. The area drainage has been modified and the diversion drain goes round the colony to hit a point on the northern boundary line of the block where some water drained from northern side also joins. This nala then heads towards south west direction over the block to finally join the Kelo river. The later part of the nala is proposed to be diverted and aligned along the northern boundary of the block to join the Kelo river, thus, preventing the original nala to traverse within the block for ease and safety of mining operations

The water quantity calculated based on the maximum rainfall comes to 16.06 cum/sec (refer Table 10 earlier).

FIG 7 : ALIGNMENT OF PROPOSED NALA DIVERSIONS AND LOCATION OF HFL & EMBANKMENT

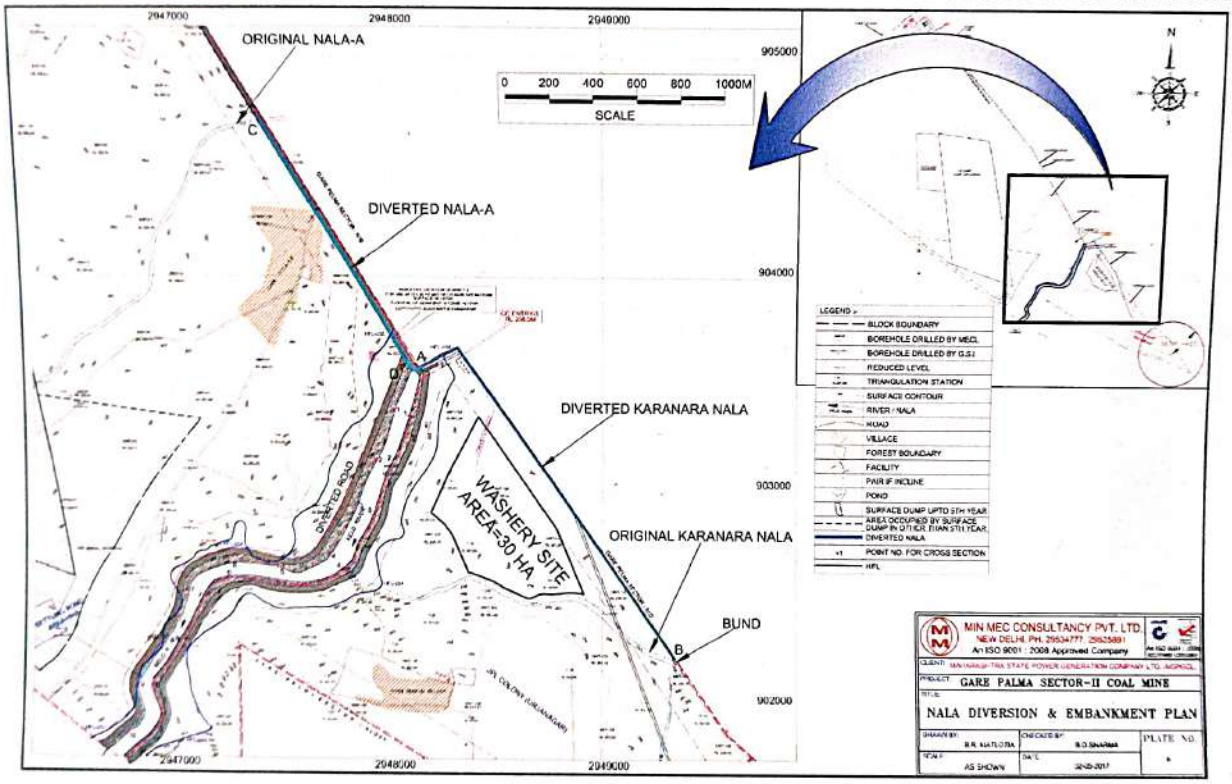
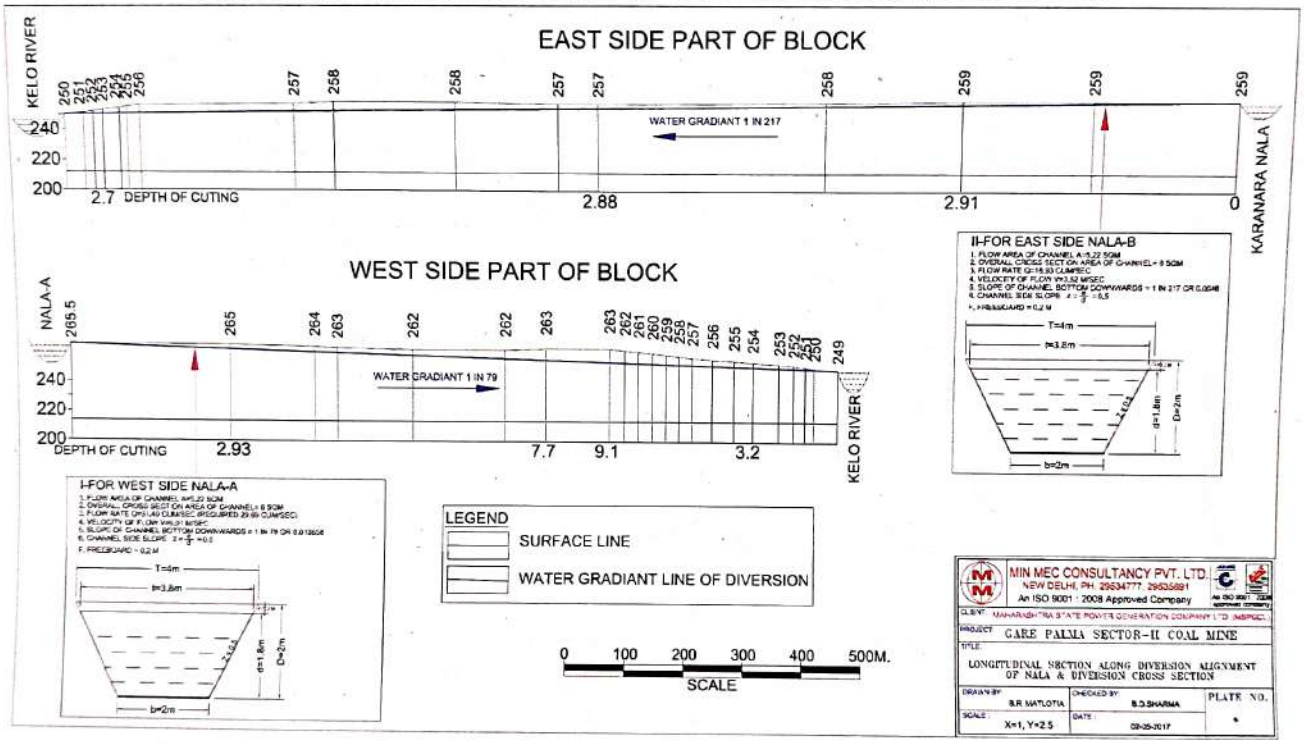


FIG 8 : LONGITUDINAL SECTIONS OF PROPOSED DIVERSION CHANNELS



The longitudinal cross section of the alignment shows that the maximum cutting required to be don below surface level will be about 3 m, forming a water gradient of 1 in 217.

The flow section area on an average comes to 5.22 sq.m. as per Manning's equation (same as in case of Nala-A but the velocity is 3.63m/sec which is less than 6.01m/sec in case of nala-A).

Additionally, a freeboard of 0.2m has been provided.

Froude number provides information on whether the flow is subcritical, critical or supercritical flow. The calculations have shown that value of Fr comes to 0.988, hence the flow regime will be subcritical. Installation of any energy dissipation structures within the channel will not be required.

The diverted nala section should be lined and the banks should be fully protected by stone pitching on either side.

8.0 DESIGN OF EMBANKMENT

8.1 DATA AVAILABILITY

a. Rainfall

The Mahanadi basin receives most of the rainfall from the south-west monsoon during the period from June to October.

There is only rain gauge stations at Tamnar, Lailunga, Gharghoda and Raigarh as discussed earlier in Section 5.0. Adequate rainfall data is available in addition to the G&D data. The data collected has been given in Annexure I.

b. Gauge & Discharge Data

There is no gauge and discharge site at the proposed mines site or upstream of the mine site. Hence, the G&D data of Kelo at Raigarh G&D site established by CWC is considered for water availability studies. The gauge station was established in 1995 and discharge was established in 1997. The data could be procured for the period 1996-2003. The data collected has been given in Annexure II.

The basin flow parameters of the river with hydro-meteorological similarity has been considered to arrive at the flow pattern of Kelo stretch under study.

The Kelo at Raigarh G&D station is located downstream of not only the mine site but also of half of Raigarh city. Thus, the station is at a distance of approximately 27 km aerially from the coal block.

After the construction of Kelo Dam, the flow data at Kelo at Raigarh G&D would be influenced by the dam flow, and thus, has not been collected.

8.2 DESIGN FLOOD

It may be noted that Kelo river passes through or is adjoining various coal blocks upstream as well as downstream of Gare-II Coal Block. The treatment of Kelo rover for the purpose of design flood , High Flood Level (HFL) and design of embankment cannot actually be treated standalone for Gare-II. The immediate adjoining block in north of Gare-II is Gare IV/6 for which WAPCOS has already estimated the design flood for 50 and 100 years . As the exit point of Kelo river at Gare IV/6 is the entry point of Kelo at Gare-II, the flood values or bed level cannot change. Similarly, the exit point of Kelo for Gare-II will be the same as the entry point of Kelo at Gare-I. It is prudent to note that it is more important to seamlessly integrate the embankment of Gare-II with that of Gare IV/6 to ensure continuity and prevent spilling of river over the embankment. Accordingly, calculations considered by WAPCOS for the immediate upstream block has been considered.

As per IS 12094:2000, a flood of 50 and 100 years return period are required for designing of Embankment for protection of predominantly agricultural area and places of importance like mining area and township etc. Accordingly based on the annual flood peak series of Kelo river observed at Kelo G&D station (Latitude 21°53' 47", longitude 83°24' 22") the flood peaks of Kelo with return period of 50 yrs and 100 yrs have been estimated using statistical method i.e. flood frequency method and the values of the flood peaks works out as 1357 cumecs and 1522 cumecs, respectively, by Gumbel EV-1 distribution which is the best fit distribution in this case. Since the above values are based on observed peaks, considering the instantaneous peaks the return period peaks are increased by an order of 10%. The 50 years and 100 years return period peaks thus work out as 1493 cumecs and 1674 cumecs respectively.

The G&D site station is much downstream of the proposed embankment site, so local enquiry was made to ascertain the

high flood level at the proposed embankment side. From local enquiry it has been gathered that the HFL is 7 m above the bed level of the river. The flood level corresponding to this height has been considered as the design flood level of the embankment i.e. 255 m at the upstream end of embankment and gradually reducing to 253 m at the end.

8.3 SOIL CHARACTERISTICS

Geotechnical data/ information available for that region indicates that the permissible Bearing Capacity of the soil in the area is 10 MT/Sq.m, 15MT/Sq.m & 31MT/Sq.m at 15m, 3m & 4.5 m depth from the lowest level of the existing natural surface level (NSL), respectively. It is also observed that clay with mixed coarse sandy soil is available for a average depth of 3 m from the ground level. This top level soil/earth excavated from the adjacent area of the embankment will be used as fill materials for the Embankment. The average natural moisture content of this soil is 15.85%, average specific gravity is 2.66 and 1.835 gm/cc is the bulk density.

(*source : Report on design of embankment on the right bank of Kelo river to protect mining area (IV/6), Tamnar tehsil, Raigarh district, Chhattisgarh*)

8.4 DESIGN OF EMBANKMENT ON RIGHT SIDE OF KELO RIVER

Kelo River (1in 50) Q = 1493 cumecs

(1 in 100) Q = 1674 cumecs

Lacey's Perimeter $= 4.83(1493)^{0.5}$

$= 186.63$ m

The observed G&D site is much below the embankment location and also seeing the importance of coal mining area, the alignment of the embankment has been fixed as per the IS 12094:2000 with following configuration :

(1) Free Board = 3.0 m
(2) River Side slopes :- 2:1 (H:V)
(3) Country Side Slope 2:1 (H:V)
(4) Slope Protection - On river side, the embankment slope has been protected by stone pitching of 0.3m thickness. On

MAHARASHTRA STATE POWER GENERATION CO LTD. Executive Director (E&S) Mumbai

Country Side, turfing has been proposed for protection of slope.

The location of the embankment can be seen in Fig 7. Its cross section can be seen in Fig 9 and 10. The longitudinal section can be seen in Fig 11 and 12.

The Table 11 and Table 12 shows the dimensions of the embankment at various locations (as marked in Fig 7).

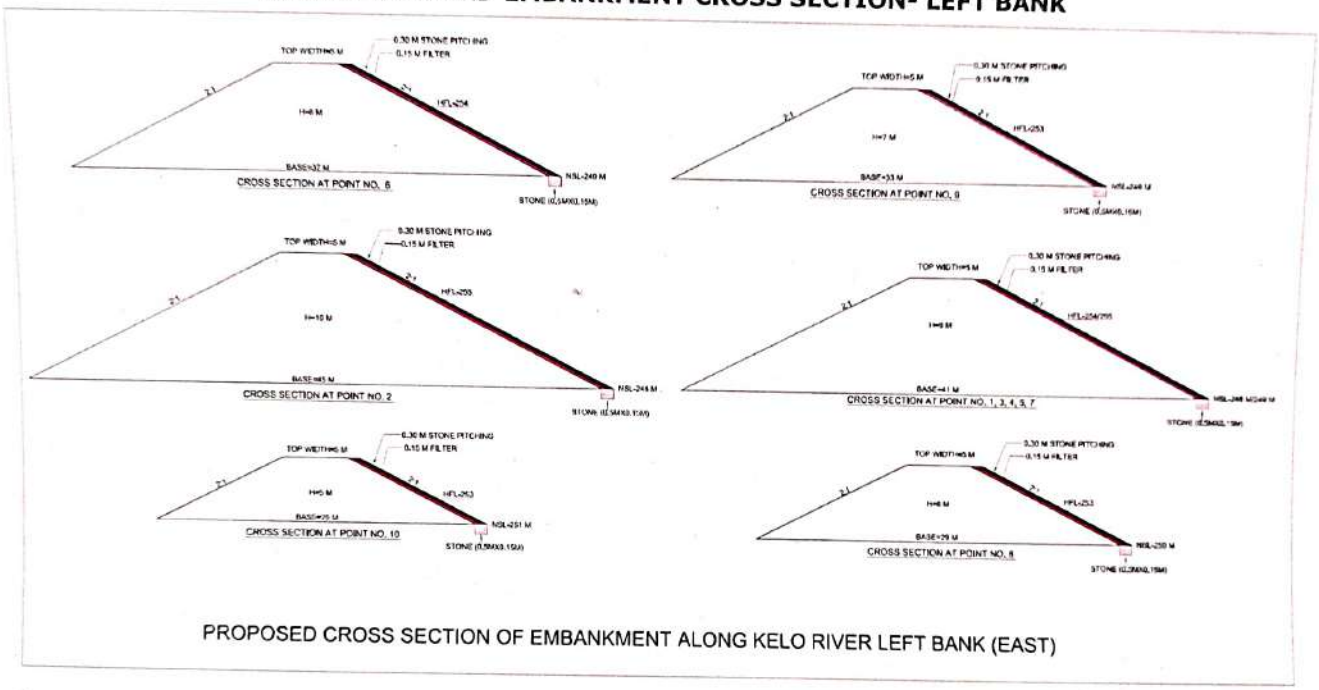
TABLE 11
DIMENSIONS OF EMBANKMENT ALONG KELO RIVER- RIGHT BANK (WEST)

Point No.	Bed level, m RL	NSL (Right bank), m RL	HFL, m RL	Height of embankment, m	RL of top of embankment, m RL	Base width, m
1	248	250	255	8	258	37
2	248	248	255	10	258	45
3	248	248	255	10	258	45
4	248	248	255	10	258	45
5	247	252	254	5	257	25
6	247	249	254	8	257	37
7	247	250	254	7	257	33
8	247	253	254	4	257	21
9	246	253	253	3	256	17
10	246	252	253	4	256	21

TABLE 12
DIMENSIONS OF EMBANKMENT ALONG KELO RIVER- LEFT BANK (EAST)

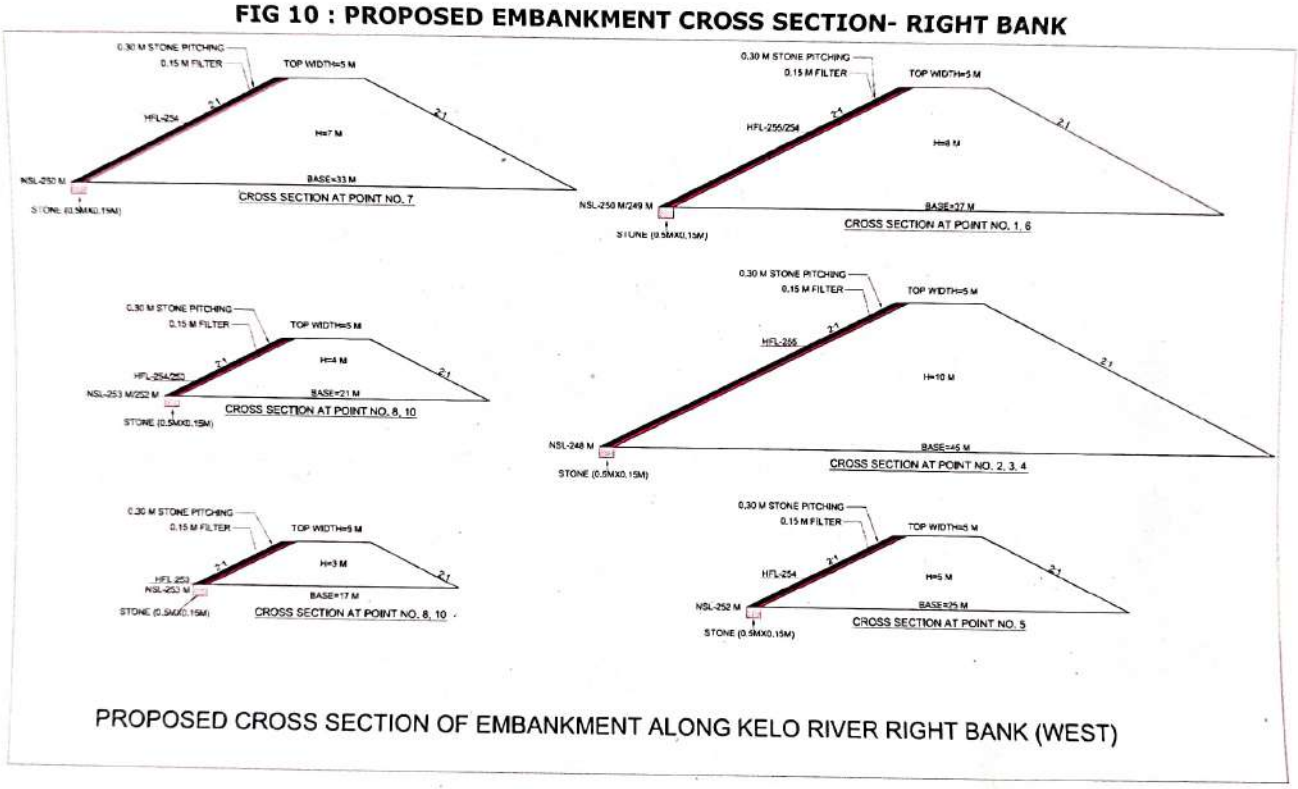
Point No.	Bed level, m RL	NSL (Right bank), m RL	HFL, m RL	Height of embankment, m	RL of top of embankment, m RL	Base width, m
1	248	249	255	9	258	41
2	248	248	255	10	258	45
3	248	249	255	9	258	41
4	248	248	254	9	257	41
5	247	248	254	9	257	41
6	247	249	254	8	257	37
7	247	248	254	9	257	41
8	247	250	253	6	256	29
9	246	249	253	7	256	33
10	246	251	253	5	256	25

FIG 9 : PROPOSED EMBANKMENT CROSS SECTION- LEFT BANK



PROPOSED CROSS SECTION OF EMBANKMENT ALONG KELO RIVER LEFT BANK (EAST)

FIG 10 : PROPOSED EMBANKMENT CROSS SECTION- RIGHT BANK



PROPOSED CROSS SECTION OF EMBANKMENT ALONG KELO RIVER RIGHT BANK (WEST)

FIG 11 : PROPOSED EMBANKMENT LONGITUDNAL SECTION- LEFT BANK

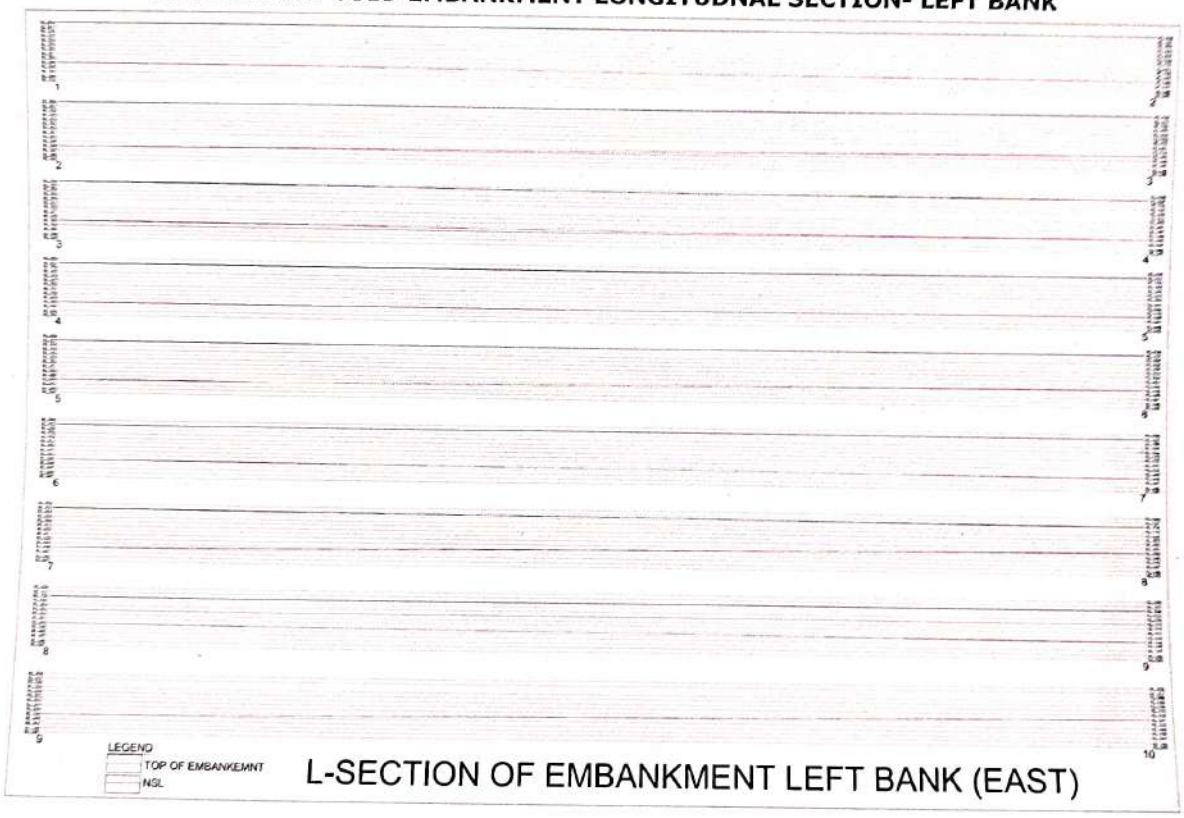
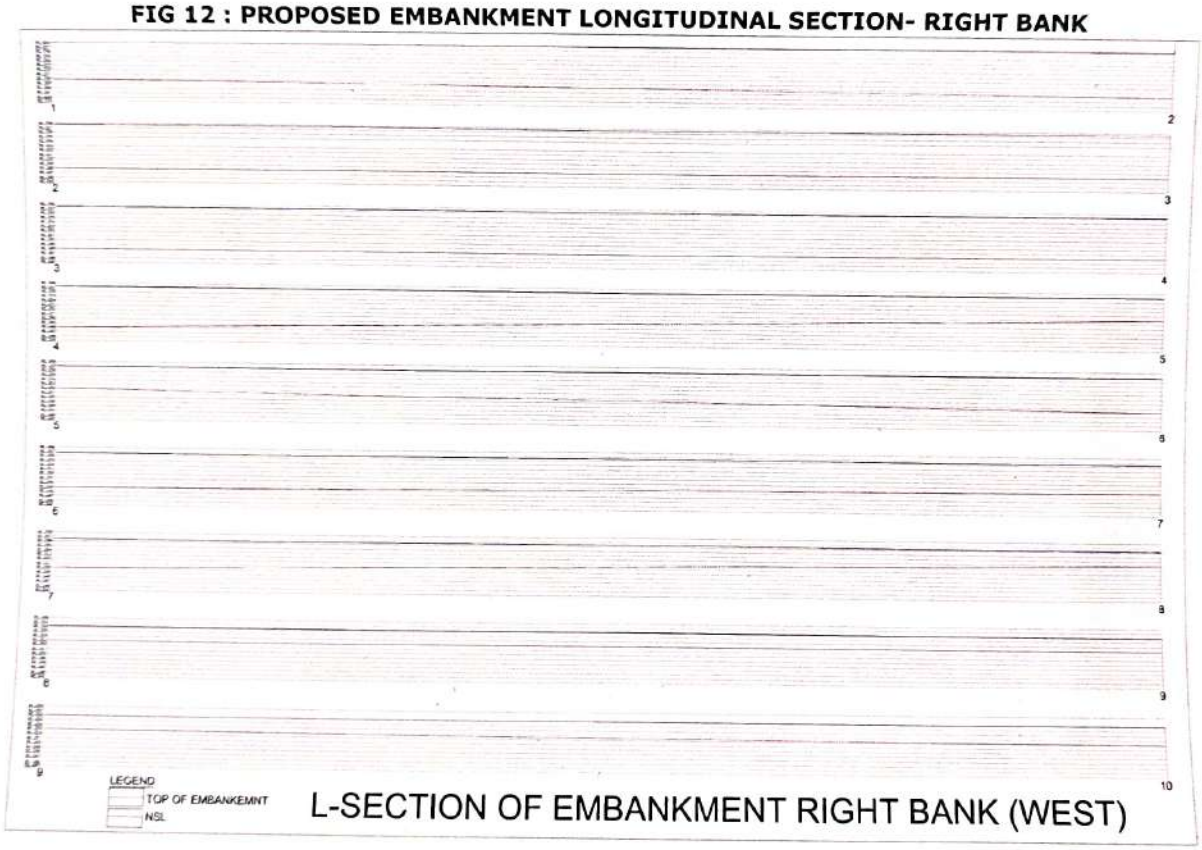


FIG 12 : PROPOSED EMBANKMENT LONGITUDINAL SECTION- RIGHT BANK



9.0 IMPACT OF MINING ON KELO RIVER

Kelo river passes through the eastern corner of the ML area. Kelo River is an important tributary of River Mahanadi. It also supplies water for drinking use to the urban settlements (Raigarh town) and for industrial requirements. The river is about 112 km long. It rises at an elevation of 710.36m. It enters plains after traversing 34.60 km from its origin. There will not be any impact on the path of the Kelo river due to mining in the Gare II coal block. The natural seepage from Kelo will increase during monsoons while the flow will be augmented by rainwater as well as mine sump water discharge (refer Section 10.1 for impact on flow). Compared to the base flow of Kelo river, the fluctuations due to decrease in catchment or increase due to mine water discharge are marginal.

Furthermore, siltation into the Kelo river will increase due to the material handling activities within the mine lease (refer Section 10.2 for siltation calculation). Thus, precautions are a necessity as detailed in Section 10.3.

9.1 Impact on flow

The catchment area of river Kelo upto Kelo on Raigarh G&D site is 950 sq.km. (source : http://india-wris.nrsc.gov.in/wrpinfo/index.php?title=Kelo_at_Raigarh_HO_242 accessed 30.04.2017)). The catchment upto Raigarh G&D is significant because 9.23 km upstream (measured along flow path) of the station, the Kelo Dam has been constructed. The impact of the mining activities will be felt upto the Kelo dam at most, whereafter the flow is regulated by the release of water from Kelo Dam. The distance of Kelo Dam is approximately 17 km from the site, aerially.

The catchment of Kelo upto the "Kelo Major Irrigation Project (MIP)" near Danot village of District Raigarh is 920.21 sq.km. as per EIA/EMP for Kelo Major Irrigation Project prepared by AFCL, March 2008.

The flow in Kelo river from its catchment as measured at Kelo G&D site (Latitude 21° 53' 47" and longitude 83° 24' 22") has been studied from 1996-97 to 2002-03 and the maximum flow observed was 739.2 cumecs on 11th September 1998 (Refer Annexure I).

The impact on Kelo river is anticipated in terms of seasonal fluctuations in flow. The eastern portion of the mine falls within the catchment of Kelo river, which is 406 sq.km. upto the southernmost point exit point from the mine. The western portion of the mine falls in the catchment of a nala originating from Silot RF and joining Pajhar nadi after flowing through various villages including

Kunjemura village. The catchment of the nala is 42.7 sq. km. The total catchment of the two is 448.94 sq.km. The catchment of the Kelo river and of the nala has been assessed from toposheet as shown in **Fig 13**.

The mine lease area with its facilities will be 2583.486 ha i.e. 25.835 sq.km. which works out as following percentage of catchment upto different points:

(i) Upto mine site (448.94 sq.km.) - 5.75%

(ii) upto Kelo MIP (920.21 sq.km.) - 2.81%

(iii) upto Raigarh G&D station (950 sq.km.) - 2.72%

The excavated area with & without backfill will be 24.4055 sq.km which would work out as following percentage of catchment upto different points:

(i) Upto mine site (448.94 sq.km.) - 5.44%

(ii) upto Kelo MIP (920.21 sq.km.) - 2.65%

(iii) upto Raigarh G&D station (950 sq.km.) - 2.57%

As backfilling will be concurrent to mining, the maximum void size at any point (25th year) has been estimated as of more than 737.42 ha (7.37 sq.km.) at any point of time. This would work out as following percentage of catchment upto different points:

(i) Upto mine site (448.94 sq.km.) - 1.64%

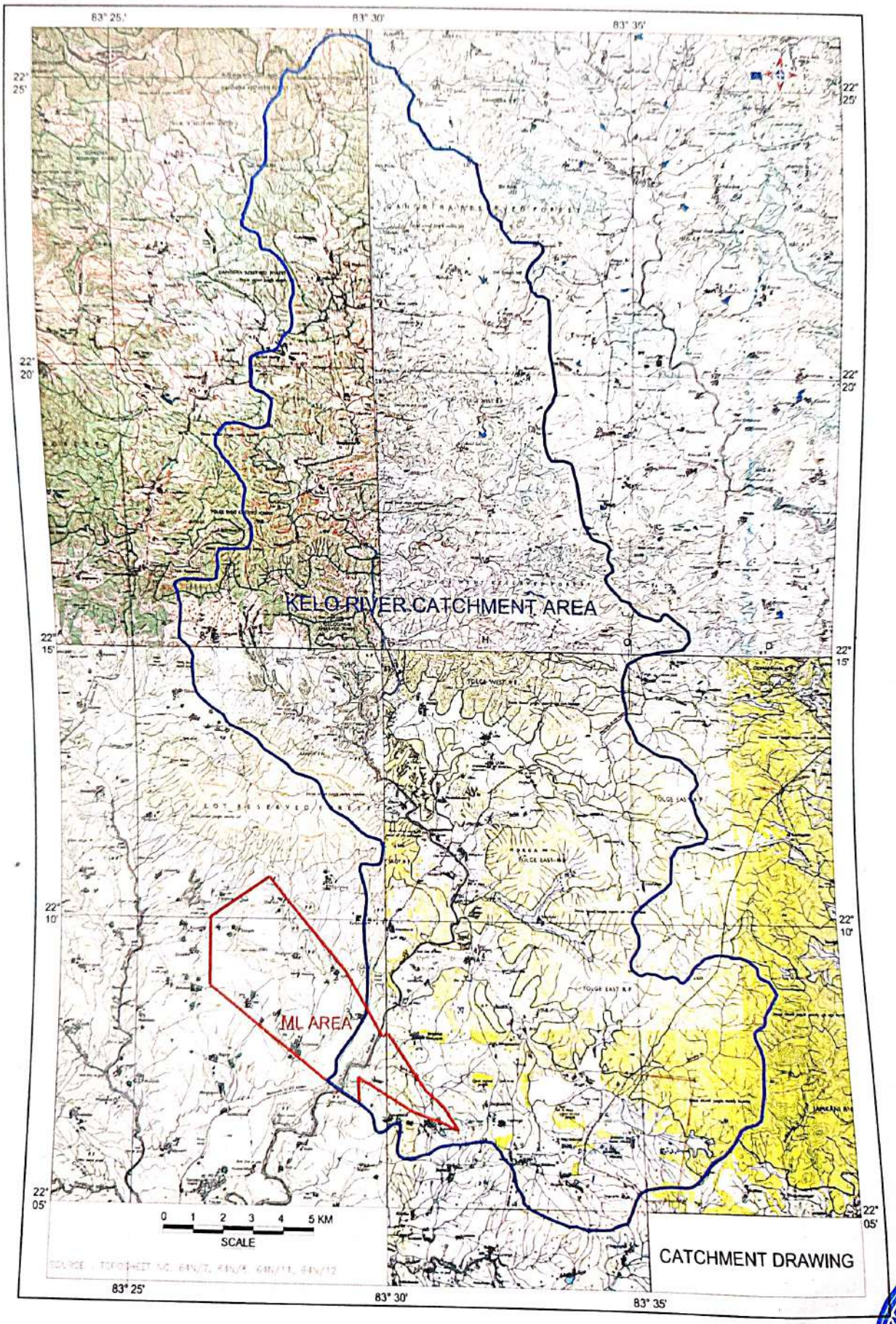
(ii) upto Kelo MIP (920.21 sq.km.) - 0.80%

(iii) upto Raigarh G&D station (950 sq.km.) - 0.78%

Therefore, of the entire flow from the catchment upto Kelo MIP, affect will by a reduction of 0.8% only which is a low impact on the downstream water balance. As per the calculations for mine discharge in "Hydrogeological Study Report Of Gare Pama Sector- II Coal Block", peak mine discharge is anticipated to be of the following order :

- Open cast (20th year) – 894 cum/day
- Underground (seam III) – 38125 cum/day
- Total (maximum) = 39019 cum/day

FIG 13 : CATCHMENT OF KELO RIVER UPTO THE GARE-II COAL BLOCK



Of this, the mine use water requirement of 1546 cum/day shall be met. The balance shall be 37473 cum/day i.e. 0.433 cumecs for disposal into Kelo river. In comparison to the peak discharge during monsoon season, this is 0.058%, which is negligible. During non monsoon, when the Kelo river is having lean flow, this volume of water will be still be negligible. However, it may be noted that the proposed mine is not the only mine who will discharge into the Kelo river and therefore the cumulative impact shall be different.

The opencast as well as underground mining will be occurring within a distance of 17-45 m of the bank of Kelo river. Hence, the natural seepage from Kelo will increase during monsoons. Also, there will be addition of water into Kelo from the pumped out mine sump water. However, from study of the hydrogeological map (Fig 19 & 20 of Hydrogeological Study), it is apparent that the flow of groundwater is towards Kelo river on the left bank area. Since the majorityof the lease area is located on the right bank of Kelo river, the base flow of river water due to ground water effluence is not anticipated a much on the west side as compared to east side.

The seepage of Kelo flow water into mine workings leading to impact on flow in Kelo river is a valid concern. The river water seepage will continue during mining similar to the way it is occurring naturally at present for the following reasons:

1. Between the river and the mine pit boundary, a minimum distance of 17 m to 45 m shall always be maintained at different sections of the river.
2. The river bed shall not be disturbed.
3. Since the characteristics of soil and aquifer shall not be disturbed, the hydraulic conductivity of the intervening soil body shall remain same as at present.
4. The inflow (transmissivity) is a function of the hydraulic conductivity, soil properties and saturation.
5. During mining, the inflow from river bed into the soil shall continue from Kelo at the same rate as at present since the intervening soil body characteristics will not change.
6. The water seeping into the mine shall be collected in mine sump, pumped to surface reservoir where settlement shall take place, monitored for Suspended Solids and released back into the Kelo river.
7. It is not intended to stop the natural inflow into mine pit as any measure like sub-surface obstructive sheets/ walls or interceptor bores for pumping shall disturb the soil and aquifer characteristics

Study of scientific literature shows that over long term, the hydraulic conductivity can change due to various factors such as mechanical stress, infiltration, solute/ contaminant movement, saturation, etc. Even in the same soil strata, the variation is hydraulic conductivity can be high thus affecting transmissivity into wells/ voids. If the water table is inside a soil layer with significant transmissivity, the water table may be drawn down whereby the transmissivity reduces and the flow of water to a well/ void diminishes. Unsaturated hydraulic conductivity decreases as volumetric content decreases because the cross-sectional area of water flow decreases, tortuosity increases and drag forces increase. However, on the other hand, in saturated soils, pathways can form which can increase the transmissivity. Moreover, there are natural fluctuations in the hydraulic conductivity during seasons.

Thus, in a dynamic scenario where the mine void will be constantly changing in terms of depth and length due to excavation as well as backfilling and the length of aquifer exposed shall be only for few month or years at a time, it is difficult to anticipate the exact long term changes in hydraulic conductivity. However, at present it may be rational to assume that atleast the present seepage from the river shall continue during non monsoon seasons. Also during open cast mining, the reversal of the hydraulic head is anticipated, especially during the monsoon season when the hydraulic head within the banks of the river will be higher than the hydraulic head in the mine pit. Hence, during monsoon season inflow into the mine pit from Kelo river will be higher.

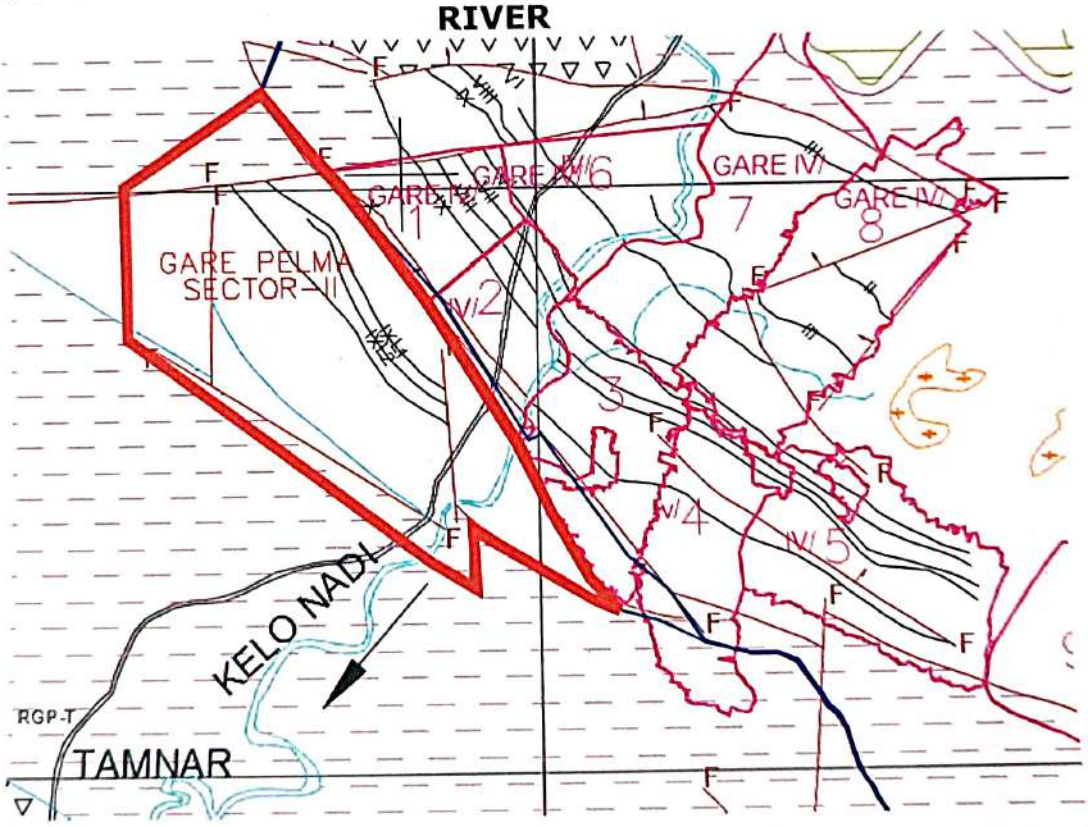
Seepage from Kelo into mine

As discussed earlier, since the beds/stream strike in North-South direction and dip towards west, there are chances of river water seepage along the bedding planes of sedimentary sequence. In view of the fact that no disturbance to sub-soil over a width of 17-45 m between the river bank and mine pit, the present flow rates are anticipated to continue. Since mining is proposed as per The Coal Mines Regulation Act of 1957 as well as the Mines and Minerals (Regulation & Development) Act 1957, only a 15 m barrier is required to be left between the embankment of Kelo river & the mine area. Mining shall eventually be done as per the permission granted by DGMS.

Cumulative impact : The perennial flow into the Kelo river is due to the water seepage from shallow aquifer from the eastern side of the river. Looking at the regional map showing the various blocks in **Fig 14** upstream of Gare-II, as the excavations for opencast mining take place, on the eastern side, reversal of head has taken/ will take

place and the natural contribution of flow in the Kelo shall decline in the stretch passing along Gare IV/5, Gare IV/2&3, Gare II and Gare I. The total affected length shall be approximately 10 km. Furthermore, as the mines on the western side start operation i.e. Tilaipali, Gare IV/8, Gare 1V/6, Gare III, Gare II and Gare I, there shall be reversal of head, especially during monsoon, leading to increase in seepage into the mine pits. This water will be pumped to the surface, utilized to the extent possible and then discharge back into Kelo or its tributaries. The quantification of impact on flow cannot be carried on the basis of the available data. However, it is quite possible that although there shall be decline in flow due to mining, there shall also be recharge of flow due to mine discharges which might lead to a balance.

FIG 14 : COAL BLOCKS UPSTREAM OF GARE-II ALONG KELO RIVER



The total catchment area of Kelo upto mine site (as per **Fig 13**) is 406 km^2 out of which an area of 12.799 sq.km. has been excavated for Gare IV/1,2&3 mines, 0.718+0.247 sq.km for Gare IV/4 sq.km, 1.822 sq.km for IV/7 mine, totalling to 15.586 sq.km will have to be deducted to account for excavations due to mining in upstream side. Thus, 390.414 sq.km. area of the catchment is not excavated as in March 2017 as assessed from Google Earth images. 3.8% of the catchment upto Gare-II south boundary or 1.64% of the catchment upto Kelo MIP or 1.6% of the catchment upto Raigarh G&D.

The above assessment is basic and based on study of publicly available reports and maps.

9.2 Siltation

Increase of siltation in to Kelo river due material handling activities within the mine lease, is a real possibility. Kelo river is a significant tributary of river Mahanadi, which it meets about 15 kms downstream of Jharsuguda in Odisha. The studies carried out by CWPRI in Mahandi basin have given a value of annual average sedimentation load as 466 tonnes/sq.km for Mahanadi basin. The calculations done for the various landuses of the mine shows that the siltation from the mine lies below the average given for the Basin.

The quantum of sand load carried by water depends upon the magnitude of flow, rainfall intensity, nature of formation, vegetation cover and slope. The adverse impact caused due to movement of sediment and land degradation need to be managed. To draw mitigation plan the quantum of sediment need to be estimated on account of mining activity. The standard method for estimation of water erosion and sediment removal is by universal equation developed by U.S. Dept of Agriculture, which is as under.

$$A = RKLSCP$$

Where

A = Average annual soil loss tonnes/ ha

R = Rainfall factor = $\frac{\Sigma KEI}{100}$

KE = $210.3 + 89 \log I$

I = Rainfall intensity in cm/hour

L = Length of slope

S = Steepness factor

C = Cropping & Mergent factor

K = Soil erodibility factor

P = Supporting conservative practices

The soil erodibility varies between 0.4 to 0.17 (Manual of soil and water conservation). An average value of 0.1 may be taken to estimate silt/sediment load generated. To evaluate rainfall intensity continuous rainfall record would be required, but based on available data and experience highest rainfall intensity has been taken as 25 cm/hour.

$$R = \frac{210.3 + 89 \log 25}{100} = 3.347$$

The steepness factor has been taken as 0.5 since the dump slope is kept as 2:1. Total length of slope for the waste dump is taken 3300 m for the 5th year stage plans and 1300 m for top soil dump. The cropping management & supporting conservation practice has not been condition without mitigation. In mitigation measure the value of each is taken as 0.5.

The external dump is the main source of generation of sediment load is mining industry. The sediment has been worked out based on aforesaid method under normal condition and after mitigation measures such as compaction, garland canal desiltation chambers/pits are constructed and plantation is done. The generated silt load at the end of 5th year of mining in the mine pit as well has been evaluated and given in **Table 13**. The silt / sediment load settles down in settling tank most of the time, except when sufficient time does not elapse during rains if mining continuous simultaneous to rainfall.

TABLE 13
SEDIMENT LOAD (TONNE PER ANNUM)

Source	Per Hectare		Total dump Area at 5th Year, ha	Total Generation	
	Without mitigation	With mitigation		Without mitigation	With mitigation
Surface dump	552.3	276.1	380	209874	104937
Topsoil	217.6	108.8	60	13.056	6528

The sediment load will be dredged and disposed in the OB dumps. The surface dump and topsoil dump will rehandled and backfilled as well as reused before 10th year. Thus, the above calculations apply only till the time external dumps and top soil dump exist.

9.3 Precautions during mining

1. Provision of garland drains around pit, dump and backfilled area.
2. Garland drain to connect to settling tank and thereafter discharged to surface reservoir(s)
3. Overflow from surface reservoirs to be monitored for suspended solids and thereafter released to Kelo river.

During mining a statutory barrier of 15 m is required to be left between the mine workings and the Kelo river bank. A bund shall be

constructed along the western bank of the Kelo river, the alignment and dimensions of which have been arrived at after a detailed study in Section 8.0 earlier. The width of the embankment shall vary from 17 m to 45 m. Therefore the barrier width will vary from 17 m to 45 m. On the western side of the embankment on right bank and on the eastern side of the embankment on left bank, mining shall be carried out. The level of top of this embankment will at least be 3 metre higher than the HFL of the river at every point. It is further planned to strengthen the embankment on riverside by placing large boulders in wire net bags to prevent erosion and damage to the embankment by floods in river/nala besides grouting any weak portions of the embankment. The embankment will also be stabilised by road rollers and vibrators followed by plantation of grass and bushes all over to prevent soil erosion. The height of the bund shall vary from 3 m to 10 m.

The location of the proposed bund can be seen in **Fig 7**. The construction of the bund shall reduce the flood plain of the Kelo river along a length of approximately 2 km along the western and eastern banks. The constriction of flow along this length of the river may warrant a further raising of the height of the bunds in order to accommodate the same volume of flow as at present. Thus, the prior approval from DGMS shall be taken on the design of the bund and the conditions imposed by DGMS shall be adhered to for the safety of both the mine and the river.

ANNEXURES

ANNUAL RAINFALL RECORDED AT IMD STATION, RAIGARH (1901-2010)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Deviation (%)
1901	23.1	49.3	15.9	23.9	17.0	109.3	222.8	317.7	218.8	15.9	9.9	0.0	1023.5	-24.9
1902	9.4	2.1	0.7	5.6	8.6	86.5	321.7	330.8	288.2	8.8	1.8	17.3	1081.4	-20.6
1903	4.0	13.4	2.8	1.7	32.0	142.0	513.0	293.0	189.4	66.0	1.4	0.6	1259.3	-7.5
1904	0.9	5.0	40.0	0.1	77.3	205.7	304.7	652.1	149.4	44.9	0.5	3.3	1483.9	8.9
1905	5.8	14.9	41.5	44.1	25.8	94.5	366.2	460.5	495.0	4.3	0.0	1.2	1553.7	14.1
1906	3.9	44.5	28.9	0.1	7.3	279.2	547.1	346.8	203.1	36.8	2.3	2.9	1503.0	10.4
1907	0.2	41.9	32.5	83.1	11.2	335.8	211.3	450.0	116.7	3.3	2.3	11.6	1299.7	-4.6
1908	12.8	22.2	10.3	3.4	10.9	263.5	315.7	504.5	177.3	48.4	0.0	0.8	1369.8	0.6
1909	1.4	11.4	0.4	59.7	15.8	229.0	489.3	289.5	159.0	3.0	0.0	5.7	1264.0	-7.2
1910	6.9	3.5	17.6	11.6	10.1	188.2	387.4	436.5	264.5	77.9	13.9	0.0	1418.1	4.1
1911	3.8	0.2	35.0	0.9	12.9	424.1	216.1	440.6	298.7	73.1	22.1	0.2	1527.6	12.2
1912	0.3	38.8	2.7	16.7	18.0	43.8	448.3	438.7	182.8	13.3	8.3	0.2	1212.0	-11
1913	0.0	50.2	36.0	5.3	22.0	258.9	362.0	426.5	196.9	52.3	1.7	10.5	1422.4	4.4
1914	1.3	10.4	32.4	40.8	25.7	193.1	296.1	465.0	247.6	6.8	0.0	9.3	1328.5	-2.5
1915	16.0	49.8	31.0	9.8	17.3	99.1	300.2	409.3	247.9	44.8	14.3	0.0	1239.5	-9
1916	0.0	14.5	0.2	6.3	8.6	199.9	353.1	439.7	188.9	71.6	3.1	0.0	1285.9	-5.6
1917	1.0	45.1	5.8	9.2	43.3	205.6	358.4	513.9	305.6	168.6	0.4	0.6	1657.6	21.7
1918	8.9	0.9	11.7	4.6	24.1	324.7	237.4	585.9	192.6	3.8	0.8	5.3	1400.6	2.8

ANNEXURE : I

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Deviation (%)
1919	44.6	36.0	37.6	11.8	26.7	278.9	409.5	598.0	188.9	99.1	8.9	3.4	1743.3	28
1920	2.3	11.4	37.9	8.3	10.5	87.0	553.4	436.2	103.4	11.5	0.0	0.0	1261.9	-7.4
1921	32.3	9.4	0.2	5.8	0.2	299.9	368.3	526.4	176.5	13.9	0.0	0.0	1432.8	5.2
1922	8.3	0.4	0.2	6.8	8.0	265.1	521.1	392.8	329.6	50.6	11.5	0.6	1594.9	17.1
1923	0.0	44.5	6.0	10.9	2.7	102.2	405.7	537.0	226.9	23.6	5.0	0.1	1364.7	0.2
1924	21.4	13.6	3.0	20.3	9.9	83.5	376.2	356.6	300.0	60.3	14.7	0.7	1260.1	-7.5
1925	0.0	2.7	5.3	6.9	47.7	215.5	475.0	661.9	147.8	15.9	6.9	0.3	1585.9	16.4
1926	4.0	1.0	68.3	20.7	38.8	115.6	413.5	649.1	311.2	42.4	2.4	8.8	1675.7	23
1927	3.4	23.9	68.7	1.3	12.3	170.0	554.3	639.3	112.3	54.0	10.0	0.5	1650.1	21.2
1928	3.5	10.2	7.5	15.9	16.3	135.6	634.4	290.4	265.6	91.4	0.0	2.5	1473.4	8.2
1929	14.0	23.1	3.2	14.9	7.6	175.5	611.2	629.0	177.9	113.9	0.0	19.9	1790.2	31.4
1930	0.9	0.8	24.3	17.6	5.4	122.0	332.9	274.0	263.2	29.4	23.8	8.0	1102.3	-19.1
1931	1.0	36.5	21.2	10.6	9.0	45.1	438.2	590.0	223.5	81.2	15.6	2.6	1474.4	8.2
1932	0.0	26.0	1.4	7.1	18.8	86.9	664.8	495.3	217.9	15.7	13.9	1.2	1548.9	13.7
1933	8.7	16.9	10.3	31.8	32.0	233.7	337.9	477.7	204.4	55.4	3.9	5.8	1418.6	4.2
1934	3.8	2.2	1.6	10.8	0.5	201.9	478.2	699.8	266.1	55.9	14.6	0.9	1736.3	27.5
1935	2.4	3.3	2.6	18.7	3.3	124.0	488.4	543.0	241.5	3.9	0.0	0.0	1430.9	5.1
1936	2.2	56.4	24.6	2.6	41.3	381.3	560.9	468.8	287.5	91.6	5.1	8.2	1930.8	41.8
1937	0.0	56.5	24.6	40.3	8.2	93.2	555.6	339.9	205.7	68.3	0.0	0.0	1392.4	2.2
1938	12.1	23.9	14.6	11.1	28.8	211.5	307.0	396.1	226.5	94.4	3.9	0.0	1329.9	-2.4

ANNEXURE : I Contd..

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Deviation (%)
1939	7.9	10.7	29.7	14.6	1.0	178.5	474.7	345.4	229.3	68.3	2.7	0.0	1362.8	0.1
1940	0.3	34.2	77.8	12.7	19.4	135.2	366.7	541.4	106.7	34.6	3.8	5.3	1338.0	-1.8
1941	14.0	5.8	25.0	2.3	20.4	274.9	237.7	414.0	165.8	33.8	3.7	0.0	1197.4	-12.1
1942	12.7	55.0	21.5	24.5	10.0	135.6	546.0	537.0	262.9	8.3	0.7	0.1	1614.4	18.5
1943	19.9	5.1	1.4	33.9	30.0	116.5	467.4	624.3	216.6	48.0	0.8	0.0	1563.9	14.8
1944	13.4	47.4	106.5	18.0	15.9	88.7	556.6	571.4	209.7	73.7	1.2	0.0	1702.4	25
1945	12.6	13.4	0.2	17.9	14.7	191.3	403.0	276.2	375.9	69.2	4.6	4.2	1383.3	1.6
1946	0.0	10.7	16.9	29.0	23.0	242.6	549.0	559.6	296.5	57.8	10.0	1.2	1796.2	31.9
1947	15.9	8.0	34.1	6.0	4.5	138.7	515.3	375.5	360.9	51.8	3.7	7.6	1522.0	11.7
1948	8.5	13.1	18.6	9.4	13.5	203.1	338.8	346.4	334.7	35.3	26.9	1.2	1349.6	-0.9
1949	0.0	10.6	11.4	7.7	31.3	128.6	287.2	587.6	205.9	127.6	0.0	0.0	1397.9	2.6
1950	4.0	28.7	55.0	4.4	3.6	138.5	439.0	471.6	105.9	10.5	9.7	7.2	1278.1	-6.2
1951	3.0	2.0	69.1	25.4	17.1	131.6	440.2	385.2	192.3	49.3	0.6	0.0	1315.8	-3.4
1952	0.4	10.5	30.2	13.8	11.3	169.5	351.0	330.4	307.4	38.5	0.0	10.5	1273.4	-6.5
1953	16.2	0.2	0.2	11.9	4.5	143.4	342.1	596.6	240.7	31.6	1.0	0.0	1388.6	2
1954	3.1	9.6	10.3	8.2	10.5	114.4	327.5	429.6	350.6	34.0	0.0	0.7	1298.5	-4.7
1955	8.5	6.3	29.3	9.9	4.3	85.6	338.3	398.3	181.2	104.0	1.0	0.0	1166.7	-14.3
1956	6.6	10.6	4.7	1.2	50.2	249.1	498.8	569.4	301.7	36.5	3.5	5.7	1738.1	27.6
1957	5.2	2.6	34.9	12.2	9.1	140.6	573.4	431.5	126.3	33.5	0.0	0.3	1369.5	0.6
1958	11.8	9.8	26.8	21.6	13.6	68.0	540.9	370.8	305.6	112.0	3.8	0.0	1484.6	9

ANNEXURE : I Contd..

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Deviation (%)
1959	15.3	2.5	0.2	4.8	20.5	181.1	408.2	392.6	244.7	92.0	0.0	1.9	1363.8	0.1
1960	2.6	0.2	39.1	14.2	22.5	108.8	422.4	468.4	175.7	57.1	0.0	0.0	1371.2	0.7
1961	18.2	51.1	26.5	7.1	18.3	228.6	367.3	443.7	258.0	89.9	5.4	7.8	1521.7	11.7
1962	4.9	24.2	6.3	14.6	8.0	156.1	384.4	379.1	252.2	16.0	1.7	19.6	1267.2	-7
1963	4.0	3.7	31.9	19.1	38.1	109.5	314.7	510.5	231.2	75.1	1.3	0.0	1339.0	-1.7
1964	0.2	30.4	10.0	29.8	15.7	179.4	325.5	602.3	238.9	60.3	9.8	0.0	1502.3	10.3
1965	4.6	0.7	23.1	26.0	13.8	106.6	439.7	227.6	198.6	15.1	0.0	2.9	1058.8	-22.3
1966	34.4	1.6	2.9	7.8	8.4	202.5	207.2	292.5	147.1	9.0	3.6	18.0	935.0	-31.4
1967	14.9	0.2	74.5	10.8	7.1	189.0	338.8	552.1	280.2	12.3	0.0	31.6	1511.5	11
1968	13.5	13.5	22.5	20.4	8.1	126.7	344.1	312.2	238.2	49.4	2.7	3.2	1154.5	-15.2
1969	0.3	2.0	5.2	10.3	27.7	105.3	631.7	402.5	288.5	16.2	9.3	29.3	1528.4	12.2
1970	8.4	16.0	36.4	12.4	16.1	260.9	338.3	530.2	289.7	20.8	0.0	0.0	1529.1	12.3
1971	9.8	12.2	3.4	34.6	53.1	373.4	421.3	598.9	145.4	61.7	0.0	0.0	1713.7	25.8
1972	4.9	47.6	0.8	24.7	5.1	93.8	429.6	420.0	208.1	85.1	17.0	1.3	1337.9	-1.8
1973	1.2	0.2	5.5	6.6	2.6	181.4	145.8	369.9	178.9	113.1	0.6	0.5	1006.4	-26.1
1974	0.0	2.9	4.9	3.2	17.5	184.2	455.1	262.5	116.8	77.3	4.4	0.0	1128.8	-17.1
1975	1.2	13.5	24.9	6.7	16.1	234.8	497.4	307.9	246.4	89.7	3.8	0.0	1442.3	5.9
1976	5.9	3.0	5.9	33.0	18.0	77.7	467.2	374.5	374.7	1.0	6.3	1.4	1368.5	0.5
1977	4.3	2.4	0.9	47.2	63.9	184.2	516.1	465.7	209.1	32.8	29.0	13.9	1569.6	15.2
1978	10.3	48.5	41.0	48.0	10.3	336.8	333.8	465.2	319.4	33.0	5.7	19.3	1671.3	22.7

ANNEXURE : I Contd..

MAHARASHTRA STATE POWER GENERATION CO. LTD. Executive Director (E&S) Mumbai

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Deviation (%)
1979	5.0	15.0	0.2	13.5	1.7	220.8	415.8	346.3	187.5	29.2	9.7	5.1	1250.0	-8.2
1980	16.6	14.4	16.1	5.8	8.8	324.7	470.6	341.4	148.4	16.9	0.0	2.2	1366.1	0.3
1981	16.2	4.5	47.6	17.8	24.0	79.9	396.9	285.2	230.3	8.2	3.9	4.7	1119.1	-17.8
1982	11.7	12.3	55.7	19.4	24.5	157.0	347.0	534.7	289.2	6.9	12.0	2.9	1473.5	8.2
1983	1.2	22.5	17.3	17.8	34.9	162.6	375.2	325.2	165.8	53.3	0.5	3.3	1179.6	-13.4
1984	13.6	22.1	2.2	18.0	14.2	314.2	402.7	370.7	145.3	30.1	0.0	0.0	1332.9	-2.1
1985	21.1	1.7	2.1	3.4	9.4	190.1	441.9	443.4	177.5	97.8	0.0	0.5	1389.1	2
1986	20.4	36.5	2.5	13.6	12.1	185.1	393.0	500.7	132.2	9.9	10.4	11.8	1328.2	-2.5
1987	5.6	7.3	15.0	3.8	19.3	82.0	318.1	531.8	350.9	35.3	10.1	2.1	1381.4	1.4
1988	2.1	13.6	30.9	16.6	26.6	221.3	398.4	278.9	163.8	24.9	1.7	1.0	1179.9	-13.4
1989	0.1	0.2	32.7	1.7	32.3	221.2	314.3	417.6	184.0	29.7	3.9	23.7	1261.5	-7.4
1990	0.9	62.7	45.7	3.8	45.5	321.1	579.3	510.9	192.9	89.7	2.9	2.5	1857.7	36.4
1991	11.9	5.0	40.6	15.7	6.2	200.4	384.2	556.7	166.4	21.9	2.8	20.9	1432.8	5.2
1992	10.0	3.1	0.2	5.7	10.4	108.6	315.1	287.8	122.2	44.1	3.6	0.0	910.8	-33.1
1993	2.3	1.6	24.4	3.2	26.5	98.9	305.3	248.3	270.2	76.8	0.1	0.0	1057.7	-22.3
1994	15.3	9.7	29.5	14.5	21.4	281.0	477.0	454.1	118.1	78.5	1.7	0.0	1500.9	10.2
1995	7.0	5.4	57.0	4.7	23.7	122.1	418.8	298.5	231.1	41.4	4.1	0.0	1213.8	-10.9
1996	11.5	6.8	7.0	11.4	2.7	207.3	350.9	390.1	126.7	72.5	3.9	0.0	1190.6	-12.6
1997	14.9	0.3	35.8	14.3	22.7	35.8	270.6	393.1	143.7	17.0	20.3	26.9	995.4	-26.9
1998	4.6	26.0	7.6	11.7	40.9	70.2	259.3	262.4	169.1	111.9	22.4	0.0	986.1	-27.6

ANNEXURE : I Contd..

MAHARASHTRA STATE POWER GENERATION CO. LTD. Mumbai
Executive Director (E&S)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Deviation (%)
1999	7.3	6.2	0.2	0.1	24.7	153.8	278.6	583.7	156.3	34.1	0.1	0.0	1245.0	-8.6
2000	2.5	43.1	0.2	13.5	13.3	272.4	220.3	264.0	178.6	26.6	0.0	0.0	1034.5	-24
2001	0.7	0.2	37.0	15.8	21.0	125.0	346.7	480.5	74.5	55.1	6.7	0.0	1163.3	-14.6
2002	38.3	5.6	8.9	11.5	15.3	107.6	221.4	467.9	124.8	49.4	5.4	0.0	1055.9	-22.5
2004	18.8	0.0	0.0	0.0	0.0	168.5	289.2	474.8	61.9	36.6	0.0	0.0	1049.8	-22.9
2005	37.5	8.2	0.0	0.0	0.0	277.1	427.6	310.4	121.6	64.4	0.0	0.0	1246.8	-8.5
2006	0.0	0.0	0.0	0.0	91.2	117.5	308.2	430.6	110.2	26.1	5.3	0.0	1089.1	-20
2007	0.0	35.2	17.2	0.0	29.6	233.1	342.3	318.2	239.5	40.1	36.6	0.0	1291.8	-5.2
2008	22.4	21.3	27.8	31.5	2.3	256.7	298.1	586.5	261.5	5.8	0.0	0.0	1513.9	11.2
2009	0.0	0.0	0.0	0.0	0.0	15.3	650.4	194.8	92.2	25.5	0.0	0.0	978.2	-28.2
2010	0.0	0.0	0.0	0.0	0.0	117.1	319.5	251.4	251.2	21.3	7.3	20.5	988.3	-27.4
Average	**8.3**	**16.3**	**20.5**	**14.3**	**18.5**	**177.2**	**398.7**	**435.6**	**215.6**	**47.4**	**5.3**	**4.2**	**1362.0**	

(Source: http://www.indiawaterportal.org/met_data, https://data.gov.in/catalog/all-india-area-weighted-monthly-seasonal-and-annual-rainfall-mm)

ANNEXURE : I Contd..

MAHARASHTRA STATE POWER GENERATION CO LTD
Executive Director (E&S)
Mumbai

ANNUAL RAINFALL RECORDED AT GHARGHODA BLOCK (1977-2017)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1977	0.0	0.0	0.0	0.0	0.0	371.7	515.9	349.8	130.3	24.5	14.0	0.0	1406.2
1978	0.0	20.4	56.0	22.7	0.0	39.9	351.4	289.0	95.8	0.0	0.0	0.0	875.2
1979	0.0	0.0	0.0	0.0	0.0	79.0	154.4	242.2	100.6	31.3	10.4	0.0	617.9
1980	0.0	0.0	0.0	10.0	0.0	195.2	562.2	306.8	244.5	16.6	0.0	0.0	1335.3
1981	20.8	0.0	11.0	0.0	0.0	98.4	471.7	342.7	147.6	19.6	0.0	0.0	1111.8
1982	13.6	15.6	57.6	0.0	47.0	24.2	174.6	744.0	94.7	35.6	0.0	0.0	1206.9
1983	0.0	50.2	8.6	15.8	42.2	87.5	469.3	342.0	354.4	24.6	0.0	10.4	1405
1984	33.6	31.2	0.0	0.0	0.0	267.6	334.2	403.4	82.8	31.6	0.0	0.0	1184.4
1985	65.4	29.2	0.0	0.0	34.6	120.1	538.0	317.2	131.1	47.0	0.0	0.0	1282.6
1986	30.8	70.8	18.8	49.0	21.4	401.2	585.4	207.9	105.6	70.6	38.6	3.2	1603.3
1987	13.2	0.0	3.2	2.0	32.2	117.8	732.2	82.4	200.7	34.6	49.8	0.0	1268.1
1988	2.0	53.0	0.0	15.0	12.0	185.3	411.0	401.2	135.5	39.4	0.0	0.0	1254.4
1989	0.0	0.0	5.8	0.0	0.0	272.8	494.4	264.8	314.4	19.2	0.0	13.8	1385.2
1990	0.0	21.6	14.6	10.8	86.6	260.2	453.8	228.2	180.4	75.6	9.2	0.0	1341
1991	41.7	11.2	18.8	0.0	0.0	112.5	451.1	535.4	189.2	26.2	0.0	71.0	1457.1
1992	0.0	11.2	14.8	0.0	0.0	176.3	361.8	292.0	136.2	10.6	0.0	0.0	1002.9
1993	0.0	0.0	11.0	0.0	0.0	195.7	226.9	298.6	379.2	0.0	0.0	0.0	1111.4
1994	0.0	0.0	0.0	0.0	0.0	444.0	535.2	420.4	73.0	5.0	0.0	0.0	1477.6
1995	0.0	0.0	19.0	0.0	0.0	82.4	389.0	246.2	20.0	86.4	0.0	0.0	843
1996	0.0	0.0	0.0	0.0	0.0	175.0	421.4	449.0	149.0	8.0	0.0	0.0	1202.4
1997	0.0	0.0	0.0	0.0	0.0	94.5	290.0	203.0	181.3	0.0	14.0	38.7	821.5
1998	175.9	0.0	0.0	0.0	0.0	166.0	288.0	307.0	264.0	89.8	15.0	0.0	1305.7
1999	0.0	0.0	9.0	0.0	0.0	219.0	341.8	409.2	327.0	29.0	0.0	0.0	1335
2000	0.0	0.0	0.0	0.0	0.0	126.0	185.7	186.6	181.7	0.0	0.0	0.0	680
2001	0.0	0.0	0.0	0.0	16.0	203.4	461.4	253.3	121.7	133.1	0.0	0.0	1188.9

ANNEXURE : I CONTD.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2002	0.0	0.0	0.0	0.0	36.2	240.4	329.8	509.0	445.5	143.2	0.0	0.0	1704.1
2003	0.0	10.5	0.0	0.0	0.0	157.8	274.7	383.9	548.7	221.2	0.0	0.0	1596.8
2004	44.2	0.0	0.0	0.0	27.0	166.0	431.8	687.3	113.6	53.2	0.0	0.0	1523.1
2005	46.0	17.4	0.0	6.2	8.2	560.0	499.9	316.2	173.2	171.0	0.0	0.0	1798.1
2006	0.0	0.0	69.2	14.0	15.0	154.3	377.3	299.9	98.8	23.0	0.0	0.0	1051.5
2007	0.0	67.7	3.5	5.0	58.3	323.1	402.1	458.2	256.0	43.2	35.0	0.0	1652.1
2008	0.0	12.0	47.6	30.0	0.6	260.4	362.6	497.8	347.8	10.0	0.0	0.0	1568.8
2009	0.0	0.0	0.0	0.0	16.0	15.8	629.0	279.6	119.0	141.4	46.6	0.0	1247.4
2010	0.0	0.0	0.0	0.0	14.0	144.7	310.3	243.7	245.0	0.0	0.0	16.3	974
2011	0.0	0.0	0.0	20.6	0.0	106.6	229.9	282.0	526.1	0.0	0.0	0.0	1165.2
2012	61.2	0.0	0.0	0.0	0.0	177.7	283.3	591.2	265.9	6.4	36.7	2.9	1425.3
2013	0.0	12.9	3.7	37.5	0.0	183.8	312.4	486.5	117.8	207.1	0.0	0.0	1361.7
2014	14.3	85.6	46.9	0.0	85.6	257.4	427.0	343.7	217.2	43.8	0.0	0.0	1521.5
2015	5.0	0.0	14.7	10.3	0.0	271.2	416.1	372.1	118.4	29.3	0.0	5.5	1242.6
2016	0.0	4.4	40.2	0.0	32.7	108.8	514.9	246.2	347.9	44.6	0.0	0.0	1339.7
2017	2.0	0.0	0.0										
Average	**13.9**	**12.8**	**11.6**	**6.2**	**14.6**	**191.1**	**400.0**	**353.0**	**207.0**	**49.9**	**6.7**	**4.0**	**1240.9**

ANNEXURE : I Contd..

MAHARASHTRA STATE POWER GENERATION CO. LTD. Executive Director (E&S) Mumbai

ANNUAL RAINFALL RECORDED AT LAILUNGA BLOCK (1999-2016)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1999	0.0	0.0	0.0	0.0	0.0	183.5	294.0	369.0	274.0	90.0	0.0	0.0	1210.5
2000	0.0	0.0	0.0	0.0	0.0	0.0	213.5	232.5	145.5	9.0	0.0	0.0	600.5
2001	0.0	0.0	6.0	0.0	21.5	212.0	516.5	309.3	102.5	95.0	0.0	0.0	1262.8
2002	2.0	0.0	26.0	0.0	47.0	214.5	256.0	588.5	652.5	43.0	2.0	0.0	1831.5
2003	0.0	35.0	13.0	17.0	0.0	361.0	169.3	265.9	474.2	382.0	46.0	16.0	1779.4
2004	43.0	0.0	0.0	20.0	42.0	266.2	533.6	584.1	308.8	104.5	0.0	0.0	1902.2
2005	67.0	91.0	0.0	0.0	0.0	426.0	601.5	260.0	190.0	91.0	0.0	9.0	1735.5
2006	0.0	0.0	50.0	24.0	99.0	70.5	425.5	330.5	84.5	18.0	0.0	0.0	1102.0
2007	0.0	40.0	31.0	18.3	38.0	130.5	532.0	242.0	165.5	12.0	66.0	0.0	1275.3
2008	2.0	10.0	34.0	30.0	0.0	323.0	386.0	239.0	269.5	0.0	0.0	0.0	1293.5
2009	0.0	0.0	0.0	0.0	0.0	58.5	392.7	196.0	149.2	162.0	33.0	0.0	991.4
2010	0.0	0.0	0.0	0.0	0.0	131.0	189.0	144.5	203.0	15.0	0.0	12.0	694.5
2011	0.0	4.0	0.0	2.0	0.0	146.0	191.5	224.6	389.5	2.0	0.0	0.0	959.6
2012	30.0	16.0	0.0	0.0	0.0	457.6	162.2	257.7	351.0	0.0	37.5	0.0	1312
2013	0.0	0.0	0.0	31.0	10.0	81.0	175.0	233.4	82.5	181.7	0.0	0.0	794.6
2014	2.5	11.0	55.3	0.0	99.0	274.2	150.7	168.8	119.9	45.4	0.0	0.0	926.8
2015	12.3	0.0	9.5	30.5	0.0	172.8	469.3	249.4	71.9	59.0	0.0	0.0	1074.7
2016	0.0	8.3	11.5	0.0	7.5	78.0	513.6	227.2	280.0	13.0	0.0	0.0	1139.1
Average	**8.8**	**12.0**	**13.1**	**9.6**	**20.2**	**199.2**	**342.9**	**284.6**	**239.7**	**73.5**	**10.3**	**2.1**	**1215.9**

ANNEXURE : I Contd..

ANNUAL RAINFALL RECORDED AT TAMNAR BLOCK (2009-2017)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2009	0.0	0.0	0.0	0.0	0.0	23.7	624.7	260.9	94.9	148.5	0.0	0.0	1152.7
2010	0.0	0.0	0.0	0.0	0.0	118.0	327.8	267.9	282.4	0.0	0.0	7.7	1003.8
2011	0.0	67.0	0.0	0.0	0.0	117.5	360.4	581.9	526.1	0.0	0.0	0.0	1652.9
2012	180.5	16.0	0.0	0.0	0.0	232.6	214.8	433.5	227.2	2.0	37.0	2.0	1345.6
2013	0.0	0.0	7.0	16.0	3.0	127.0	256.7	277.0	136.5	193.5	0.0	0.0	1016.7
2014	0.0	40.0	28.0	0.0	25.0	99.0	394.1	168.9	152.2	0.0	0.0	0.0	907.2
2015	0.0	0.0	2.0	0.0	0.0	227.5	360.0	299.0	79.2	12.2	0.0	0.0	979.9
2016	0.0	0.0	15.7	0.0	10.7	92.5	396.4	396.5	285.2	8.0	0.0	0.0	1205
2017	6.2	0.0	0.0										6.2
Average	**20.7**	**13.7**	**5.9**	**2.0**	**4.8**	**129.7**	**366.9**	**335.7**	**223.0**	**45.5**	**4.6**	**1.2**	**1153.7**

ANNEXURE : I Contd..

ANNEXURE : II

Daily, 10-daily& monthly Discharge data River a Mahanadi/Kelo at Kelo G&D site

District: Raigarh
State: Chattisgarh
Distance from origin: 431.166 Km

Latitude: 21° 53' 47"
Longitude: 83° 24' 22"

Water Year: 1996-97

Unit: Cumecs

Date	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1	0	5.86	88.95	172	11.35							
2	0	6.89	194.4	133.6	9.5							
3	0	2.55	67.11	97.27	9.18							
4	0	3.82	58	75.09	8.21							
5	0	2.51	72.61	44.34	7.98							
6	0	85.81	45.71	95.84	7.9							
7	0	50	80.96	114.1	8.09							
8	0	23.18	41.28	114	7.19							
9	0	8.99	30.46	117.2	7.01							
10	0	5.66	75.79	96.68	6.82							
11	0	7.09	124	130.8	6.33							
12	0	199.9	44.77	58.47	6.26							
13	0	83.29	30.54	36.7	6							
14	0	50.42	28.35	38.27	5.57							
15	0	39.91	40	44	5.47							
16	0	11.44	64.08	81.46	4.46							
17	0	6	70.69	35.58	3.93							
18	0	6.32	88	90.47	3.83							
19	0	5	129.1	37.74	3.74							
20	0	4.73	190.1	24.34	3.7							
21	0	150	200.4	14.59	0							
22	12.52	121.4	247.9	8.5	0							
23	65	175.1	124.7	7.72	0							
24	13.64	123.2	113.2	8.67	0							
25	8.2	78.77	55	9.64	0							
26	4.94	469	53.64	9.06	0							
27	4.11	226.6	116.3	15.32	0							
28	1.95	118	50.53	10.68	0							
29	1.69	50	33.19	10	0							
30	15	32.2	171.9	23.78	0							
31		32.96	169.7		0							
Mean max min discharge summary												
Day 1-10	0	19.5	75.5	106	8.3	0	0	0	0	0	0	0
Day 11-20	0	41.4	81	57.8	4.9	0	0	0	0	0	0	0
R.Days	14.1	143.4	121.5	11.8	0	0	0	0	0	0	0	0
Monthly	14.1	70.5	93.6	58.5	6.6	0	0	0	0	0	0	0
Max	65	469	247.9	172	11.4	0	0	0	0	0	0	0
Min	0	2.5	28.4	7.7	0	0	0	0	0	0	0	0
Runoff volume and depth												
Monthly(MCM)	11	188.9	250.7	151.7	11.4		0	0	0	0	0	0
Monthly(mm)												
a) Mean Annual Discharge(cumecs)=					58.7		d) Annual specific discharge (cumecs/km2)=					
b) Annual Runoff Volume(MCM)=					613.7		e) Annual Runoff depth(mm)=					
c) Monsoon Runoff Volume(MCM)=					602.3		f) Monsoon Runoff depth(mm)=					
			Peak Annual Discharge= 0 cumecs						Catchment Area= NA km2			

MAHARASHTRA STATE POWER GENERATION CO LTD
Executive Director (E&S)
Mumbai

ANNEXURE : II

Daily, 10-daily& monthly Discharge data River a Mahanadi/Kelo at Kelo G&D site

District: Raigarh
State: Chattisgarh
Distance from origin: 431.166 Km

Latitude: 21° 53' 47"
Longitude: 83° 24' 22"

Water Year 1997-98

unit: Cumecs

Date	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1	0	38.53	210.9	103	6.72							
2	0	15.9	92.03	64.67	0.79							
3	0	15.97	62.81	60.27	5.93							
4	0	200.1	29.19	6.64	5.21							
5	0	35.46	45.5	7.17	0.82							
6	0	10.97	91.87	146.9	6.03							
7	0	5.72	70.56	150	8.9							
8	0	6.29	39.33	200.1	8.81							
9	0	5.01	8.87	1177	5.13							
10	0	4.67	1.8	363.6	0.49							
11	0	43.96	7.07	304.5	0.49							
12	0	20.47	44.8	150.4	0.49							
13	0	6.65	37.6	110	5.62							
14	0	4.68	49.78	90	5.1							
15	0	3.6	150	100	4.87							
16	0	2.86	105.06	152.9	0							
17	0	2.1	50	115.6	0							
18	0	20.86	150	115.1	0							
19	0	33.6	174.5	116.9	0							
20	0	100.8	250	82.89	0							
21	0	118.5	107.9	41.2	0							
22	0	83.71	222	41.72	0							
23	0	42.9	185.1	75.38	0							
24	35	40.68	120	65.49	0							
25	40	120.1	56.12	58.82	0							
26	10	55.99	29.88	46.56	0							
27	2.85	35	56.83	34.11	0							
28	30.2	15.27	69.49	23.61	0							
29	50.19	42.19	79.71	10.5	0							
30	100	58.76	67.21	8.48	0							
31		50.8	67.1		0							

Mean max min discharge summary

Day 1-10	0	33.9	65.3	227.9	4.9	0	0	0	0	0	0	0
Day 11-20	0	24	101.9	133.8	3.3	0	0	0	0	0	0	0
R.Days	38.3	60.4	96.5	40.6	0	0	0	0	0	0	0	0
Monthly	38.3	40.1	88.2	134.1	4.4	0	0	0	0	0	0	0
Max	100	200.1	250	1177	8.9	0	0	0	0	0	0	0
Min	0	2.1	1.8	6.6	0	0	0	0	0	0	0	0

Runoff volume and depth

Monthly(MCM)	23.2	107.3	236	347.6	5.7	0	0	0	0	0	0
Monthly(mm)											

a) Mean Annual Discharge(cumecs)=	73.1	d) Annual specific discharge (cumecs/km2)=	
b) Annual Runoff Volume(MCM)=	719.9	e) Annual Runoff depth(mm)=	
c) Monsoon Runoff Volume(MCM)=	714.3	f) Monsoon Runoff depth(mm)=	

Peak Annual Discharge= 0 cumecs

Catchment Area= NA km2

MAHARASHTRA STATE POWER GENERATION CO LTD
Executive Director (E&S)
Mumbai

ANNEXURE : II

Daily, 10-daily& monthly Discharge data River a Mahanadi/Kelo at Kelo G&D site

District: Raigarh
State: Chattisgarh
Distance from origin: 431.166 Km

Latitude: 21° 53' 47"
Longitude: 83° 24' 22"

Water Year 1998-99

unit: Cumecs

Date	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1	0	4.5	8.11	31.9	9.48							
2	0	4.3	32.5	55.49	7.76							
3	0	11	12.78	149.6	9.48							
4	0	40.48	112.9	50.88	20.82							
5	0	70	79.69	36.85	9.48							
6	0	60.91	89.33	21.07	9.3							
7	0	35	107.8	39.2	8.47							
8	0	12.24	72.96	44.64	7.97							
9	0	10.24	32.67	44.18	7.68							
10	0	20.23	13.13	101.9	7.49							
11	0	145.5	30.67	739.2	7.34							
12	0	80.14	107.4	300.3	7.19							
13	0	28.75	95.03	250.7	7.19							
14	0	53.28	94.51	156.7	6.87							
15	0	20.06	63.71	120	6.47							
16	0	10.08	62.46	64.95	6.4							
17	0	7.61	31.66	41	6.6							
18	0	27.2	13.22	30.81	9.19							
19	0	60.42	45.15	24.6	8.11							
20	0	30.94	30.9	18.29	9.3							
21	0	12.93	35.34	11.97	24.91							
22	0	10.75	21.85	10.43	43.67							
23	0	7.77	16.22	9.45	29.57							
24	0	8.11	11.1	9.82	96.29							
25	0	8.39	9.38	9.53	28.31							
26	0	7.06	11.26	15.23	15.05							
27	175	34.32	41.02	8.88	11.96							
28	100	12.42	95.4	8.53	11.67							
29	15	10.12	110.35	8.18	10.62							
30	12	7.69	100.23	12.77	10.5							
31		5.37	80.19		6.48							
Mean max min discharge summary												
Day 1-10	0	26.9	56.2	57.6	9.8	0	0	0	0	0	0	0
Day 11-20	0	46.4	57.5	174.6	7.5	0	0	0	0	0	0	0
R.Days	75.5	11.4	48.4	10.5	26.3	0	0	0	0	0	0	0
Monthly	75.5	27.7	53.8	80.9	14.9	0	0	0	0	0	0	0
Max	175	145.5	112.9	738.2	96.3	0	0	0	0	0	0	0
Min	0	4.3	8.1	8.2	6.4	0	0	0	0	0	0	0
Runoff volume and depth												
Monthly(MCM)		26.1	74.1	144.2	209.6	39.9	0	0	0	0	0	0
Monthly(mm)												
a) Mean Annual Discharge(cumecs)=						45	d) Annual specific discharge (cumecs/km2)=					
b) Annual Runoff Volume(MCM)=						493.9	e) Annual Runoff depth(mm)=					
c) Monsoon Runoff Volume(MCM)=						454	f) Monsoon Runoff depth(mm)=					
			Peak Annual Discharge= 0 cumecs					Catchment Area= NA km2				

MAHARASHTRA STATE POWER GENERATION CO. LTD. Executive Director (E&S) Mumbai

ANNEXURE : II

Daily, 10-daily& monthly Discharge data River a Mahanadi/Kelo at Kelo G&D site

District: Raigarh
State: Chattisgarh
Distance from origin: 431.166 Km

Latitude: 21° 53' 47"
Longitude: 83° 24' 22"

Water Year 1999-2000

unit: Cumecs

Date	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1	0	7.37	28.96	256	32.65							
2	0	6.27	60.96	75	24.89							
3	0	7.33	84.52	40	11.81							
4	0	6.49	120	30	9.38							
5	0	5.64	88.11	23	9.2							
6	0	4.76	150.4	17	7.68							
7	0	6.29	220	8.6	7.42							
8	0	6.59	478.1	60	7.25							
9	0	5.52	350	20	6.89							
10	0	5.46	130	20	12.07							
11	0	6.98	57.84	9.29	9.28							
12	0	30	70	15	6.77							
13	0	8.23	80	100	6.65							
14	0	6.87	65	238.3	6.76							
15	4	60.03	49	160	6.06							
16	3	42.17	32.26	90	0							
17	2.5	25	170.6	70	0							
18	6	135	100	70	0							
19	4.69	90	70	80	0							
20	3.68	52.37	70	40	0							
21	5.57	28	110	28	0							
22	7.5	90	81	40	0							
23	10	39.89	42.11	33	0							
24	22.92	22.28	38.82	90	0							
25	38.48	11.56	54.12	90	0							
26	12	7.44	75	50	0							
27	8	7.19	90	35	0							
28	5.32	153	37.21	25	0							
29	6.5	42.67	54.21	20	0							
30	5.07	55	110	18	0							
31		33	60.43		0							
Mean max min discharge summary												
Day 1-10	0	6.2	171.1	55	12.9	0	0	0	0	0	0	0
Day 11-20	4	45.7	76.5	87.3	7.1	0	0	0	0	0	0	0
R.Days	12.1	44.5	68.4	42.9	0	0	0	0	0	0	0	0
Monthly	9.1	32.5	104.2	61.7	11	0	0	0	0	0	0	0
Max	38.5	153	478.1	256	32.7	0	0	0	0	0	0	0
Min	0	4.8	29	8.6	0	0	0	0	0	0	0	0
Runoff volume and depth												
Monthly(MCM)	12.5	87.1	279	159.9	14.2	0	0	0	0	0	0	0
Monthly(mm)												

a) Mean Annual Discharge(cumecs)=	52	d) Annual specific discharge (cumecs/km2)=	
b) Annual Runoff Volume(MCM)=	552.8	e) Annual Runoff depth(mm)=	
c) Monsoon Runoff Volume(MCM)=	538.6	f) Monsoon Runoff depth(mm)=	
Peak Annual Discharge= 0 cumecs		Catchment Area= NA km2	

MAHARASHTRA STATE POWER GENERATION CO. LTD. * Mumbai *
Executive Director (E&S)

ANNEXURE : II

Daily, 10-daily& monthly Discharge data River a Mahanadi/Kelo at Kelo G&D site

District: Raigarh
State: Chattisgarh
Distance from origin: 431.166 Km

Latitude: 21° 53' 47"
Longitude: 83° 24' 22"

Water Year 2000-2001

unit: Cumecs

Date	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1	0	1.6	17	15	8							
2	0	1.55	11.54	11	7							
3	0	1.5	7.5	50	6							
4	0	5.81	6	109.6	5							
5	0	1.22	2.5	48	4							
6	0	0.97	1.5	30	3.5							
7	0	1.05	1.5	21.86	3							
8	0	0.82	2	28	2.6							
9	0	65	40.2	115.1	2.2							
10	0	6.42	35.56	50	2							
11	0	5	28	35	1.8							
12	0	9	16	25	1.6							
13	0	5.82	18	12	1.6							
14	0	6.17	23.5	8	1.4							
15	0	5.39	70	7	1.4							
16	4	68	75	9	1.2							
17	110	77.91	45	18	1							
18	10	56.4	125.8	41	1							
19	2	77.91	90	35.44	0.9							
20	1	35	51.2	40	0.9							
21	37.47	22.83	32		0.8							
22	30.55	15.88	18	28.03	0							
23	6	7.44	15	15	0							
24	5.31	5.91	11.54	23	0							
25	1.5	7.03	9.5	37.53	0							
26	1.28	25	7	25	0							
27	0.91	28	6.5	23.75	0							
28	23	30	6	14	0							
29	11.29	11.88	15	10	0							
30	5.71	8	13	20	0							
31		23	16	10	0							
Mean max min discharge summary												
Day 1-10	0	8.6	12.85	47.9	4.3	0	0	0	0	0	0	0
Day 11-20	25.4	34.7	54.3	23	1.3	0	0	0	0	0	0	0
R.Days	12.3	16.8	13.6	20.6	0.8	0	0	0	0	0	0	0
Monthly	16.7	19.9	26.4	30.5	2.7	0	0	0	0	0	0	0
Max	110	77.9	125.8	115.1	8	0	0	0	0	0	0	0
Min	0	0.8	1.5	7	0	0	0	0	0	0	0	0
Runoff volume and depth												
Monthly(MCM)		21.6	53.4	70.6	79.1	4.9	0	0	0	0	0	0
Monthly(mm)												
a) Mean Annual Discharge(cumecs)=						20.8	d) Annual specific discharge (cumecs/km2)=					
b) Annual Runoff Volume(MCM)=						229.6	e) Annual Runoff depth(mm)=					
c) Monsoon Runoff Volume(MCM)=						224.7	f) Monsoon Runoff depth(mm)=					
			Peak Annual Discharge= 0 cumecs						Catchment Area= NA km2			

MAHARASHTRA STATE POWER GENERATION CO. LTD. Executive Director (E&S) Mumbai

ANNEXURE : II

Daily, 10-daily& monthly Discharge data River a Mahanadi/Kelo at Kelo G&D site

District: Raigarh
State: Chattisgarh
Distance from origin: 431.166 Km

Latitude: 21° 53' 47"
Longitude: 83° 24' 22"

Water Year 2001-2002 unit: Cumecs

Date	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1	0	94.03	40.44	40.45	28.43							
2	0	47.44	72.83	155	15							
3	0	11.29	78.32	126.9	10.06							
4	0	13.7	92.58	95	9.4							
5	0	200	80	45.68	13.97							
6	0	49.86	70.27	88	90							
7	0	14.61	35.15	48.78	50							
8	0	14	13.62	32.02	31.66							
9	0	40.24	11.61	25	13.58							
10	0	45.54	49.34	13	10.16							
11	0	53.93	33.94	12.11	13.26							
12	0	130	14	11.24	26.81							
13	0	151.6	38.19	26.76	13.85							
14	0	190	44.86	28.99	11							
15	4.2	170	33	18.84	9.36							
16	4.2	143.9	34.36	11.61	0							
17	4.1	550	13.21	60.85	0							
18	3.95	350	36.59	26.88	0							
19	3.5	140.2	15	10.73	0							
20	3.4	110	280	8.37	0							
21	4.95	115	118.8	11.76	0							
22	5.07	155.5	220	12.08	0							
23	4	230	160	11	0							
24	18	90	134.6	10.01	0							
25	80	270	210	7.91	0							
26	11.83	132.7	85	9.64	0							
27	8.88	80.18	123	13.2	0							
28	15	62.09	129.2	9.2	0							
29	25	45.54	79.54	9.09	0							
30	200	54.12	33.3	8.88	0							
31		48.27	35.41		0							

Mean max min discharge summary

Day 1-10	0	53.1	54.4	67	27.2	0	0	0	0	0	0	0
Day 11-20	3.9	199	54.3	21.6	14.9	0	0	0	0	0	0	0
R.Days	37.3	116.7	120.8	10.3	0	0	0	0	0	0	0	0
Monthly	24.8	122.7	77.9	33	23.1	0	0	0	0	0	0	0
Max	200	550	280	155	90	0	0	0	0	0	0	0
Min	0	11.3	11.6	7.9	0	0	0	0	0	0	0	0

Runoff volume and depth

Monthly(MCM)	34.2	328.6	208.8	85.4	29.9	0	0	0	0	0	0
Monthly(mm)											

a) Mean Annual Discharge(cumecs)=		64.6	d) Annual specific discharge (cumecs/km2)=
b) Annual Runoff Volume(MCM)=		687	e) Annual Runoff depth(mm)=
c) Monsoon Runoff Volume(MCM)=		657.1	f) Monsoon Runoff depth(mm)=
Peak Annual Discharge= 0 cumecs			Catchment Area= NA km2

MAHARASHTRA STATE POWER GENERATION CO LTD. Executive Director (E&S) Mumbai

Daily, 10-daily& monthly Discharge data River a Mahanadi/Kelo at Kelo G&D site

District: Raigarh
State: Chattisgarh
Distance from origin: 431.166 Km

Latitude: 21° 53' 47"
Longitude: 83° 24' 22"

Water Year 2002-2003 unit: Cumecs

Date	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1	0	2.87	6.64	175	0							
2	0	55	9.47	100	0							
3	0	40.47	11.29	62.62	0							
4	0	13	75	210	0							
5	0	6	63.56	95	0							
6	0	8.5	32.63	148.03	0							
7	0	6	14.05	160	0							
8	0	2.63	9.9	370	0							
9	0	1.28	10.23	260	0							
10	0	0.7	33.63	375	0							
11	0	0.66	49	252.43	0							
12	5	0.654	68.72	380	0							
13	5	0.67	275	157.56	0							
14	10	0.67	185	73.86	0							
15	3	4.61	100	40	0							
16	2.5	83.94	66.51	20	0							
17	3	35.88	51.83	14.32	0							
18	5.5	127.64	38.5	11	0							
19	19	40.02	33.97	10.69	0							
20	20	27.02	33.08	10.27	0							
21	20	75	29.42	9.74	0							
22	7.36	56.77	91.32	9	0							
23	11	44.98	65.11	104.69	0							
24	53.16	18	44.69	25	0							
25	7.93	9	40	14.56	0							
26	6.5	5.21	33.18	10.76	0							
27	6	2.51	12.79	9.8	0							
28	6.26	3	95.42	9.28	0							
29	4.5	1.8	388.88	8.5	0							
30	3.3	1.6	130	7.68	0							
31		2	225		0							

Mean max min discharge summary

Day 1-10	0	13.6	26.6	195.6	0	0	0	0	0	0	0	0
Day 11-20	8.1	32.2	90.2	97	0	0	0	0	0	0	0	0
R.Days	12.6	20	105.1	20.9	0	0	0	0	0	0	0	0
Monthly	10.5	21.9	75	104.5	0	0	0	0	0	0	0	0
Max	53.2	127.6	388.9	380	0	0	0	0	0	0	0	0
Min	0	0.7	6.6	7.7		0	0	0	0	0	0	0

Runoff volume and depth

Monthly(MCM)	17.2	58.6	200.8	270.8	0	0	0	0	0	0	0
Monthly(mm)											

a) Mean Annual Discharge(cumecs)=	57.1	d) Annual specific discharge (cumecs/km2)=	
b) Annual Runoff Volume(MCM)=	547.4	e) Annual Runoff depth(mm)=	
c) Monsoon Runoff Volume(MCM)=	547.4	f) Monsoon Runoff depth(mm)=	
Peak Annual Discharge= 0 cumecs		Catchment Area= NA km2	

Source : *Report on design of embankment on the right bank of Kelo river to protect mining area (IV/6), Tamnar tehsil, Raigarh district, Chhattisgarh by WAPCOS*

MAHARASHTRA STATE POWER GENERATION CO. LTD. Executive Director (E&S) Mumbai