Environmental Impact Assessment

October 2020

India: Bengaluru Metro Rail Project

Phase 2A (Outer Road Ring Metro Line)

Volume 2
Main Report

Prepared by Bangalore Metro Rail Corporation Ltd. (BMRCL), India for the Asian Development Bank.

CURRENCY EQUIVALENTS

(as of 9 June 2020)

Currency unit	–	Indian rupee (₹)
₹1.00	=	$0.0132661
$1.00	=	₹75.380000

ABBREVIATIONS

ADA	Aeronautical Development Agency
ADB	Asian Development Bank
AL	Acceptable Limit
AMSL	Above Mean Sea Level
ASI	Archaeological Survey of India
ASR	Air Sensitive Receptors
ASS	Auxiliary Sub-Stations
AW2	Normal Loading Condition - Seating + 4 passenger per Sq. m in standee area
AW3	Crush Loading Condition - Seating + 6 passenger per Sq. m in standee area
AW4	Exceptional Dense Crush Condition –Seating+8 passenger per Sq. m in standee area
BBMP	Bruhat Bengaluru Mahanagara Palike
BDA	Bangalore Development Authority
BDL	Below Detectable Limit
BESCOM	Bengaluru Electricity Supply Company Limited
BMA	Bangalore Metropolitan Area
BMRCL	Bangalore Metro Rail Corporation Ltd
BMTC	Bangalore Metropolitan Transport Corporation
BOD	Biochemical Oxygen Demand
BWSSB	Bangalore Water Supply & Sewerage Board
CAGR	Compound Annual Growth Rate
CAAQMS	Continuous Ambient Air Quality Monitoring Stations
CBTC	Communication Based Train Control
CGWB	Central Ground Water Board
CMC	City Municipal Council
CMP	Comprehensive Mobility Plan
CPCB	Central Pollution Control Board
CSB	Central Silk Board
DMC	Driving Motor Car
DPR	Detailed Project Report
DRDO	Defense Research and Development Organization
DTG	Distance to Go
DULT	Directorate of Urban Land Transport
EC	Environmental Clearance
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan

EP	Environment Protection
ESMF	Environmental and Social Management Framework
GDDP	Gross District Domestic Product
GDP	Gross Domestic Product
GOI	Government of India
GOK	Government of Karnataka
GSDP	Gross State Domestic Product
HAL	Hindustan Aeronautics Limited
HSR	Hosur-Sarjapur Road
IBAT	Integrated Biodiversity Assessment Tool
IBL	Inspection Bay Lines
IDC	Interest During Construction
IFC	International Finance Corporation
IISC	Indian Institute of Science
ILO	International Labor Organization
IRJ	Insulated Rail Joints
ISRO	Indian Space Research Organization
KBA	Key Biodiversity Areas
KIA	Kempe Gowda International Airport
KIADB	Karnataka Industrial Area Development Board
KSPCB	Karnataka State Pollution Control Board
LHS	Left Hand Side
MC	Motor Car
MLD	Million Liters per Day
MOEFCC	Ministry of Environment, Forest and Climate Change
MOHUA	Ministry of Housing and Urban Affairs
MU	Million Units
MVA	Mega Volt Ampere
MW	Mega Watt
NAAQS	National Ambient Air Quality Standards
NAL	National Aerospace Laboratories
NGT	National Green Tribunal
NH	National Highway
NIMHANS	National Institute of Mental Health and Neuroscience
NOC	No Objection Certificate
OCC	Operations Control Centre
O&M	Operation and Maintenance
ORR	Outer Ring Road
OSHA	Occupational Safety and Health Administration
PA	Protected Area
PAH	Polycyclic Aromatic Hydrocarbons
PAP	Project Affected Persons
PL	Permissible Limit
PHPDT	Peak Hour Peak Direction Traffic

PM	Particulate Matter
PPE	Personal Protective Equipment
RBL	Repair Bay Lines
REA	Rapid Environmental Assessment
RFCTLARR	Right to Fair Compensation and Transparency in Land Acquisition and Rehabilitation and Resettlement
RHS	Right Hand Side
RMP	Revised Master Plan
RSS	Receiving Sub-Station
SBL	Stabling Bay Lines
SCADA	Supervisory Control and Data Acquisition
SEC	Specific Energy Consumption
SEIAA	State Environmental Impact Assessment Authority
SIA	Social Impact Assessment
SOD	Schedule of Dimensions
SPCB	State Pollution Control Board
SPS	Safeguard Policy Statement
SWR	South Western Railways
TBM	Tunnel Boring Machine
TC	Trailer Car
TEC	Tree Expert Committee
TMC	Town Municipal Council
TSS	Traction Sub-Station
V/C	Volume-Demand-to-Capacity
WBG	World Bank Group

WEIGHTS, MEASURES AND UNITS

dB (A)	–	A-weighted decibel
ha	–	hectare
km	–	kilometer
Cum	–	Cubic meter
Kg/ha	--	kilogram per hectare
km^2	–	square kilometer
KWA	–	kilowatt ampere
Leq	–	equivalent continuous noise level
meq/L	–	milli-equivalents per liter
mg/kg	–	milligram/kilogram
ml	–	milliliter
MPN	–	Most Probable Number
NTU	–	Nephelometric Turbidity Unit
ppm	–	parts per million
µg	–	microgram
µs/cm	–	micro siemens per centimeter
m	–	meter
MW	–	megawatt
PM 2.5	–	particulate matter of 2.5-micron size
PM 10	–	particulate matter of 10-micron size

NOTES

(i) The fiscal year (FY) of the Government of India and its agencies ends on 31 March. “FY” before a calendar year denotes the year in which the fiscal year ends, e.g., FY2019 ends on 31 March 2019.

(ii) In this report, "$" refers to United States dollars.

1

TABLE OF CONTENTS

List of Tables

List of Figures

List of Annexures

B. Impacts on Physical environment

i. Air quality and Greenhouse gas emissions

211. Dust generation and gaseous emissions from construction machinery are the main air quality issue associated with the construction of metro project.

212. Inhabited stretches along the proposed metro alignment such as commercial zones, schools, hostels, hospitals, office occupancies, place of public worship, etc. are considered as Air Sensitive Receptors (ASRs). The temporary impact of air pollution will be on the adjacent inhabited areas along the project alignment, metro stations, metro depots and associated construction establishment areas under the project. There are 29 ASRs considered to be affected by the air pollution and noise generated from construction activities of the project, these are listed in table 5-4.

Table 5- 4: Details of Air Sensitive Receptors (ASRs) along the proposed Metro corridor

Sl. No.	Name of Schools & Colleges	Chainage (Km)	LHS/ RHS	Distance from Center Line (M)
1	Alliance School of Business	0+000	LHS	80
2	St Mira's High School	0+000	LHS	26
3	Karanth Speciality Hospital	0+000	RHS	110
4	Mathew Hospital	1+200	LHS	43
5	Stepping Stones International Schools	1+300	RHS	255
6	Asian Specialty Hospital	1+600	RHS	64
7	JSS Public School	1+900	RHS	117
8	Devi Eye Hospital	1+900	LHS	25
9	Narayana Hrudayalaya Hospital	1+900	RHS	205
10	Ananya ENT Dento-facial Clinic	2+100	LHS	263
11	Samarthanam Trust for the Disabled	2+200	RHS	200
12	Freedom International School	2+400	RHS	142
13	Shakuntala Devi International Institute of Management Science & Pre-University College	2+400	RHS	200
14	Oxford Management College	2+400	RHS	287
15	National Public School	2+400	RHS	225
16	Institute of Media Management & IT Studies	2+700	RHS	275
17	Government School	3+700	RHS	70
18	KKECS College of Pharmacy	5+600	RHS	150
19	India International School	5+900	RHS	50
20	Krupanidhi College	6+800	RHS	50
21	New Horizon College of Engineering	8+700	RHS	182
22	Vims Specialty Hospitals	10+400	RHS	45
23	CJRJS College	10+700	LHS	255
24	Ravindra Bharathi School	10+900	LHS	115
25	MGA Hospital	11+300	LHS	104
26	Punjab Technical University, Centre for Distance Education	11+600	LHS	43
27	Atlanta Montessori School	12+500	RHS	36
28	SBF Healthcare	13+900	RHS	95

Sl. No.	Name of Schools & Colleges	Chainage (Km)	LHS/ RHS	Distance from Center Line (M)
29	Lowry Adventist College	16+900	LHS	61

Design and pre-construction stage – positive impact

213. The project is designed to enable movement of people in a more efficient and environment friendly manner by using the train which is running on cleaner energy (electricity) as opposed to vehicles using pollution emitting petroleum-based fuels. Hence, the project is expected to have a positive impact on the air quality within the local project influence area.

Construction stage – major negative impact

214. **Impact:** Primary sources of dust during construction phase include activities like site preparatory earthworks; demolition of existing structures; foundation excavation works; loading and unloading soil and construction materials and material handling; etc. The operation of heavy equipment & construction machinery; transporting vehicles, traffic diversion, etc. causes gaseous emissions to the air. In addition, dust and gaseous emissions are released from the batching plants, hot mix plant and diesel generators; stone crushing unit operations in the stone quarries. Main pollutants released during construction are particulate matter and gaseous pollutants like Carbon Monoxide, Oxides of Nitrogen and Sulphur Dioxide, deteriorating quality of ambient air along the project corridor and at construction establishments. DG sets will be used at construction sites for various construction activities and construction camps. Particulate and gaseous emissions are expected from DG sets. The impacts will be of short term and limited in nature.

215. **Mitigation measures:** During construction, the following mitigation measures will be implemented in order to minimise the impact on air quality.

- Water spraying is needed to compact the soil properly and to prevent dust. All construction sites, material haulage roads (unpaved) and the traffic diversion routes should be sprayed with water at least two to three times a day and whenever dust is starting to occur;
- The materials transported to and from the construction site must be properly covered with tarpaulin;
- Unnecessary idling of construction equipment and transportation vehicles should be avoided as much as possible;
- Temporary stockpiles of soil or other material must be covered or sprayed with water on a regular basis, particularly during dry or windy conditions;
- All stockpiles must be located far from residences and businesses where possible, placing of dusty material storage piles near ASRs should be avoided;
- Barricading to a height of 3 m will be provided to reduce dust generation.
- All construction equipment should be operated and maintained to specifications to minimize emissions of gaseous pollutants. Construction vehicles used for the construction shall be serviced regularly to ensure that the air pollutants emissions are not exceeding the norms prescribed by CPCB and have a valid Pollution Under Control Certificate;
- Siting of all construction establishments such as batching plant, crusher plant, construction camps, hot mix plants and offices shall ensure compliance to all legal requirements and strictly adhere to conditions stipulated in the obtained consent for operation of such plants;

- Batching plants, Hot (asphalt) mix plants, crushers, etc. should be located at least 500 m down windward of human settlements. These establishments must be fitted with dust suppression units and comply with all the general and specific conditions of the consent;
- Ambient air quality monitoring shall be done regularly at all the representative sensitive locations to ensure that all the emissions from construction activities are within the National Ambient Air Quality Standards by CPCB and therefore ensuring the effectiveness of mitigation measures taken;
- Proper site selection, appropriate location of plant and regular maintenance and monitoring of DG sets will minimize the impacts of these sets. Suitable mitigation measures such as using chimneys of required height will be ensured as per the KSPCB norms. Contractor shall prefer to utilize power from BESCOM as primary source and DG sets shall be used only as power back-ups to conserve the low-sulphur diesel.

216. **Residual Impact:** After implementation of the mitigation measures described above residual impacts are expected to be minor or negligible.

Operation stage – positive impact

217. The project is expected to result in modal shift of passengers from road to the metro line. With this it is expected that traffic on the road (buses, cars and two/three wheelers) will reduce and there will be less traffic jams. Hence, overall, the air quality within the local project influence area will improve due to reduced emissions from road traffic.

218. Air pollution can be expected from DG sets used during power disruption. However, the impact is considered insignificant as the impact will be incidental and only for short periods of time.

219. Based on the ridership numbers in table 2-1, a build-up period of 3 years, a 4% increase in ridership per year and a design life of the project of 25 years there will be an estimated net emission reduction of about 650,000 tons of CO_2. Other pollutants that will be reduced include PM, NO_x, HC, and CO.

ii. Surface water quality and quantity

220. There are a number of important water bodies along the proposed metro alignment which may be impacted from construction activities, as presented in table 5-5. These water bodies may get affected by the construction activities during construction phase, if proper precautions are not taken.

Table 5- 5: Details of water bodies adjacent to proposed metro corridor

Sl. No.	Water bodies / Lakes	LHS / RHS	Distance from Water body (m)
1	Agara Lake	LHS	30
2	Bellandur Lake	LHS	300
3	Ibbalur Lake	LHS	30
4	Pond	LHS	60
5	Stream	both sides	25
6	Mahadevapura Lake	RHS	44
7	Pond	RHS	50

Sl. No.	Water bodies / Lakes	LHS / RHS	Distance from Water body (m)
8	Pond	LHS	25
9	Pond	RHS	30
10	B Naranyanpura Lake	LHS	40
11	Benniganahalli Lake	RHS	30

Design and pre-construction stage – moderate negative impact

221. **Impact:** Location of the stations can have long term implications on the already degraded quality of nearby water bodies due to discharge of sewage and waste-water generated from operation of the stations. Without proper waste-water and sewage treatment facilities there is a risk of the surrounding environment mainly surface water bodies to receive the untreated waste-water.

222. Six stations are located near a water body. These are: Agara Lake Station next to Agara Lake; Ibbalur Station near Ibbalur Lake; Bellandur Station near Bellandur Lake; Kodibisanahalli Station near streams connecting to Bellandur Lake; DRDO Sports Complex near Mahadevapura Lake and Saraswathi Nagar Station near B. Naranyanpura Lake. Although Bellandur Lake used to be ecologically important it is nowadays heavily polluted. Hence it is important to prevent any further deterioration of the water quality at Bellandur Lake and its tributaries by not discharging any untreated waste-water or sewage into the surrounding environment. If not mitigated the pollution impact, though small in spatial scale, will be long term. Hence, the overall significance of the impact is rated as moderate.

223. **Mitigation Measures:** The risk of water pollution from the stations can easily be mitigated by including a proper sewage treatment system within the design of the station facility. Monitoring of waste-water generated from the stations during the initial stages of project operation will be required to be carried out to confirm that the water does not contain any harmful pollutants.

224. Residual impact: With the inclusion of septic tanks and other sewage treatment measures in the stations and provision for monitoring the grey water discharged from the stations, the residual impact is expected to be minor and negligible.

Construction stage – moderate negative impact

225. **Impact:** Sourcing of construction water in Bangalore city is a big problem. Utilization of water resources available in the city may further worsen the problem of water scarcity. Hence it is very important to source water required for construction without affecting the existing users. Therefore, water required for construction shall not be sourced from public water resources and supplies. Contractor shall procure water from approved sources only. All necessary permissions are obtained from concerned authorities before extracting water for construction works. Water is also required for curing purposes. Water will be contaminated from the washings and the surplus water from curing activities and will have to be treated before disposal.

226. Establishment of temporary construction camps and labour camps during the construction of project will require water and cause water pollution due to disposal of untreated sewage and garbage. If these wastes are let into the water bodies without proper treatment, it will lead to water pollution and an increased the risk of outbreak of communicable diseases through polluted drinking water.

227. Use and maintenance of construction equipment might lead to oil spills which could impact the quality of nearby water bodies.

228. The debris generated from the demolition of structures and excavation for pile foundation could potentially find its way to the nearby water bodies adjacent to the project corridor. This will not only silt up the lakes but also impact the aquatic life.

229. Mitigation measures:

- Arrangement for water used in construction shall be made by the contractor, in such a way that the water availability and supply to nearby communities remains unaffected. A Construction Water Management Plan shall be prepared prior to commencement of the construction works and implemented after getting approval from Environmental Specialist of the Designated Engineer (DE). The Contractor shall also obtain prior permission from the concerned water authority;
- The Contractor shall take all precaution to minimize the wastage of water during construction activities;
- Careful planning shall be adopted to avoid the spillage of soil and debris into the water body during transportation and disposal. Construction works close to water bodies and streams shall be avoided, especially during the monsoon period;
- Construction establishments such as construction camps, labor camps, stone crushing units should be located away from the water bodies. Domestic and sewage wastes from labor camps shall be treated with a sewage treatment system to comply with the standards specified by CPCB and WBG before disposal. The choice of treatment system is up to the contractor, however contractor has to submit the location, layout and basic facility provision of each labor camp to DE and BMRCL prior to their construction. Testing of effluent has to be done in accordance with the rules and regulations of CPCB and SCPB;
- The excavated earth, stones or any other construction material, shall be properly handled, stacked and disposed of so as not to end up in the nearby drainage system and block the flow of water. All required precautions shall be taken to ensure no silt, soil or construction material reaches and silts up the adjacent water bodies;
- The water used for curing structures shall be passed through settling tanks before it is disposed of outside the construction site. Muck shall not be allowed to confluence with any water course;
- Sustainable methods of curing such as curing by sprinkling, reuse of water shall be adopted for curing. Contractor may source the treated water from local Sewage Treatment Plants to use in the construction and curing purpose;
- Moisture retaining fabric coverings saturated with water shall be used for curing. Wet coverings such as wet gunny bags, hessian cloth, jute matting, straw etc., shall be wrapped to vertical surface for keeping the concrete wet. For horizontal surfaces saw dust, earth or sand are used as wet covering to keep the concrete in wet condition for a longer time;
- Chute drains with sediment trap or silt fence and garland drains shall be planned at erosion susceptible areas to avoid ingress of silt into the water bodies;
- Fuel storage and refilling sites for construction vehicles and equipment shall be kept away from cross drainage structures and water bodies. Fuel tanks shall be placed in a catch basin large enough to hold the entire contents of the tank and additional ten percent;
- The vehicles and equipment shall be properly maintained and repaired to avoid contamination from fuel and lubricants. Oil interceptors shall be installed at the construction camps sewerage systems to ensure oils and oil-based products do not pollute the soil or reach nearby waterbodies.

230. **Residual impact:** After implementation of the mitigation measures described above residual impacts are expected to be minor.

Operation stage – moderate negative impact

231. **Impact:** As discussed in the design and pre-construction stage, the project stations can have long term implications on the quality of nearby water bodies (streams, rivers, ponds) due to discharge of sewage and waste-water generated from operation of the stations.

232. **Mitigation Measures:** The stations will be equipped with proper sewage treatment plants of adequate capacity. It is expected that after treatment the waste water meets the requirements to be released into the connecting urban sewage system. The contractor will need to ensure sewage system has a large enough capacity to handle the additional sewage. Monitoring of waste-water generated from the stations during the initial stages of project operation will be required to be carried out to confirm that the water does not contain any harmful pollutants.

233. **Residual impact.** With proper implementation of the proposed sewage treatment the residual impact is expected to be negligible. In order to verify this expectation, the effluent of the stations will be monitored during the initial stage of operations. This monitoring requirement is included in the Environmental Monitoring Plan.

iii. Groundwater quality and quantity

Design and pre-construction stage – neutral impact

234. There is no significant impact expected on either ground water or water table by the project activities. The metro alignment is proposed along the median of the existing paved Outer Ring Road and will therefore not make a significant impact on the ground water percolation and ground water potential.

Construction stage – moderate negative impact

235. **Impact:** Because of the water scarcity it is very important to source water required for construction from sources other than public water resources and supplies. Establishment of temporary construction camps and labour camps during the construction of project will require water and may cause water pollution due to spills which could impact the quality of the groundwater. Spillage of fuel from underground storage or above ground storage facility could adversely affect the quality of groundwater.

236. **Mitigation measures:** The Construction Water Management Plan shall describe the way water for construction activities and camps is sourced and has to be approved by the DE prior to commencement of the works. If boring of a new tube-well is unavoidable, proper sanction and approval from local authorities and Central Ground Water Board should be obtained. Fuel tanks shall be placed in a catch basin large enough to hold the entire contents of the tank and additional ten percent. Oil interceptors shall be installed in the construction camps sewerage systems to ensure oil and oil-based products do not pollute the soil or groundwater and to comply with the standards specified by CPCB and WBG before disposal. The choice of treatment system is up to the contractor, however contractor has to submit the location, layout and basic facility provision of each labor camp to DE and BMRCL prior to their construction. Testing of effluent has to be done in accordance with the rules and regulations of CPCB and SCPB. In case of discharging

sewage into the existing sewage system the contractor will need to ensure that the sewage system has a large enough capacity to handle the additional sewage. Underground storage facilities are prohibited, and above ground storage facilities will be equipped with concrete impervious pavement. Any spillages with the potential to reach the groundwater will be cleaned up as soon as possible. The vehicle and construction equipment shall be properly maintained, and refuelling / maintenance of vehicles shall not be done on bare ground. Diesel Generator sets shall be placed on a cement concrete platform with oil and grease trap to control the oil ingress into soil/water bodies.

237. **Residual impact:** After implementation of the mitigation measures described above residual impacts are expected to be minor.

Operational stage – moderate negative impact

238. **Impact:** Increase in the number of passengers and trains at the stations will require more water for drinking, toilet, cleaning and other purpose like AC, chiller and other purposes and will therefore have a lasting negative impact on the availability of public water. Operation of all the stations can have long term implications on the quality of ground water in the project area due to discharge of sewage and waste-water generated from operation of the stations, however the impact will be localized in terms of area of influence.

239. **Mitigation measures:** The risk of ground water pollution from the stations can be mitigated by sewage treatment facilities and waste-water treatment facilities in every station. It is expected that after treatment the waste-water meets the requirements to be released into the connecting urban drainage facilities. The contractor will need to ensure sewage system has a large enough capacity to handle the additional sewage. During the initial stage of project operation monitoring of waste-water generated from the stations will be required to confirm that the water does not contain any harmful pollutants.

240. The risk of depleting ground water resources can be addressed by sourcing water from existing water supply systems (municipality) with adequate capacity. Rainwater harvesting and recharge pits shall be proposed all along the median. Rainwater collected on the viaduct structures shall be suitably guided through chute pipes and made to recharge the ground water after passing through oil interceptors to ensure that the oil traces do not enter the recharge pits. Monitoring of ground water quality near the stations must be carried out during the initial stages of project operation in order to confirm the ground water quality is not affected by the project.

241. **Residual impact.** With proper implementation of the proposed mitigation measures the residual impact is expected to be negligible. In order to verify this expectation, the ground water quality near the stations will be monitored during the initial stage of operations. This monitoring requirement is included in the Environmental Monitoring Plan.

iv. Land degradation and pollution

Design and pre-construction stage – minor negative impact

242. **Impact:** The location of the stations might have long term implications on the generation of waste/trash and polluting land in the immediate vicinity of the project area. The waste management systems and linkage with existing local waste management systems for the stations and depots will play an important role in ensuring that waste generated from the stations do not end up in the areas near the project site. If not managed the impact will be limited to the vicinity of the stations. Though it will be a long-term problem the severity of the impact in terms of causing health problems to the general public and

serious environmental issues is minor. Hence the significance of land degradation and pollution impacts during pre-construction stage is considered minor.

243. **Mitigation Measures:** The problem of waste can easily be mitigated by including provisions for trash and waste management in the design of the stations and linking them up with existing local municipal waste management systems.

244. **Residual impact:** The residual impacts after mitigation are expected to be negligible.

Construction stage – minor negative impact

245. The project involves construction of approximately 800 pile foundations which requires soil to be excavated and safely disposed of at the pre-identified and approved disposal sites. The estimated total earth work excavation from pile drilling, pile cap and open foundation activities is estimated at 123,709 m^3 and the concrete debris is estimated at 7,822m^3. The details are given in table 5-6.

Table 5- 6: Quantity of Soil Debris and C&D waste generated (m^3)

Package	Source of debris (At viaduct and station)	Quantity(m^3)
I	A. Earth work excavation	
	a. Pile drilling muck	41,768
	b. Pile cap and open foundations	17,193
	B. Concrete Debris	4,177
II	A. Earth work excavation	
	a. Pile drilling muck	38,221
	b. Pile cap and open foundations	26,527
	B. Concrete Debris	3,645
Total earth work excavation		**123,709**
Total concrete Debris		**7,822**

246. **Impact:** The impact on the topography is insignificant as the complete alignment is elevated and follows median of existing Outer Ring Road and the impact on topography is limited to metro station locations. However, there will be significant change in topography at the locations of construction camps, labour camps, material storage yards, gravel & sand quarries.

247. The project is not expected to have a significant impact on soil erosion however minor impact on soil erosion due to runoff from unprotected excavated areas might occur. During the monsoon season, excavated soil may tend to move from construction site along with surface run-off, in absence of suitable mitigation measures to mitigate the soil erosion. It is necessary to limit the removal of ground cover, trees or shrubs only to the area needed for permanent works to minimize the impact on soil.

248. The soil/debris that will be generated during foundation excavations for pile construction needs to be carefully and safely disposed of. Lots of waste slurry is also generated during pile foundation construction which might cause soil pollution if not disposed of properly. Problems could arise from dumping of construction debris (concrete, bricks), waste materials (from contractor's camp) etc. causing surface and ground water

pollution. Maintenance, servicing construction machinery and fuel refilling of transportation vehicles at construction camps may lead to soil pollution.

249. Land clearing for the project will involve removal of trees which have a very important role in binding the soil intact. Stripping of topsoil to level the ground at the construction site will lead to the loss of developed and stable soil. The elevated structure of viaduct will have high amounts of runoff water during monsoon season and if this runoff is not drained off properly, this may lead to flooding and accelerated soil erosion on the at grade roads.

250. Removal of existing bituminous pavement at grade for preparatory works of pile foundation and indiscriminate disposal might cause soil pollution.

251. Mitigation measures:

- At locations where soil is susceptible for erosion the exposed surface area shall be limited to minimum and construction shall be scheduled immediately after land clearing;
- Soil erosion can be effectively controlled by careful planning, timing of cut and fill operations and safe disposal of excess excavated unserviceable soil, especially during monsoon season;
- The soil erosion can best be mitigated by removing vegetative cover only from the specific site on which construction is to take place and by disturbing the vegetation in adjacent areas as little as possible.
- Removal of bituminous wastes from existing roads should not be disposed of in nearby water bodies, open spaces and parks and wastes should not be left unmanaged on the roadsides. Bituminous material should be examined for PAH to establish if it can be recycled. If not, the bitumen shall be treated as hazardous waste and disposed of in pre-identified and approved disposal sites;
- The excavated soil from the pile foundations shall be stockpiled and covered such that the soil is not eroded away and it should be transported securely to the approved disposal sites;
- The topsoil from all areas of cutting, shall be stripped to a specified depth of 150 mm and stored in stockpiles of heights not exceeding 2 m. The stored topsoil shall be spread back to maintain the original characteristics of the soil;
- Adopting waste minimization technologies would minimize the generation of waste materials to be disposed and thereby the cost incurred for transportation and handling will be reduced;
- The construction and demolition waste generated during the construction phase should be managed in accordance with the C&D Waste Management Rules, 2016. As far as possible, demolition and construction waste should be segregated and recycled. The unserviceable waste left after recycling should be dumped in pre-identified and approved pits as per Construction & Demolition Waste Management Rules. All required permissions shall be obtained from the concerned authorities before disposal of the debris;
- Materials shall be sourced from existing legitimate quarries as much as possible. The Contractor shall establish a new quarry only if the lead from existing quarries is uneconomical and alternative material sources are not available. Contractor can only establish a new quarry with the prior consent of DE and after all the required permissions / consents from SPCB are obtained. The Contractor shall prepare a reinstatement plan for the quarry site which must be approved by the DE;
- Excavated soil will be used as backfill wherever possible. The remaining soil debris will be suitably disposed of to the pre-identified approved locations;

- Contractor shall prepare debris disposal plan to deal with surplus debris materials and submit it to Environmental Specialist of DE for approval. This plan must include a screening of the Environmental and Social risks that result from the debris disposal. The plan must also include an analysis of alternative options in terms of location, technology, design, etc. If waste debris is dumped in abandoned quarries or borrow pits the debris must be applied in layers of maximum 1 meter at a time and compacted mechanically. Once the filling is complete, the entire debris disposal area shall be provided with a layer of good earth on the top and cover with vegetation, subject to the approval of BBMP and the Environmental Expert of DE.

252. **Residual Impact:** With proper implementation of the proposed mitigation measures the residual impact during construction will be minimal.

Operational stage – neutral impact

253. As long as BMRCL has a sufficient budget allocation for the storage, handling and disposal of generated wastes at the stations the project is not expected to have an impact on land degradation or pollution during its operational stage.

C. Impacts on Biological environment

i. Trees and vegetation

254. Trees are major source of air purification in urban areas making cities environmentally more sustainable. Trees clean air by absorbing CO_2 from the atmosphere during photosynthesis and play an important role in climate amelioration. In addition, trees will help to control temperature, thus reducing the urban heat island effect.

Design and pre-construction stage – moderate negative impact

255. **Impact:** The alignment follows the median of the ORR in order to minimize land acquisition needs, with the added benefit of limiting the impact on existing trees and vegetation. In relation to the scale of the project the number of trees and amount of vegetation required to be removed is small. Hence the overall significance of the impacts on trees and vegetation from the project design point of view is found to be moderate.

256. **Mitigation measures:** Best efforts have been made to minimize removal of trees (together with reducing land acquisition needs) and vegetative cover by locating the alignment along the center of the ORR.

257. **Residual impact:** Since the project design includes a provision for compensatory afforestation of trees at a ratio of 1:10 and provision for restoring vegetative cover on the median of the ORR, the impacts on trees and vegetation will be fully mitigated.

Construction stage – moderate negative impact

258. **Impact:** Impact on the trees is unavoidable as the alignment of the metro corridor is taken almost along the median of existing ORR. There will be significant impact on trees located in the median. Not all the trees along the alignment are to be cut. Small trees along the alignment can be transplanted to suitable locations.

259. Removal of trees will impact the quality of air. A total of 1248 trees located on the median and station locations will be affected along Phase 2A. The breakup of trees impacted along the alignment and stations are given in table 5-7 below.

Table 5- 7: Details of trees impacted along the metro project corridor

Sl. No.	Project Component	No. of trees impacted		Total
		Package 1	Package 2	
1	Viaduct Section	233	809	1042
2	Metro Stations	110	96	206
	Total	343	905	1248

260. Most of the trees which may be affected by the project will be transplanted to a suitable location, as much as possible within the project's area of influence.

261. Mitigation measures:

- Tree cutting and felling shall be done only if the tree is in the way of construction and only after receiving clearance from State Forest Department and after receipt of BMRCL's written permission. No damage shall be caused to the trees during construction activities other than the trees marked for felling;
- Trees cleared shall be replaced with minimum of 10 tree saplings per tree cut or according to conditions specified by TEC or Forest Department. Saplings must be of native species and must be ideally replanted within the project area of influence. The saplings will be monitored for their survival for three years. Re-plantation shall be taken up every year with new saplings where saplings fail to survive. Compensatory plantation will help the city to increase the green cover;
- No paint thinner, paint, plaster or other liquid or solid excess or waste construction materials or wastewater shall be dumped near the tree or anywhere else;
- Wherever excavations are made in the ground near the roots of trees, appropriate measures shall be taken to prevent exposed soil from drying out and causing damage to tree roots;
- All possible efforts shall be made to transplant trees to a suitable and preapproved location, ideally within the project's area of influence. Transplanting of tree depends on general health, form and structure of the tree; size and quality of root system; size of trees, species and conservation status of a tree; availability and suitability of a receptor site, time for preparation, cost effectiveness, etc.;
- In case a transplanted tree does not survive it will be compensated under the afforestation program with a minimum of 10 saplings per tree;
- Two rows of suitable ornamental plants shall be planted in medians of at grade roads all along the proposed metro alignment.

262. **Residual impact:** With proper implementation of the tree transplantation plans, the tree afforestation program and the re-vegetation of the median of the at grade roads a residual impact on trees and vegetation is not to be expected in the long term.

Operation stage –neutral impact

263. Since most affected trees will be transplanted the increase in the number of trees within the city will be limited to a few thousand. It is expected that the newly planted trees will start providing the ecosystem services similar to that of the trees removed by the 15th year or so after plantation. Although the extra trees will have a positive impact on air quality the impact will be too limited to make a significant change.

ii. Terrestrial fauna

Design and pre-construction stage – neutral impact

264. The proposed project is within Bengaluru city and does not pass through any forests and eco-sensitive zones. Bannerghatta National Wildlife Sanctuary is at a distance of approximately 9 km which is the nearest wildlife sensitive protected area. The list of birds and reptiles commonly found around Bengaluru is given in annexure – 3.There are no endangered or protected terrestrial faunal species in the project area and the project alignment is located along the median of the road in an urban area. Hence the design stage impact on terrestrial fauna is rated to be neutral with no positive or negative impacts.

Construction stage – minor negative impact

265. **Impact:** As stated above, there are no endangered or protected species in the project area. The scattered green spaces (neighbourhood parks) in Bengaluru city vary in size and mainly cater to recreational purposes and do not support large number of birds. The trees which are impacted by the project are usually small and mainly located on the median of ORR and do not serve as shelter to avian community. However, occasionally a tree that has to be removed could have nesting birds. Furthermore, construction activities may result in killing of insects, rodents and other smaller animals during excavation works for the elevated sections and stations of the project alignment. Due to these potential impacts it cannot be stated that there will be no impacts, however the overall significance of impacts on fauna during project construction is considered minor.

266. **Mitigation measures:** Before the transplantation or felling of trees, the contractor will inspect the tress for presence of nests. If any trees have nests, the nests will be transferred to another nearby tree. This activity of transferring the nests will be done under the guidance of the local forestry or wildlife authority. The contractor will be prohibited from intentionally killing animals or birds in the project area.

267. **Residual impact:** Given the overall low level of risk on impact on terrestrial fauna it is expected that there will be no residual impacts.

Operation stage – neutral impact

268. No noticeable positive or negative impact on terrestrial fauna is expected to occur during operation of the metro line.

iii. Ecologically important areas

Design and pre-construction stage – neutral impact

269. As described in the baseline environment chapter, water bodies located adjacent to the proposed alignment vary in quality due to sewage inflow and pollution. Restoration efforts have led to quality improvements in some of the lakes, leading to the gradual return of common native fauna species such as the rat snake, green grass snake, Indian bullfrog and birds like kingfishers, spot billed ducks, grey herons and median egrets. However, these water bodies are not regarded ecologically important areas. The lakes will not be impacted directly and any disturbance to species would be temporary.

Construction stage – minor negative impact

270. **Impact:** Extraction of sand needed for construction has the potential to destroy biodiversity on the riverbanks. In order to put an end to river sand mining, the state government had banned river sand mining to encourage use of manufactured sand.

271. **Mitigation measures:** Sand shall be procured from identified and approved sand mines only. If the sand is being procured from new sand quarry / supplier, it shall be ensured that requisite license / lease has been obtained from the concerned Authorities, the Department of Mines & Geology, Government of Karnataka.

272. **Residual impact:** No residual impact is expected on ecologically important areas as long as resource materials are sourced from approved legitimate suppliers.

Operation stage – neutral impact

273. Due to the lack of ecologically important areas near the alignment no impact is expected during operation of the metro line.

D. Impacts on Social Environment

i. Private land and buildings

Design and pre-construction stage – moderate negative impact

274. **Impact:** During pre-construction stage the proposed metro project requires land to be acquired and structures to be demolished. Total land required for Phase 2A project is estimated at 53,475.27 m^2 of which 20,899.33 m^2 is private land and 32,575.94 m^2 is government land (see table 5-8 and 5-9).

Table 5- 8: Land acquisition for Stations

Sl. No.	Station	Station wise land requirement in m^2		
		Govt.	Pvt.	Total
1	Central Silk Board	472.75	2683.74	3156.49
	Multi parking near Central Silk Board	0	1944.92	1944.92
	Bus bay near Central Silk Board	14328.00	0	14328.00
2	HSR Layout station	1530.59	0	1530.59
3	AgaraLake Station	3355.43	0	3355.43
4	Ibbaluru Station	0	2103.96	2103.96
5	Bellanduru Station	1428.83	1571.73	3000.56
6	Kadubisanahalli Station	0	2980.27	2980.27
7	Kodibisanahalli Station	2974.83	1415.44	4390.27
8	Marathahalli Station	2406.48	0	2406.48
9	ISRO station	1485.22	2995.72	4480.94
10	Doddenekundi Station	1515.45	1522.67	3038.12
11	DRDO sports complex	0	2444.93	2444.93
12	Saraswathi Nagar Station	3030.90	0	3030.90
	Total	**32528.48**	**19663.38**	**52191.86**

Source: BMRCL Dec 2019

Table 5- 9: Land acquisition for Viaduct

Sl. No.	Prop ID No.	Sy. No.	Govt / pvt.	Name of Owner	Extent (m^2)	
					Private	Govt.
1	ORR-IBL-6	38/2A1	Pvt.	Narasareddy	201.17	
		32/A2	Pvt.	N Thyagaraj	84.29	
2	ORR-MRTH-4	95	Govt.	Govt		47.46
		94/4	Pvt.	Nagaraj S/O Muniswamy Reddy	650.81	
3	ORR-MRTH-4-10	35	Pvt.	Anjaneya Devsthana Trust	161.99	
4	ORR-MRTH-2	33	Pvt.	S.Vishwanath	13.34	
5	ORR-MRTH-3	33	Pvt.	J Magjuli	55.38	
6	ORR-KR-PURAM-2	125	Pvt.	Lowry Memorial School	62.07	
					1235.95	**47.46**
				Total	**1283.41**	

Source: BMRCL Dec 2019

275. The project affected families are limited in number (46 owners and 62 tenants) as the private land being acquired for construction of viaduct is minimal and the private land required for construction of proposed metro stations is limited. 7 out of 13 metro stations are located on vacant government lands. Approximately 108 structures are affected by the proposed metro project, especially at the proposed metro station locations. The type of structures impacted include both residential and commercial buildings. The details of structures affected are given in table 5-10. Further details of different types of buildings and land ownerships along with rehabilitation and resettlement details of displaced families areaddressed in Social Impact Assessment (SIA) report and Resettlement Plan (RP).

Table 5- 10: Details on Structures impacted and Open lands (Nos.)

Phase No.	Residential Structures	Commercial Structures	Vacant lands
2A	19	86	03

276. In compliance with the ADB's SPS construction works can only take place on land that has been fully compensated and structures maybe demolished only after full compensation has been paid to the structure owner. However, there are risks of affected people being disgruntled due to various reasons such as: delays in receiving compensation; disputes or court cases regarding land ownership; being unsatisfied with the compensation amount; etc. Such disgruntled people may file complaints against the project causing delays in project construction. Given the limited number of affected people the significance of impacts on acquisition of land and property is considered as moderate.

277. **Mitigation measures:** Construction of metro stations has been planned in such a way that impact on the adjacent structures is minimized and land acquisition is avoided as much as possible. Project-affected persons, families and households shall be compensated before the start of project as per the statutory provisions before the commencement of project. The impacts shall be addressed as per the KIADB Act with compensation at par with Land Acquisition, Rehabilitation and Resettlement Act, 2013 and Safeguard Policy Statement, 2009 of ADB. Advance notice, as per Resettlement Plan will be given to the encroachers and squatters present within in the Corridor of Impact, and they will be given financial assistance as relocation allowances. R and R activities shall be undertaken as per BMRCLs Entitlement Framework and completed before construction starts.

278. **Residual Impact:** Successful payment for acquisition of private land and structures requires several conditions as mentioned above. Given these conditions it cannot be ruled out that there may be some residual impacts wherein payment of compensation to some affected people could be severely delayed and therefore project construction could be locally delayed.

Construction stage – moderate negative impact

279. **Impact:** Besides the land required for stations and viaduct foundation, land is also required during construction for establishing construction camps, casting yards, material storage and labor camps.

280. **Mitigation measures:** All temporary land required for construction establishments and labor camps will be preferably Government lands and away from Bengaluru city in order to reduce the impact of these construction establishments. The conditions for location and management of these establishments and camps are given in the EMP. The temporary lands shall be transferred back to the owner after the land has been restored to its original state before the completion of construction works. Contractor has to collect baseline data on the quality of ambient air, ambient noise, soil, surface water and groundwater before establishing the labor camps, construction camps, batching plants or any other plant required for the project.

281. **Residual impact:** With proper implementation of the proposed mitigation measures no residual impact is expected.

Operational stage – positive impact

282. Opening of the phase 2A of Bengaluru metro will increase accessibility of the area. It can be expected property values will rise in a wider area around the alignment and possibly around the stations due to the large daily influx of metro users. The attached technical assistance seeks to enhance GOK's capacity on transport-oriented development, an urban development model to re-align growth and densities along new mass transit corridors and creating higher density mixed-use, mixed-income, resource-efficient neighborhoods that are safe, compact, resilient, and inclusive and help reduce the city's carbon footprint. BMRCL also commits to fund the aesthetic development along the proposed corridor to mitigate aesthetic losses and enhance the positive effects of the infrastructure. With these, the overall impact of the metro during its operational stage will be positive.

ii. Public infrastructure and utility structures

Design and pre-construction stage – moderate negative impact

283. **Impact:** The alignment will pass utility services such as sewer, water pipes, storm water drains, telephone cables, overhead electrical transmission lines, electric pipes, roads, traffic signals, Skywalks such as the Ecospace Skywalk and others. At Kadubeesanahalli Junction a major gas pipeline is located in the median of the ORR which needs to be shifted prior to the construction works. The public structures and utility services are essential and will need to be maintained in working order during different stages of construction. Untimely shifting of utilities and dismantling of public structures will affect the construction schedule and project costs. Hence, proper planning and advanced actions (permissions and clearances) will need to be taken for shifting utility and private structures. Shifting of utilities is a challenging activity that requires several steps in seeking approval from the respective utility agencies. Poor planning and coordination and lack of information sharing to the local public could result in delays in the project schedule and

increase project costs. Since the project alignment is located in a densely populated area, there is a high risk of receiving complaints from the local public. However, this risk is limited to the pre-construction and early stages of construction. Hence, the overall significance of impact is rated as moderate.

284. **Mitigation measures:** Contractor has to prepare a utility shifting plan in close coordination with DE, BMRCL and the utility service providers involved for timely and safe shifting of utilities. The plan needs to describe among others how private landowners will be compensated if utilities need to be shifted into private land. Timely informing of the communities involved is crucial in order to prevent community complaints as much as possible. All the utilities shall be shifted to proper and pre-approved locations before the start of construction.

285. **Residual impact**. The residual impact is expected to be negligible as eventually the utilities will be shifted, and all services and public structures will be restored.

Construction stage – moderate negative impact

286. **Impact**: Although utility services will be shifted away from construction sites prior to the start of construction, unforeseen temporary disruptions in utility services cannot be ruled out. This will cause inconveniences and nuisance to the public during construction.

287. More inconvenience can be caused by complete or partial traffic diversions. Traffic shall have to be diverted into service roads and other alternate roads. The traffic diversions will create traffic nuisance in addition to inconvenience of exposure to emission of dust, pollutant gases, and increased noise levels to the inhabitants living adjacent to the proposed project corridor.

288. Traffic diversion arrangements are required to be done at all major junctions and project stretches without alternative roads to avoid traffic chaos. Details of major junctions and project stretches without service roads where traffic control and diversion will be a challenging task are given in the Table 5-11.

Table 5- 11: Major Junctions along the proposed project

Sl. No.	Junction Name	Chainage (km)	Remarks Availability of alternative routes
1	Central Silk Board	0+300	
2	HSR junction	2+000	Grade separator present
3	Agara Junction	3+650	Grade separator present
4	Ibbalur Junction	5+400	Grade separator present
5	Bellandur Junction	6+700	Grade separator present
6	Devarabeesanahalli Junction	7+700	Grade separator present
7	Kariyammana Agrahara Road Junction	8+550	No Grade Separator
8	Kaadubeesanahalli Junction	9+250	Grade separator present
9	Marathhalli Junction	11+300	Grade separator present
10	Doddanekundhi Junction	12+600	No Grade Separator
11	Railway Crossing (ROB)	13+200	Railway Over Bridge
12	Doddanekundhi Junction	14+050	Grade Separator present
13	Mahadevapura Junction	15+150	No Grade Separator
14	Mahadevapura Main Road Junction	15+550	Grade Separator present
15	Narayanapura Junction	16+300	No Grade Separator
16	KR Puram Junction	16+800	Grade Separator present
17	NH4 Junction, (KR Puram Bridge)	17+250	Grade Separator present
18	TIN Factory Junction	18+100	No Grade Separator

289. **Mitigating measures:** Contractor shall prepare a utility shifting plan prior to the start of the construction works. The utility shifting plan must include procedures for the event unforeseen disruption of utility services occurs. Prior to the actual excavation works a detailed site investigation will be undertaken in order to exactly locate all utilities by making trench pits to avoid damage to any utility.

290. As the metro alignment follows median of ORR, the construction activities are limited to the central part of ORR which has four lane divided carriage way with service roads on either side. Hence, it is not necessary to completely block the road. A clear passage shall be maintained on both sides of ORR road, for smooth operation of through traffic and local vehicular movements. Traffic diversions should be planned well ahead of schedule of construction activities and information on traffic diversions shall be disseminated to local public and commuters in advance.

291. Traffic diversion arrangements must adhere to the Guidelines on Traffic Management in Work Zones (IRC:SP:55-2014) and must be detailed in a Traffic Management Plan, to be prepared by the contractor and to be approved of by PIU and local police prior to the commencement of the works.

292. Haulage of materials and dismantled and excavated debris by trucks should be planned during non-peak hours so as not to aggravate traffic jams.

293. **Residual impact**. With proper communication and preparation, the residual impact of the shifting of utilities is expected to be negligible. Minor residual impact of traffic diversions will likely be unavoidable but will be limited in duration.

Operational stage – neutral impact

294. All activities on shifting of utility structures and restoration of normal utility services and public services will be completed during the construction stage. Hence, there will be no positive or negative impacts on public utilities during operation of the metro line.

iii. Noise

Design and pre-construction stage – major negative impact

295. **Impact.** The project alignment will run through densely populated urban areas of Bengaluru. While this is necessary for maximizing benefits for the public and making the project economically viable it also poses high risks in terms of generating noise and disturbance for people living/working and commuting close to the project alignment.

296. 124 noise sensitive receptors have been found to be located within 150 m on either side of the project alignment. This includes residences, commercial buildings, educational institutes, hospitals, sports facilities, places of worship and parks. Incorporation of noise reducing design features in the railway tracks and rolling stock and including provisions and budget for noise barriers within the project design stage is critical to ensure that there will be no long-term significant noise related impacts to residents and sensitive receptors along the project alignment. If this is not taken care of during project design stage the noise impacts can be long term and affect a large number of people and sensitive receptors. Based on this the risks related to noise during the pre-construction stage is considered as major.

297. The noise sensitive receptors along the proposed metro corridor are tabulated in the table 5-12 below.

Table 5- 12: Noise sensitive receptors along the proposed metro corridor

No	Receiver Name	Type	Chainage (km)	Distance from the nearest track (m)
1	Silk Board Interchange (u/c)	COM	0.066	60.03
2	Central Silk Board	COM	0.155	59.79
3	Spadana Pearl	RES	0.582	104.47
4	Gayatri Luxury New Pg	RES	0.623	60.49
5	Footprints Playschool and Daycare	SCH	0.652	100.06
6	Sesame St School	RES	0.819	78.56
7	Fernhill Apartment	RES	1.163	62.29
8	Bhagavathi Hospital	COM	1.314	52.72
9	Oyo 14799 Hotel	RES	1.32	53.82
10	Matthew Hospital	COM	1.331	48.42
11	Bruhat Bengaluru Mahanagara Palike	RES	1.366	34.39
12	JambuSavari EDFA in Edn	COM	1.42	48.5
13	Carmel Garden Public School	SCH	1.436	72.39
14	FITJEE	COM	1.541	50.81
15	Conflict receiver 2A	COM	1.541	7255.86
16	Chodeshwar Temple	SCH	1.568	45.99
17	Vidhya Bharati College	PRK	1.608	39.49
18	Devi Eye Hospital	COM	1.924	24.6
19	JSS Public School	SCH	1.958	121.99
20	Freedom Park	PRK	2.286	67.28
21	Freedom International School	SCH	2.404	110.01
22	NPS Montessori HSR	SCH	2.535	71.59
23	Mantri Surovar Condominium	RES	2.65	69.22
24	Agara Park	PRK	3.251	81.17
25	Ayyappa Temple	PRK	3.473	52.84
26	Rama and Radha Krishna Temple	REL	3.58	76.51
27	Sun Temple	REL	3.585	45.9
28	Mosque	REL	3.602	104.1
29	Oman Topaz	RES	3.863	30.46
30	Sobha Oryx	RES	3.936	33.45
31	HSR Traffic police Station	COM	4.929	18.89
32	Jai Hanuman Temple	COM	4.955	35.84
33	Sri Laxmi PG	RES	5.289	51.32
34	Columbia Asia Hospital	HSP	5.351	64.25
35	Royale Concorde International School	SCH	5.57	133.58
36	Microsoft Corporation India	COM	5.739	66.57
37	Sopha Hbiscus Apt	RES	5.838	32.77

No	Receiver Name	Type	Chainage (km)	Distance from the nearest track (m)
38	Salapuri Softzone	COM	6.053	36.11
39	Citrus Hotel	RES	6.161	36.26
40	Kristal Jade Apartment	RES	6.228	31.45
41	The Eye Foundation	HSP	6.259	37.8
42	Cloudnine Fertility Hospital	COM	6.291	25.61
43	Golden Residency	RES	6.378	43.62
44	Apollo Hospital	COM	6.717	27.99
45	Broadcom	COM	7.162	77.01
46	Accenture	COM	7.289	81.21
52	Marriot Courtyard Fairfield	RES	7.407	64.2
53	Novotel Bengaluru	RES	7.549	44.04
54	Passport Seva Kedra	COM	7.653	31.68
55	Dugra Saffron Square Apartments	RES	7.709	23.76
56	The Grand Adigas Residency	RES	7.731	35.14
57	Icon Premier Hotel	RES	7.811	38.37
58	Vajram Esteva Condominium	RES	7.875	45.63
59	Sakra World Hospital	HSP	7.892	133.11
60	Sri Abhayahastha Ganapathi Temple	COM	7.933	19.33
61	Country Club	SF	8	134.42
62	Wells Fargo	COM	8.403	57.56
63	Salarpuria Touchstone Bldg	COM	8.63	79.45
64	Salarpuria Aura	COM	8.664	52.62
65	Salarpuria Hallmark	COM	8.744	35.28
66	Salarpuria Primeria	COM	8.815	22.99
67	Aloft Bengaluru Cessna Business Park	COM	9.063	171.07
68	V Care Sports Academy	SF	9.108	61.66
69	Swammy Legato Bldg	COM	9.194	1.2
70	Aakruthi Sushine Apartment	RES	9.204	84.78
71	VR Chambers	COM	9.27	1.91
72	Oracle Tech Hub	COM	9.519	9.67
73	SLS Serenity Apartments	RES	9.53	67.71
74	IndiQube Gamma	COM	9.605	47.48
75	JP Morgan	COM	9.654	39.75
76	High Sky Hotels	RES	9.713	98.79
77	Adobe Tower Blk A	COM	9.778	30.35
78	Kadubeesannahali Cricket Ground	SF	9.808	106.4
79	Fujitsu India	COM	9.851	69.95
80	Little Karthik Nagar School	SCH	9.852	2827.7
81	Radisson Blue Bengaluru	RES	10.539	33.87
82	SNS Pg for Women	RES	10.553	71.86

No	Receiver Name	Type	Chainage (km)	Distance from the nearest track (m)
83	Ashray Pg for Women	RES	10.629	67.45
84	The Orange Hotel	RES	10.679	24.38
85	Neha Pg for Ladies	RES	10.873	124.05
86	V Care Health Center	COM	10.873	140.25
87	Aishwarya Opulance Apartements	RES	10.986	16.03
88	Sri Chaitanya School	COM	11.235	30.52
89	Govt Primary School	SCH	11.713	151.99
90	Fab Hotel Lotus Park	RES	12.258	37.16
91	Jeevika Hospital	HSP	12.39	42.5
92	Hindustan Academy Boys Hostel	SCH	12.566	82.71
93	Regional Remote Sensing Institute	COM	12.632	77.93
94	Karthik Nagar Park	PRK	12.72	73.22
95	Little Karthik Nagar School	SCH	12.756	37.75
96	Serra International Preschool - Marathah	SCH	12.819	35.98
97	DVL Residency	RES	12.9	23.65
98	Pleasant Villa	RES	13.091	45.35
99	Ring View Residency	RES	13.155	36.93
100	KTR Residency	RES	13.237	56.06
101	Laymen's Evangelical Fellowship Church	REL	13.442	124.81
102	Durga Petals F Block	RES	13.607	123.1
103	Lore Pride Apartment	RES	13.742	144.11
104	Darovar Portico ORR Hotel	RES	14.008	16.18
105	Lenovo India	COM	14.025	76.26
106	Bagmane Constellation Business Park	COM	14.51	99.82
107	Soul Space Arena Mall	COM	14.543	19.18
108	IndiQube ETA	COM	14.662	55.71
109	DEll EMC Tower B	COM	14.755	62.77
110	DELL EMC Tower A	COM	14.856	62.35
111	VTB Shenhameru Convention Hall	COM	14.947	55.21
112	Bagmane World Technology Center	COM	14.977	54.9
113	The Iris Inn	RES	15.965	54.51
114	Anjaneva Temple	REL	16.318	103.89
115	Kempegoda Playground	PRK	16.38	70.45
116	NCC Ivory Heights	RES	16.438	35.03
117	Mapple Heights Apartments	RES	16.523	101.58
118	Lowry Memorial Educational Institutions	SCH	16.682	117.37
119	Lowry Memorial High School	SCH	16.855	55.84
120	Lowry Adventist College	SCH	17.038	39.12

No	Receiver Name	Type	Chainage (km)	Distance from the nearest track (m)
121	Lowry Adventist College 2	SCH	17.04	58.33
122	Lowry Guest Rooms	RES	17.093	90.56
123	Gentry Mens Hotel	RES	17.143	53.72
124	Aisshwarya Excellency Apartment	RES	17.929	111.1

COM: commercial; HSP: hospital; REL: religious; RES: residential; SCH: school; SF: sports facility; PRK: park

298. **Mitigation measures:** A number of measures are being taken in project design to minimize and mitigate noise impacts. These include:

- For elevated corridors, ballast less track structure is supported on two layers of rubber pads to reduce noise and vibrations. In addition, baffle wall as parapets will be constructed up to the rail level so as reduce sound levels. Noise at source will be controlled or reduced by incorporating suitable feature in the design of structures and layout of machines and by use of resilient mounting and dampers etc.;
- Proposed project involves construction of approximately 800 pile foundations. Generally, piling is driven using an impact hammer which often produces excessive noise and is therefore not the preferred method for phase 2A. Alternative methods such as auger-piling, in-situ casting, vibration or hydraulic insertion should be used wherever possible. If pile driving is unavoidable the noise must be reduced by various dampening and shielding methods;
- including provision for noise barriers at locations where the noise levels are expected to exceed baseline levels by more than 3dB(A);
- requirement for operation stage noise monitoring in the operation stage environmental monitoring plan.

299. **Residual impact:** Given the efforts taken in the design stage and taking into account the experiences from previous metro line construction in Bengaluru it is expected the design of the ORR metro will not lead to any residual impact. This is supported by the noise and vibration study that has been carried out, which can be found in annex 5.

Construction stage – major negative impact

300. **Impact:** The community living adjacent to the proposed project corridor and workers involved in construction of project will be adversely affected by increase in ambient noise levels due to construction activities. Various construction activities such as demolition of structures along the proposed alignment and station locations; grading, excavation and drilling operations for pile foundations; construction of viaduct structures, stations and facilities; movement of heavy construction vehicles, equipment and machineries to construction site; loading, transportation and unloading of construction materials and transportation of unserviceable materials from construction site to disposal sites; etc. Further, activities such as blasting at stone quarry sites, crushing plants, asphalt production plants, produce significant noise during the construction phase. Traffic diversions during construction also contribute to the increase in noise. Poor maintenance of equipment; faulty or damaged mufflers; loose engine parts; rattling screws, bolts or metal plates contribute to increased noise. Improper handling and operation of equipment also increase noise levels.

301. Table 5-13 summarizes the noise generated from different construction equipment which are regularly used in project construction. Equipment and operation noise levels are expressed in terms of L_{Max} noise levels.

Table 5- 13: Average noise levels generated from equipment used in construction[11]

Sr. No.	Equipment	Noise Level in dB(A) (L_{max} @ 50 feet (DBA, slow))
1	Batching Plant	83
2	Concrete Pump Truck	82
3	Dumpers	84
4	Cranes	85
5	Dozer	85
6	Generators	82
7	Excavator	85
8	Trailer	84
9	Jackhammer	85
10	Hydraulic Hammer	90
11	Compactor (ground)	83
12	Compressor (air)	78
13	Impact Pile Driver	95
14	Vibratory Concrete Mixer	80
15	Auger Drill Rig	85

302. Increase of noise to around 90 dB (A) creates fatigue of the hearing organs. Prolonged stay in an area with increased noise levels gradually induces deafness and may induce various types of temporary physiological changes, such as hypertension, change heart-rate, excessive perspiration, vomiting tendency, vertigo and exhaustion.

303. The existing noise level during daytime ranges from 58 to 79 dB(A). During nighttime the existing noise level ranges from 46 to 71 dB(A). The lowest ambient noise levels during both day and nighttime exceed the limits for silence, educational as well as residential areas (see annex 5). The IFC-EHS guidelines allow a 3 dB maximum increase from the background noise when the existing noise already exceeds the standards (a 3 dB noise increase represents a doubling of the existing noise level). Project activities should therefore be prevented from increasing the elevated noise levels by more than 3 dB. Noise sensitive receptors like schools, hostels, hospitals and libraries may be disproportionately affected by the project activities both during construction and operation phase as individuals are considered as potentially more vulnerable / sensitive. Construction workers are affected by the construction noise. The intermittent and impulse noises are less dangerous than continuous noise due to the short exposure duration except under the situation when the level exceeds 115 dB (A). The exposure to a noise level >115 dB(A) is not permitted under the Building and Other Construction Workers' (Regulation of Employment and Conditions of Service) Central Rules, 1998.

304. A detailed noise modelling study has been carried out for the project (see annex 5). Assessment of the predicted noise during construction has shown that the use of in-situ piling will not result to noise impacts greater than 3 db(A). The standard use of a 3-meter noise wall will further reduce the noise levels. During piers construction, unmitigated noise levels will exceed the allowable 3 dB(A) increase during nighttime. However, the installation of the 3-meter noise wall will be effective in reducing the noise impacts to below a 3 db(A) increase. During footing construction, the expected noise increase will exceed the 3 dB(A) even with the use of the standard 3-meter noise wall due to the possible use

[11]These values represent the default values for use in the Roadway Construction Noise Model (RCNM), Federal Highway Administration's (FHWA), national model for the prediction of construction noise.

of vibro-hammers and a backhoe equipped with pavement breakers. These impact devices have relatively high rated noise power levels of 132 and 93 dB(A), respectively. Without the 3-m noise wall, footing equipment may increase noise levels by 21 dB(A) at the façade of the Chodeswar Temple and Bruhat Bengaluru Mahanagara Palikeby as much as 28 dB(A). With noise impacts exceeding the baseline by these magnitudes the increase in noise at the receiver location are expected to be from 13-14 dB(A) indicating the inadequacy of noise wall which are usually effective to mitigate by 5-10 dB(A) as a general rule. The conditions to use these high noise equipment will be very limited and will occur only when the metro alignment shifts from one side of the road to the other, these locations are detailed in annex 5.

305. **Mitigation measures:** The effective control of construction noise can be achieved by using a three-part approach consisting of control of the noise at the source, path and at the receptor. The following mitigation measures should be employed in order to minimise the impact of increased noise levels during the construction of metro project:

- Use of 3-meter high noise wall at construction sites;
- The use of more quiet methods of pavement breaking like saws and high-pressure water jetting to cut pavement to reduce noise levels by about 20 dB(A) compared to excavated mounted breakers, particularly in residential and silence zone areas.
- Noise levels will be regulated by stopping the noise generating construction works at nighttime near the inhabited localities. Noisier construction and demolition activities that cannot meet the standards for nearby sensitive receptors are prohibited between 10PM and 6AM to reduce construction noise impacts during night hours.
- Continuous loud noises around noise sensitive receptors such as schools, hospitals, etc. that exceed the corresponding project noise limits[12] for the specific receptor shall be avoided. Restriction of construction activity to limited time periods depending on applicable noise standards for sensitive receptors present in the area shall be observed;
- Monitoring of construction activity, provisions for immediate notification when measured noise levels exceed project limits, and adjustment of noise abatement controls as necessary to increase their effectiveness will be employed by the contractor as part of the Noise Monitoring and Control Plan stipulated in the BMRCL SHE Manual.
- Properly maintained equipment and machinery, designed with built-in silencers, mufflers and enclosures and shock absorbing pads shall be used in the construction. This will reduce the noise by 5 to 10 dB(A);
- Noise producing stationary equipment should be located away from noise sensitive receptors to decrease the impact of noise;
- Construction establishments such as batching plants, casting yards, construction camps, hot mix plants shall be sited away from the human habitations;
- Enclosures should be installed around the construction establishments to obstruct the noise transmission;
- The plant and equipment used in construction shall strictly conform to CPCB and BMRCL SHE manual noise standards. Noise standards for motor vehicles are notified under Central Motor Vehicle Rules, 1989 and amendments. Every motor vehicle shall be constructed and maintained so as to conform to noise standards specified in the Environment (Protection) Rules, 1986;

[12] Applicable CPCB, IFC EHS, or BMRCL SHE Manual limits, whichever is most stringent

- Considerable noise is produced by intake and exhaust parts of the engine. In such cases mufflers can be used for controlling the noise. Muffler requirements shall be made as per contract specifications;
- Poor maintenance of equipment; faulty or damaged mufflers; loose engine parts; rattling screws, bolts or metal plates contribute to increased noise. Improper handling and operation of equipment also increase noise levels. Specifications / instructions shall be included to the Contract to ensure all equipment are regularly inspected for faulty or damaged mufflers; loose engine parts; rattling screws, bolts or metal plates contributing to increased noise;
- Turning off construction equipment during the prolonged periods of non-use eliminates the noise from construction equipment. Continuous loud noises around noise sensitive receptors such as schools, hospitals, etc., shall be avoided. Restriction of construction activity to limited time periods can be effective in reducing noise induced impacts;
- Construction equipment and vehicles carrying castings, spoils, concrete or other materials can be routed through streets that could cause least disturbance to residents. The contractor shall propose and get the approval for such proposed hauling routes prior to the construction;
- Adjacent property owners and the public will be informed by the contractor of upcoming noise generating construction activities with sufficient lead time to allow feedback in case schedule needs to be adjusted;
- Efforts shall be made to reduce truck trips by using maximum load capacity, decreasing fill requirements, and combining trips where possible;
- Ensure proper personal protective devices as per Occupational Safety and Health Administration standards to all the persons working in high noise zones;
- Regular monitoring of noise levels shall be done at noise sensitive locations near the construction sites and construction establishments to monitor and have a control over increase in noise. If noise levels exceed the prescribed Leq, suitable mitigation measures like using additional silencers in noise generating equipment; erecting additional noise barriers and the use of proper PPEs shall be implemented;
- Increased noise and its transmission to sensitive receptors from the construction sites can be controlled and regulated by providing suitable noise barriers. These noise barriers are erected to suit the acoustic requirements and aesthetic considerations;
- Suitable sign boards to restrict use of horns and to set a speed limit shall be erected at all the noise sensitive receptors.

306. **Residual impact:** With proper implementation of the proposed mitigation measures the residual impact will be minor to moderate, some level of noise due to construction activities will likely be unavoidable. Impacts will be local and temporary and are therefore considered to be acceptable as long as every effort has been taken to prevent these impacts.

Operation stage – major negative impact

307. **Impact:** Noise from operating metro trains and track structures is of concern, especially for noise sensitive receptors and residential areas. However detailed noise modelling has shown that for phase 2A, the designed parapet wall height is adequate to ensure noise level increase is kept within the 3 dB(A). The results of the modeling can be found in annex 5. No residual noise impacts are anticipated, and no further mitigation is required until 2041. Noise and air pollution are expected from DG sets used during power disruption. However, this is insignificant as the impact will be only for short period of power interruption.

iv. Vibration

Design and pre-construction stage – major negative impact

308. **Impact:** Incorporation of vibration reducing design features in the railway tracks and rolling stock within the project design stage is critical to ensure that there will be no long-term disturbance and damage to properties near the project alignment. If this is not taken care of during project design stage the vibration impacts can be long term and require extra costs for fixing or compensating for damaged structures. It can also attract negative media attention and bring reputational risks. Hence, the risks related to vibration during the pre-construction stage are considered to be major.

309. Mitigation measures:

- Vibrations from operating trains caused from rail-wheel interaction, particularly at curves which will be taken care by use of resilient mounting and dampers etc. In addition, this can be reduced by minimizing surface irregularities on the wheel and rail;
- Vibrations can be reduced by improving track geometry, providing elastic fastenings, and separation of rail seat assembly from the concrete plinth with insertion of resilient and shock absorbing pad;
- Installation of elastomeric bearings, separating the track desk and the pier, resilient rail fasteners (Spring clip, rail pad, elastic pad and compression spring) and continuously welded rails, etc., are known to reduce induced vibrations on the surrounding buildings;
- During operation continuously welded rails, etc. are known to reduce induced vibrations on the surrounding buildings;
- Quality of the track and the rolling stock is very important in controlling induced vibrations in the nearby structures. Vibration emanates from rail - wheel interaction and the same can be reduced by minimizing surface irregularities of wheel and rail. Both the wheel and the rail should be free from surface wear/ irregularities (corrugation/ flat etc.) and the defective units of the rolling stock should be removed from the operation;
- In vibration sensitive areas, track on floating slab can be provided so as to avoid propagation of noise to adjacent structures.

310. During the initial operation stage, the occurrence of vibration will be monitored, provisions for this monitoring are incorporated in the environmental monitoring plan.

311. **Residual impact:** Given these efforts taken in the design of the metro line it is expected that residual impacts will not be significant. A detailed vibration assessment has been carried out (see annex 5), which confirms that no residual vibration impacts are expected.

Construction stage – major negative impact

312. **Impact:** Vibrations are expected to be generated due to construction activities of proposed project which have the potential to cause some damage to the building and properties. Therefore, various mitigation measures are to be adopted during the construction stage to prevent any such damage.

313. Pile driving for piers generates vibrations. Vibration is pronounced in hard rock sections. Transmission of vibrations depends on several parameters such as type of pile rigs used in piling; type of rocks at construction site; distance of receptor from the construction site; age and condition of the buildings adjacent to the alignment; etc.

314. The noise and vibration study (annex 5) calculated typical vibration levels at 25 ft generated by pile driving and pavement breaking. The predicted levels of vibration are 0.056 in/sec and 0.007 in/sec respectively, which are lower than the criteria value of the U.S. FTA's construction vibration damage criteria and guidance values for extremely fragile structures and ruins, which is 0.08 in/sec (see table 5-14). However, the vibration from pile driving will be distinctly perceptible according to these criteria, as can be seen in table 5-15.

Table 5- 14: Guideline Vibration Damage Potential Threshold Criteria[13]

	Maximum PPV (in/sec)	
Structure and Condition	**Transient Sources**	**Continuous/Frequent Intermittent Sources**
Extremely fragile historic buildings, ruins, ancient monuments	0.12	0.08
Fragile buildings	0.2	0.1
Historic and some old buildings	0.5	0.25
Older residential structures	0.5	0.3
New residential structures	1.0	0.5
Modern industrial/commercial buildings	2.0	0.5

Note: Transient sources create a single isolated vibration event, such as blasting or drop balls. Continuous/frequent intermittent sources include impact pile drivers, pogo-stick compactors, crack-and-seat equipment, vibratory pile drivers, and vibratory compaction equipment.

Table 5- 15: Guideline Vibration Annoyance Potential Criteria

	Maximum PPV (in/sec)	
Human Response	**Transient Sources**	**Continuous/Frequent Intermittent Sources**
Barely perceptible	0.04	0.01
Distinctly perceptible	0.25	0.04
Strongly perceptible	0.9	0.10
Severe	2.0	0.4

Note: Transient sources create a single isolated vibration event, such as blasting or drop balls. Continuous/frequent intermittent sources include impact pile drivers, pogo-stick compactors, crack-and-seat equipment, vibratory pile drivers, and vibratory compaction equipment.

315. **Mitigation measures**: As per RDSO (Research Designs and Standards Organization) Guidelines 2015, baseline and vibration monitoring studies have to be conducted along the project corridors prior to the construction activities to determine the extent of impacts. BMRCL has prepared detailed Building Condition Survey Reports for Phases 2A and 2B which will be made available to the contractor prior to mobilization.

316. As per BMRCL SHE Manual, the contractor shall prepare a monitoring scheme prior to construction nearby historical / heritage structures and other sensitive locations. This scheme for monitoring vibration level shall be submitted to Employer for his approval. Vibration will be measured during the entire during piling and concrete pavement breaking activities on nearest structures to ensure that project limits are not exceeded. Vibration meters will be installed on the nearest and most fragile structures along the active construction front during piling and concrete paving operations.

[13] U.S. FTA's construction vibration damage criteria and guidance values from the Caltrans' Transportation and Construction Vibration Guidance Manual

317. The vibration level limits for work sites adjacent to the alignment shall conform to the permitted values of peak p velocity as given in project SHE Manual and shown in table 5-16.

Table 5- 16: Construction Vibration Limits

AGGGEGATE DURATION	LIMIT
Sustained (1hr/day)	0.01 in/sec
Transient (<1 hr/day)	0.03 in/sec
Transient (<10 min/day)	0.10 in/sec

318. Vibration during construction depends on the type of equipment and the piling method used in construction. Vibrations generated will be very small in diaphragm wall method and cast-in-situ piling method;

319. When construction vibration limits are exceeded the contractor will implement additional mitigation measures to reduce the vibration impact. The vibrations from pile driving activity could be reduced by deep barriers (in excess of 10 m). In-ground barriers such as trenches, either open or filled trench with a material such as bentonite or concrete will significantly reduce the transmission of vibrations to the surrounding area.

320. **Residual impact**: With proper execution of the proposed mitigation measures the residual impact is expected to be negligible. If any damage is caused and proven to be valid then it will be incumbent on the contractor to pay compensation.

Operation stage: – neutral impact

321. A vibration assessment of the operational situation has been conducted in order to predict the vibration impacts of the future line. Based on the design speed of 34 km/h the assessment shows that no vibration impacts are to be expected during operational phase.

v. Occupational health and safety

Design and pre-construction stage – moderate negative impact

322. **Impact:** The project is a large infrastructure project that will require the use of several types of equipment and machinery, large number of workers and will ultimately cater to movement of a large number of public. The main risks which need to be addressed during the design stage is the provision of health and safety design features and facilities in the stations and trains to create a safe and healthy working environment for the operational staff during operation stage of the project.

323. Inclusion of health and safety design features in project design is a permanent activity. In terms of spatial scale health and safety requirements is limited to the stations and the project rail line. Though injuries and accidents of operational staff can have grave consequences, the chances of them occurring are low provided India has good experience in managing similar rapid transit projects. Hence, the overall significance of the OHS risks during design stage is considered moderate.

324. **Mitigation measures:** The project design will include state of art design features including on safety based on experiences from several metros under operation in India and will adhere to the requirements of BCMRL's SHE Manual.

325. **Residual impact:** It is expected that there will be no residual impacts.

Construction stage – moderate negative impact

326. **Impact.** The project will involve large scale construction activities including handling and transport of large quantities of material and operation of heavy machinery and equipment. These activities pose health and safety risks to the workers.

327. **Mitigation measures**: BMRCL has adopted its own safety, health and environment (SHE) manual, covering among others the work-related risks and corresponding mitigation measures. The Contractor will be required to control the construction site, keep it clean and provide facilities such as dust bins and collectors for the temporary storage of all waste. This waste should be adequately stored to avoid pollution of water supplies and water sources and to avoid dust formation. The Contractor will be responsible for the safe removal and/or storage of all waste in order to prevent environmental pollution of any type that may be harmful to people or animals.

328. All necessary safeguards should be taken to ensure the safety, welfare and good health of all persons entitled to be on the sites and to ensure that works are carried out in a safe and efficient manner. All personnel working at vulnerable site locations will wear safety helmets and strong footwear. It should be ensured that all workmen and staff employed on site use proper safety equipment – for example, eye protectors, ear plugs, safety helmets, the designated safety equipment when working over water – and that proper rescue equipment is available. Fire extinguishers and first-aid equipment will be kept at all sites.

329. Encountering unexpected polluted soil and waste during construction works may be a safety risk for workers and environment, if not handled properly. Sufficient quantity of PPEs like masks, hand gloves and gum boots should be kept ready. Plan for storage and safe disposal of polluted soil and waste should be ready as a part of mitigation measures.

330. Contractor shall obtain permission from District Health Officer before establishing labor camps. The location, layout and basic facility provision of each labor camp shall be submitted to DE and BMRCL to obtain their approval prior to their establishment. Contractor shall follow all relevant provisions of the Building and the other Construction Workers (Regulations of Employment and Conditions of Service) Act, 1996 for construction and maintenance of labor camp.

331. The recent COVID-19 pandemic has shown again it is of utmost importance to strictly implement hygiene measures at construction sites, labour camps and housing facilities. Since the pandemic is an evolving situation, an appendix should be added to the SHE manual with the most recent applicable local protocols as well as international guidelines from agencies such as the World Health Organization on the prevention and control of the disease in the construction site and within the community. These protocols and guidelines should also be reflected in the Emergency Response Plan to be drawn up by the Contractor.

332. **Residual impact:** With proper implementation of the proposed mitigation measures the likelihood of any residual impact on occupational health and safety will be reduced as much as practically possible but are still considered as minor during construction.

Operation stage – moderate negative impact

333. With the SHE Manual of BMRCL in place, including the standard operation procedures (SOP) with regard to COVID-19, and with the lessons learned from operating phase 1 of the Bengaluru metro it can be expected phase 2A of the metro does not have a residual impact on the health and safety of BMRCL staff.

vi. Public health and safety

Design and pre-construction stage – moderate negative impact

334. **Impact.** The ORR is expected to cater to over 300,000 passengers per day in its first year of operation. Hence, it is of utmost importance for the project design to include features that are safe and convenient for the public in the stations and trains. Passengers will include all members of society including women, children, elderly and disabled people. A dedicated special coach for women passengers in each train and reserved seats for the elderly, and persons with disabilities are planned.

335. **Mitigation measures:** The project design includes a number of features to ensure safety and convenience of the public, similar to the ones used in phase 1 of the Bengaluru metro. Examples of these safety features are clear signs for entry, exit, prohibited zones, rest rooms, elevators etc.; clear public announcement system; the presence of adequate staff in stations for housekeeping and customer service purposes; fire safety alarm and response system and facilities inside the train as well as in the stations; emergency response systems and the provision of adequate air conditioning, lighting, water and other utilities in stations.

336. **Residual impacts.** It is expected that all safety risks for local public will be addressed through design measures discussed above. Community severance impacts will be addressed to some extent through the attached TA on transport-oriented development and the aesthetic development of the corridor committed by BMRCL.

Construction stage – moderate negative impact

337. **Impact:** As the project construction sites are located along one of the major and congested roads, dust may be a nuisance to the community living near to the proposed alignment. However, the degree of dust nuisance would depend on the nature of works at the particular section, duration of construction time and the local meteorology (like humidity, wind speed and wind direction). Air pollutants adversely impact human health, vegetation and materials. Human beings exposed to air pollutants may have higher incidence of cough, shortness of breath, bronchitis, chronic fibrosis, emphysema, bronchopneumonia, colds of long duration and fatigue.

338. Movement of pedestrians close to construction sites may cause potential health & safety issues especially during erecting elevated structures like viaduct components. The movement of trucks to and from construction areas will increase the traffic risk of the commuters.

339. There may be regional labour issues; safety of children and the elders; possibility of spread of communicable disease; etc. These impacts are temporary in nature but, it needs planning, coordination and management to reduce the intensity of the impact and sustainable completion of the project.

340. The commercial activities along the proposed alignment might be affected incurring loss to the retailers and businessmen. Pedestrian and residents' access may be limited by construction activities.

341. Workers will be interacting with pedestrians and members of the community in general during construction, especially along congested and heavily populated area. As such, the risk of contracting and spreading COVID-19 is considered high, both from the community to the labor force and vice versa.

342. Mitigation measures:

- Contractor shall prepare traffic management plans to address the traffic issues in the project corridor alignment and obtain the approval of PIU and local police before start of construction;
- Contractor shall provide safe and convenient passage for vehicles, and pedestrians to and from roadsides and property. Contractor shall also ensure that the existing accesses shall not be undertaken without providing adequate alternative provisions;
- As much as possible, semi-skilled and unskilled laborers will be recruited from nearby areas to create some employment opportunities and sense of well-being among local people. This will also reduce social tension of migration and the necessity establishing labor camps within the city thus alleviating impacts associated with establishment of labor camps;
- The issues related to safety shall be addressed by properly locating the labour camps and construction establishments sufficiently away from thickly populated areas to avoid the pressure on the local resources and facilities. Construction zone should be separated such that public cannot access the construction area by providing appropriate barricading, providing personal protective equipment (PPE) to laborers, educating and training the laborers and local community, and establishing labour camps far from the inhabited areas;
- Quarries and crushers shall be sited sufficiently (at least 500m) away from settlements and fertile agricultural lands preferably in the downwind direction;
- Community nearby construction sites shall be given safety education; impose fines for violating safety requirements; ensure adequate traffic flow around construction areas; provide adequate signage, barriers and flag persons for safety precautions and communicate the public through radio, TV and newspaper announcements regarding the construction activities and timeframe of projects and expected disruptions or access restrictions;
- Conduct health screening of construction workers before recruitment to ensure no workers with contagious diseases including HIV, COVID-19 and STDs are recruited;
- Conduct awareness campaigns on HIV, COVID-19 and STD for construction workers as well as local public near the construction site;
- Operation of launchers and cranes should be done under the strict supervision of a qualified engineer and a safety supervisor. Only qualified & trained crane/ launcher operators should be allowed to operate. Regular examination and servicing of crane, launchers should be taken up before commencement of work. Safe passage for pedestrians with proper fall protection arrangements and caution signboards shall be planned and provided. HSE officials of contractor shall ensure this;
- The routes, timing and logistics of the haul truck movements should be planned ahead to minimize impacts on the safety and inconveniences to commuters;
- Construction workers are ensured adequate safety measures complying as per the occupational safety requirements to prevent accidents and hazards. Safety of workers during construction should be ensured by providing them with helmets, masks, safety

goggles etc. as per The Building and Other Construction Workers' (Regulation of Employment and Conditions of Service) Act, 1996;

- The workplace shall have proper medical facilities approval by the local medical health or municipal authorities. At every workplace, a readily available first aid unit, including an adequate supply of dressing materials, a mode of transport (ambulance), nursing staff and an attending doctor, to be provided as per the provisions of the Building and other Construction Workers' (Regulation of Employment and Conditions of Service) Act, 1996;
- To ensure safe construction and temporary accesses during construction, lighting devices and safety signals shall be installed and traffic rules and regulations to be strictly followed. The electrical equipment should be checked regularly to avoid risks to workers.

343. **Residual impact:** With proper implementation of the proposed mitigation measures the likelihood of any residual impact on public health and safety will be reduced as much as possible.

Operation stage – moderate negative impact

344. With proper design of the track and stations including all mitigation measures to prevent harm to the community it is expected that community health and safety impacts will be minimal during operation of the trains and stations.

345. The risk of contracting communicable diseases like COVID-19 when using the metro system can be reduced by having proper SOPs in place and by informing and reminding the public of the importance of following these guidelines.

346. Elevated structures of the metro project will impact the light transmission below the structure thus reducing the visibility to drivers using at-grade roads which may impact the safety of vehicle users. However, since the ORR is a wide road with adequate lighting present, the impact of the metro will be insignificant as long as the lighting arrangement is restored after construction.

347. With the abovementioned measures in place it is expected the metro will have no residual impact on public health and safety.

vii. Physical and Cultural Resources

Design and pre-construction stage – neutral impact

There are no archaeological monuments notified under the Ancient Monuments and Archaeological Sites and Remains (Amendment and Validation) Act, 2010 present along the proposed metro alignment. The religious buildings near the alignment are listed in table 5-14

Table 5- 17: Religious buildings

No	Receiver Name	Type	Chainage (km)	Distance from the nearest track (m)
1	Rama and Radha Krishna Temple	REL	3.58	76.51
2	Sun Temple	REL	3.585	45.9
3	Mosque	REL	3.602	104.1
4	Laymen's Evangelical Fellowship Church	REL	13.442	124.81

5	Anjaneva Temple	REL	16.318	103.89

348. Since he nearest religious building is located 45 meters from the alignment the design of the project does not have any impact on physical and cultural resources.

Construction stage – minor negative impact

349. **Impact:** During excavation for the pile foundations of the metro the possibility exists of a chance find of articles, structures or monument is not ruled out. Therefore, measures must be taken to protect and conserve the structure or site of archaeological importance.

350. **Mitigation measures:** All fossils, coins, articles of value of antiquity, structures and other remains of archaeological interest discovered on the site shall be the property of the Government and shall be dealt with as per provisions of the relevant legislation. If valuable or invaluable articles or archaeological rarities are discovered, the excavation should be stopped and chance find procedures, to be provided by the contractor before commencement of the works, should be followed. Contractor shall take reasonable precautions to prevent his workmen or any other persons from removing and damaging any such article or thing.

351. While impact risks are low, given the sensitivity of the site, a pre-construction condition survey of the sun temple will be carried out to identify any existing cracks or damages. If necessary additional measures such as special tape or crack measuring devices will be placed to ensure there is no further damage caused by the nearby project activities (see annex 5 for the noise and vibration assessment).

352. **Residual impact:** With proper implementation of chance find procedures no impact on physical and cultural resources is expected.

Operation stage – neutral impact

353. Since there are no archaeological monuments present along the proposed metro alignment, the operation of phase 2A of the metro will not have any impact on physical and cultural resources.

E. Expected Benefits from the Project

354. Construction of a metro project in a city like Bengaluru will yield many tangible benefits such as better accessibility; reduction in atmospheric air pollution; less travel time; more comfort and improved quality of life. Some of the positive impacts are:

- Employment Opportunities - The project is expected to generate employment for unskilled laborers during construction phase and the large number of skilled work force is required to operate and maintain the system during operation phase.
- Safety – Metro trains are largely safer, efficient and faster compared to other modes and means of transportation. Also, operation of metro trains reduces traffic congestion and chaos on at-grade roads making the roads safer and reduces the incidence of accidents.
- Reduction in Traffic Congestion and resulting Air pollution and Noise pollution – Proposed metro connectivity provides quick access to commuters thus attracting public to use metro thus reducing the traffic congestion significantly on the main roads.

The reduction in traffic congestion reduces the fuel consumption and helps to conserve fuel and reduce air pollution and noise pollution on the roads.

- Increase in Green Cover – Compensatory plantation at the rate of 10 trees for each tree being cut due to the project, will increase the green cover by the time these trees mature. Additionally, a central ribbon area under the elevated track will be planted with small trees, shrubs and grasses.
- Benefits to Economy - The project will facilitate movement of people from one part to other. This safe and easy movement yields benefit to growth of economic activity due to better accessibility, savings in fuel consumption, reduction on investment on road infrastructure, reduction in vehicle operating costs, savings in travel time, improvement in safety and quality of life and reduction in loss of productivity due to health disorders resulting from pollution. Through BMRCL's dedicated team on first and last mile connectivity many improvements will be made to poor access to stations; lack of parking facilities; absence of dedicated space for buses, cabs and autorickshaws, etc.

VI. INFORMATION DISCLOSURE, CONSULTATION, AND PARTICIPATION

355. Consultation and participation with various stakeholders are an integral part of environment and social impact assessment and ADB SPS 2009. The stakeholders of the project include project affected communities and other stakeholders. Consultations at micro-level (along the alignment) and macro-level (e.g. City level institutional consultations) help planners integrate the short term and long-term requirements of the local and regional planning goals.

356. The consultations were conducted during the field visits based on informal unstructured interviews and focus group discussions. The objective of the consultations was to disseminate the project information and obtain stakeholders' views on probable environmental and social impacts that may arise during the implementation of the proposed project. Consultation at project level was conducted at pre-identified, accessible location along the alignment. The project affected families are limited in number (only 46 owners and 62 tenants) as the land being acquired for construction of viaduct is nil and the land required for construction of proposed metro stations is minimum as 7 metro stations out of 13 metro stations are located on the vacant government lands. The informal consultations were organized with individuals and nearby people, in order to present the project features and collect their views on the perceived positive and negative impacts on the environment on account of this new development. More public consultations will be conducted to ensure that the public are properly heard during various stages of implementation of the project.

357. A walk-through informal group consultation was conducted during site visits in June 2019 along the alignment stations and at affected locations of proposed metro project. During discussion, the project proposals (alignment and proposed stations); benefits of the project; impact and resettlement benefits; grievance redressal details and role of administration; etc. were explained to get their opinion and wider public input from among the general public and affected public. The details of these informal consultations are as below.

- Public of Ibbalur were happy that one of the metro stations is proposed at Ibbalur. As per preliminary designs Government Higher Primary School was getting affected by the proposed metro station. Public requested to avoid impact on the school as the children from the locality are dependent on this school. This request by public was reviewed and designs were modified to avoid impact on the school.
- Residents had some clarifications on the location of the Ibbalur metro stations and the blockage of access to their houses. The designs and plans were shown to them and assured them that their access to metro station and outer ring road has been taken into consideration during design.
- Some of the public also enquired on the status of disbursal and the types of compensation. Most of their doubts were answered and for more information they were asked to visit Land Acquisition Office, BMRCL with the details of properties and records of ownership.

- Public at Benniganahalli had several issues with respect to their properties being lost for the project. Hence, they wanted to know the contact details and the concerned person so that they get clarification on the exact area of land being impacted.
- Public of Benniganahalli area were worried that most of them who are living in the area will be displaced. This confusion was mainly due to different Phases of metro projects and the flyovers being planned and implemented in this location. The project proposals were explained to the public with the help of drawings. It was clarified to them on the structures being impacted due to project.
- There was also a request from the public to give them more time for relocation. It was assured to them that sufficient time is given to them after disbursal of rehabilitation benefits.

358. Another round of public consultation meeting for Phase 2A section was held at Higher Primary School, Outer Ring Road, Ibbalur on 16 December 2019 with a total of 30 participants. Stakeholders and project affected people were among the people who attended the meeting. The details on gender disaggregated ratio are given in the social impact assessment and resettlement plans prepared for the project. The main concerns raised by the stakeholders were on the compensation paid to them, the ongoing demolition works, and the assistance to the school which is along the proposed metro project alignment. The design of Ibbalur metro station proposed earlier was impacting the school building. BMRCL reconsidered its proposal to build metro station by changing the design slightly, to protect the school. Now, there is no need to relocate the school and local residents appreciated BMRCL for this decision. Issues raised by the stakeholders were responded to and their valuable suggestions were noted down for consideration and appropriate action. The key findings of the meeting are given in table 6.1 and the photographs are given in figure 6-1.

Table 6- 1:Major findings of Public Consultation at Ibbalur, ORR

Sl. No.	Name of Stakeholder / Project Affected Public	Grievance / Request	BMRCL's Response
1	Doddamuniyappa Saliyana	He opined that the BMRCL is demolishing the buildings after paying compensation, but he requested BMRCL officials to instruct the contractor involved in demolition activity, not to cause damage to the adjacent properties. He told that his land is being impacted and submitted the documents and records to BMRCL, however, he has not received compensation.	BMRCL officials said they will instruct the contractor to ensure that no damage is caused to the adjacent sites, with proper protection. BMRCL officials assured him to examine the submitted records.
		Requested BMRCL to extend the help to the school in some manner and they submitted a request.	BMRCL officials said the matter will be discussed with the Project Authorities and will help accordingly.
2.	Chandrashekar	The contractor has started demolition of structures and the debris generated from demolition works is	BMRCL said they will take up the issue with the contractor immediately.

Sl. No.	Name of Stakeholder / Project Affected Public	Grievance / Request	BMRCL's Response
		blocking the road and debris should be cleared from the roads regularly. Barricade should be erected around the work sites for the safety of pedestrians.	
		He has received less compensation and requestedthat the matterbe reexamined.	BMRCL officials confirmed that the compensation has been paid as per BMRCL's resettlement policy and it is not possible to either lessen or increase compensation once agreed.
		BMRCL has acquired part of land in his plot, will there be any access to the remaining land.	Officials have assured to examine the site and take appropriate action to ensure the access.
3.	Krishnappa	Contractor has demolished the structure more than the acquired land. Will the compensation be paid for the excess demolished portion?	BMRCL officials asked Mr. Krishnappa to submit request so that they can examine the facts and action will be taken.
4.	Srinivas, Tenant	He has not received the compensation and he will not vacate until he gets the compensation.	BMRCL said they will look into the matter.
		Demolition works is generating dust and noise in the area. It is noticed that demolition works are being carried out during night and early morning which is disturbing the public.	BMRCL said they will address this immediately with the contractor.

Figure 6- 1: Public Consultation Meeting Photos

359. Continuous consultations with particular attention to vulnerable groups, the public living along the alignment and consultations for stakeholders at the regional level and non-government organizations (NGOs) in the city will be conducted throughout project implementation as much as practicable given restrictions due to COVID 19. Access to the Grievance Redress Mechanism will be provided as discussed in the succeeding section.

360. Information disclosure will follow the procedure for ADB Category A projects disclosure requirements. It is the policy of the ADB to have environmental and social assessment reports made available/accessible to the general public.

361. The project EA will be responsible for the disclosure of this EIA in compliance to ADB's Communication Policy 2011 and ADB's SPS 2009. The draft Environmental Impact Assessment Report will be disclosed in the English language in the office of BMRCL. The report will also be made available to interested parties on request from the office of the BMRCL. Since this is Category A subproject, the draft EIA report will be disclosed to the public through the ADB website, 120 days before the approval of the project by ADB Board. The draft EIA report will also be made available to all stakeholders as part of the consultation process required under the SPS 2009. The final report will also be disclosed on ADB website.

A. Grievance Redress Mechanism

362. A grievance redress mechanism is in place to hear grievances and suggestions from stakeholders and affected people on issues related to the construction of metro project; R & R issues and implementation of EMP. Public Relation Officer (PRO) will be nodal officer to interact, co-ordinate and resolve the grievances. Provision is made to submit the concerns / grievances at Construction sites, Land Acquisition Office and BMRCL Headquarters. The PRO with the help of respective department heads (Social, Environment, Technical, etc) is responsible to suitably address the issues from stakeholders and project affected people through acknowledgement, evaluation, action and response approach. GRM contact information is available at the BMRCL website and drop boxes for lodging complaints will be provided at construction sites, Land Acquisition Office and BMRCL Headquarters prior to commencement of works. Information on GRM has been discussed during consultations and will be disseminated through leaflets, television and radio ads, and social media platforms as appropriate.

363. The grievances are screened for genuineness and validity after registering in the grievance register and logbook. The genuine and valid grievances will be acknowledged, evaluated, redressed, implemented and communicated in a timely manner to the complainant by the grievance redressal mechanism with the help of Grievance Redress Committee (GRC) constituted at BMRCL. Formal acknowledgment of grievance shall not exceed seven days from receipt. Depending on the severity of the grievance received, the plan of action will be provided to the aggrieved not later than a month from the receipt of complaint. Contractors and the PIU will maintain logbooks/database of grievances and will report on formal and informal complaints and feedback received as part of regular safeguards reporting.

364. Minor and local grievances will be dealt and resolved by the Contractor with the Site Engineer in-charge or Tahsildar, as necessary. This will be the first level GRM. The grievances from public or stakeholders related to project, response to parliamentary questions, public representations, court cases and right to information (RTI) applications on social and environmental issues and any other matters will be dealt by forwarding to respective department heads. Matters related to social issues and resettlement benefits are forwarded to Deputy General Manager (DGM) or General Manager (GM) Land Acquisition Department for resolution while issues related to environment and EMP implementation are directed to the Environment Officer (EO), both departments constituting the Social and Environment Management Unit (SEMU). All other technical issues are referred to the respective Deputy Chief Engineer (DCE) or Chief Engineer (CE). A copy of grievance shall be parallelly communicated to Designated Engineer (DE) for information and required action. The grievance which could not be resolved at SEMU or Technical Section level, will be referred to Grievance Redressal Committee (GRC) chaired by the Director (Projects and Planning).

365. The project-specific GRM is not intended to bypass the government's own redress process, rather it is intended to address project-affected people's concerns and complaints promptly, making the GRM readily accessible to all segments of affected persons and scaled to the risks and impacts of the project. Complaints requiring judiciary clearance will be referred and resolved through BMRCL Legal Cell. Complainants may access the formal legal system at any time.

366. The GRC comprises of following members under the Chairmanship of Director (Projects and Planning).

a. Director (Projects and Planning), Chairman
b. General Manager (LA&E), Convener

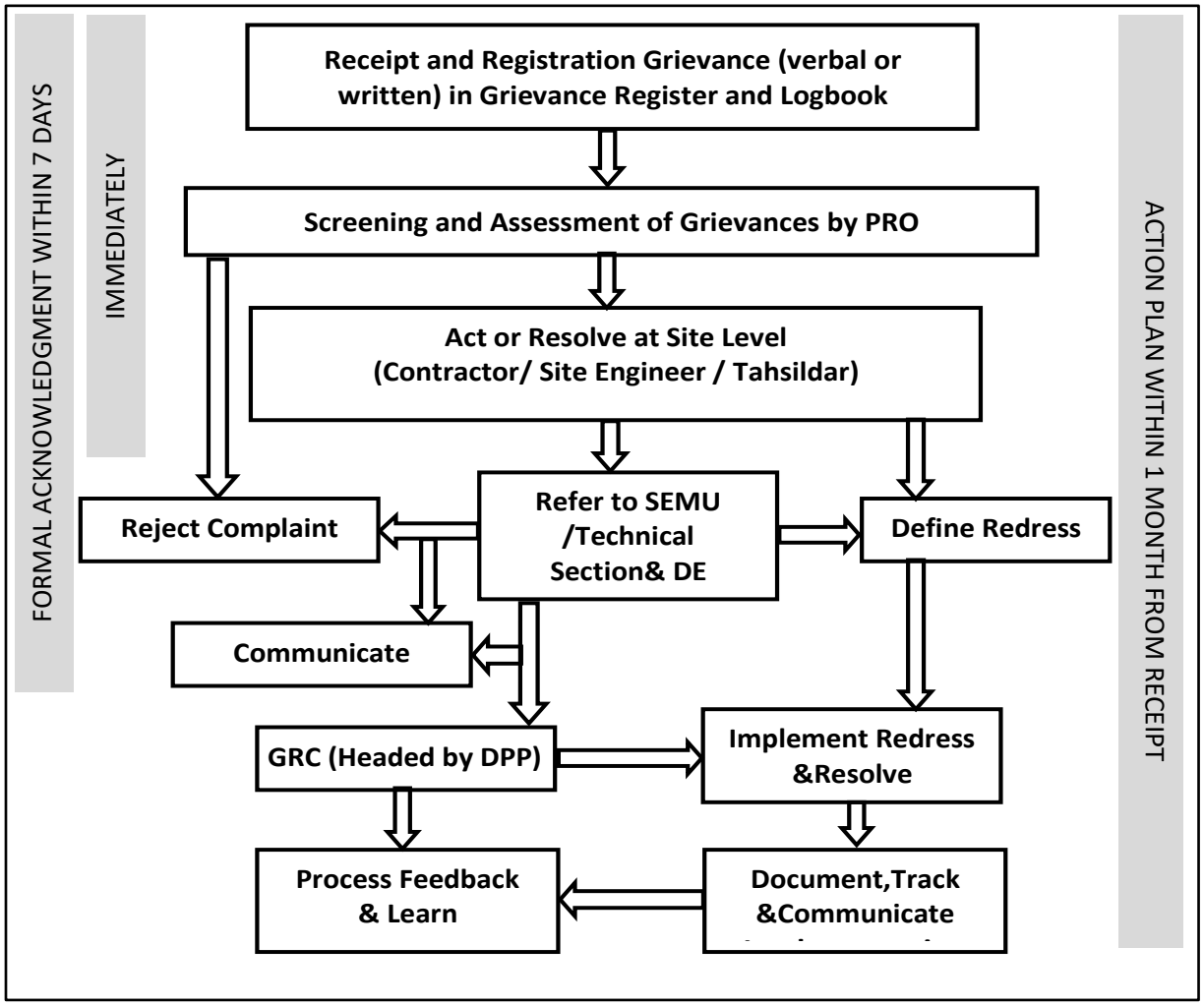
c. General Manager (F & A), Member
d. Chief Public Relation Officer, Member
e. Chief Engineer / (respective Reach), Member
f. Manager (Transportation), Member
g. Tahsildar (Respective Reach).

367. The main responsibilities of the GRC are:

(i) To provide support to stakeholders and Project Affected Persons (PAPs) on resettlement and rehabilitation benefits provided and problems and complaints arising out of land acquisition, relocation of utilities and project implementation.
(ii) To record the grievance and resolve them within stipulated time frame.
(iii) To report to the aggrieved parties about the development regarding their grievances and decision of BMRCL.
(iv) To meet regularly on a prefixed date during implementation of project.

368. The flow chart of grievances redressal mechanism is indicated in the Figure 6-2.

Figure 6- 2: The GRM Framework, BMRCL



VII. ENVIRONMENTAL MANAGEMENT PLAN

A. Introduction

369. The Environmental Management Plan (EMP) is the synthesis of all proposed mitigation and monitoring actions, set to a timeframe with specific responsibility assigned and follow-up actions defined. It contains all the information for the proponent, the contractor and the regulatory agencies to implement the project within a specified timeframe.

370. This EMP consists of a set of mitigation, monitoring and institutional measures to be taken for the project to avoid, minimize and mitigate adverse environmental and social impacts and enhance positive impacts. The plan also includes the actions needed for the implementation of these measures. The major components of the Environmental Management Plan are:

- Institutional arrangements to implement the EMP;
- Mitigation of potentially adverse impacts;
- Environmental monitoring and monitoring of EMP implementation during project implementation and operation;
- Reporting mechanism;
- Training and capacity building, and
- Budget.

B. Objectives of Environmental Management Plan

371. The main objectives of this EMP are:

- To ensure compliance with lenders (ADB) applicable safeguard policies, and regulatory requirements of Karnataka and India;
- To formulate avoidance, mitigation measures for anticipated adverse environmental impacts during construction and operation, and ensure that socially acceptable, environmentally sound, sustainable and good practices are adopted; and
- To stipulate monitoring and institutional requirements for ensuring safeguard compliance.

C. Institutional Mechanism and Arrangement for Implementation of EMP

372. The Bengaluru Metro Rail Corporation Limited (BMRCL) will function as the executing agency (EA) for the project on behalf of the Ministry of Housing and Urban Affairs (MOHUA). BMRCL has established a Project Implementation Unit (PIU) which is responsible for implementing the project to ensure and achieve certain level of quality in the project and make sure that the statutory requirements are not violated. The Managing Director that heads BMRCL will be responsible for the successful implementation of the Project. BMRCL will establish a Project Implementation Unit (PIU)at Headquarter level, headed by the Executive Director and assisted by Chief Engineer (CE) and Deputy Chief Engineers (DCE). The CEs and DCEs will look after all the technical issues of the project implementation. PIU will be assisted by Social & Environmental Management Unit (SEMU) to oversee environmental and social concerns of the project.

373. A Chief Health and Safety Officer will be hired prior to project implementation which has the capacity to review and approve health and safety plans and other related measures, particularly to sufficiently address COVID 19 impacts.

374. During construction phase the PIU will have site level offices consisting of Chief Engineer/Deputy Chief Engineer and Executive Engineer, an Environmental Engineer and a Safety Engineer. Every contract package will have its own PIU site level office.

375. SEMU of BMRCL is in-charge of the environmental and social issues during the project preparation, implementation and operation with the assistance of the Environmental Specialist of the Designated Engineer (DE) and Environmental Officer (EO) working for Contractor during construction phase.

376. Monitoring of environmental attributes will be carried out by site level PIUs with the help of environmental monitoring agencies approved by the State or Central Pollution Control Board.

377. Relationship among PIU of BMRCL, SEMU, Designated Engineer (DE) and Contractor with respect to supervision and monitoring of EMP for Phase-2A is depicted in the following Figure 7-1.

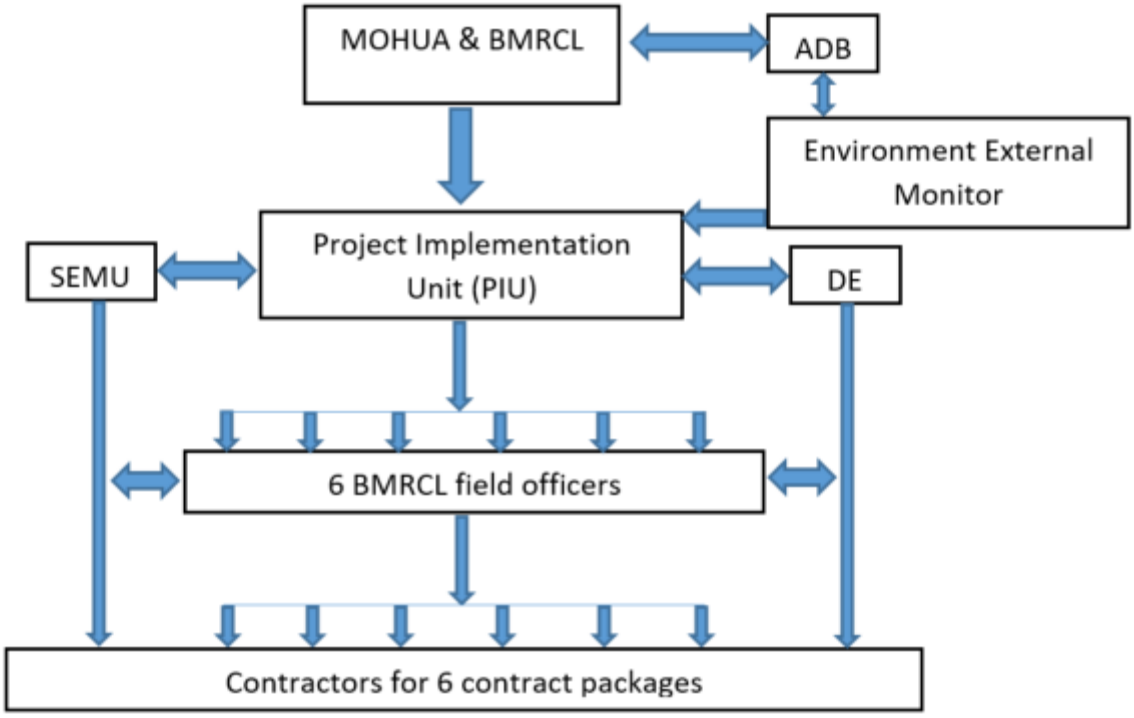


Figure 7- 3: Organizational Chart

378. **Social and Environmental Management Unit (SEMU).** BMRCL will have institutional capacity to meet the requirements for implementation of the environmental mitigation measures in the EMP and address the grievances of Social and environmental issues of the project and ensure compliances with environmental and social safeguards policies of the Government, lender and applicable National laws. DCE (Environment) reports to Chief Engineer / Executive Director who is responsible for management of social and environmental issues of the project. DCE (Environment) will be assisted by 2 Assistant Environmental Engineers and 2 Social Officers who shall be responsible to look after all

the environment and social issues related to the project during the project preparation, implementation and operation period respectively. Social Environmental Management Unit will be supported by the technical and field staff for the project implementation with the assistance of the Environmental Specialist of DE.

379. It is envisaged that the Social and Environmental Management Unit will be responsible for:

- Monitoring implementation of the EMP measures in consonance with the timeline for the project as per the approved budget;
- Maintaining interaction with the stakeholders, public and various statutory authorities pertaining to environment, land acquisition, rehabilitation and resettlement of BMRCL project;
- Interacting regularly with the Environmental Expert of DE on the status of the environmental mitigation and enhancement measures;
- Regularly inspect the project site to monitor the mitigation measures being implemented by the Contractor;
- Document and disseminate good practices, minimize and resolve bottlenecks during the implementation of EMP.

380. **Designated Engineer (DE).** The DE will be procured to assist BMRCL for implementation of project, before the project is awarded. The Environmental Specialist of DE shall be the key personnel to ensure the successful implementation of EMP provisions, there will be one Environmental Specialist per contract package. The Environmental Specialist together with the site level PIU will ensure that the Contractor complies with various EMP requirements. In addition, he will update BMRCL on the progress of environmental protection and enhancement works as envisaged in the EMP. It is envisaged that the responsibilities of the DE Environmental Specialist will include:

- Supervise and monitor the implementation of EMP by the Contractor;
- Review and approve site-specific environmental mitigation / enhancement designs submitted by the Contractor based on the EMP prepared.
- Review and recommend the Contractor on implementation plans for approval and suggest any changes that may be necessary to ensure compliance with the environmental provisions of the Contract.
- Review and approve management plans for communicable diseases such as COVID-19 and any other health and safety management plans in consultation with the BMRCL Chief Health and Safety Officer.
- Monitor tree plantation programs and the periodic environmental monitoring of air, noise, vibration, water, soil, etc. during pre-construction, construction and operation phase to ensure compliance with the statutory requirements and the EMP.
- Hold regular meetings with Contractor and keep DCE (Environment) updated regarding the progress of environmental works.
- Prepare and submit monthly and quarterly environmental progress reports to BMRCL;
- Prepare and submit semi-annual environmental progress reports to SEMU and PIU for their review and approval. PIU will submit the approved report to ADB;
- Develop and organize environmental training programs to upgrade the skills to the staff of SEMU, Contractors and the Concessionaire.

- Document and develop good practices during project implementation for wider dissemination.

381. **Contractor.** For effective implementation and management of the EMP, the Contractor shall arrange to establish a Safety, Health and Environment (SHE) Cell headed by an Environment Officer (EO) to deal with the SHE issues related to the project. Environmental Officer shall interact with the Sub-contractor, BMRCL, DE and other line departments to ensure that the mitigation and enhancement measures mentioned in EMP are adhered. Prime responsibility shall be to apprise the DE Environmental Specialist about the progress and on ground conditions. EO shall also procure the requisite clearances and NOCs for the project and handle any additional charges of safety and health. The EO or any other member of the SHE cell of the contractor must have the professional skills to be able to draw up management plans on communicable diseases such as COVID-19. EO will prepare monthly progress reports including updates on EMP implementation and submit these for review to DE Environment Specialist.

382. **External Monitor**[14]**.** For Category A projects an external independent monitor will be engaged prior to start of construction activities to monitor the implementation of EMP and its compliance. Responsibilities of the external monitor are:

- Review the EIA and EMP prepared for the project. Provide recommendations for EMP improvement if necessary;
- Review the environmental components of monitoring and progress reports prepared by the contractor and Designated Engineer to check consistency and accuracy with site conditions;
- Conduct site visits at least once every 3 months during project construction period to conduct third party monitoring of the implementation of the EMP by the contractor and supervision by the BMRCL field office and Designated Engineer (DE);
- Carry out public consultations with residents/communities living near the project site to check if the project is generating any adverse impacts;
- Provide technical guidance on ways to improve implementation of the EMP and SHE requirements under the project as well as ADB SPS and relevant GOI environmental requirements;
- Provide technical guidance on ways to avoid and minimize negative impacts on lakes and other ecological features in the project area;
- Provide technical guidance on ways to improve occupational and community health and safety in the project area;
- Advise the BMRCL and the PIU on the need for corrective actions if any.
- Based on observations during site visits, review of monitoring reports prepared by the contractor and DE and discussions with BMRCL PIU, contractor, DE and local people in the project area prepare semi-annual monitoring reports for submission to BMRCL and further submission to ADB;
- Incorporate comments and feedback on the reports from BMRCL, ADB and other relevant organizations such as the local Lake Authority, Forestry Department etc. if required.

383. ADB's Responsibilities:

[14] The External Monitor will not be involved in day-to-day project supervision or activities.

- Review EIA report and disclose the draft and final reports on the ADB website as required;
- Issue project's approval based on EIA report;
- Monitor implementation of the EMP through due diligence missions;
- Provide assistance to the EA, if required, in carrying out its responsibilities and for building capacity for safeguard compliance; and
- If necessary, provide further guidance to the EA on the format, content, and scope of the EIA report and quarterly environmental monitoring reports for submission to ADB.

D. Mitigation Measures

384. The identified environmental issues and suggested mitigation measures with institutional arrangements for implementation, supervision and monitoring have been provided in a matrix format as presented in Table 7-1. This matrix together with BMRCL's SHE Manual will be part of the contractor's bidding documents. BMRCL has also prepared the SOP for work during lockdown in light of the COVID-19 pandemic which will serve as the main guidance document for contractors and will be updated from time to time as necessary. Key anticipated potential impacts and suggested mitigation measures specific to the project are summarized in following paragraphs. These mitigation measures will be implemented as part of the project.

385. The key anticipated adverse environmental impacts from phase 2A are:

- Dislocation or involuntary resettlement of people as there will be a need for land acquisition;
- Loss of about 1248 trees for construction of rail alignment and stations;
- Risks and vulnerabilities related to occupational health and safety due to physical, chemical and biological hazards during project construction and operation;
- Noise and vibration due to pile driving machines and materials hauling.
- Increased noise and air pollution resulting from traffic volume during construction;
- Temporary impact on land and air environment due to the location of construction camp;
- Temporary impact on land, air and water environment due to establishing and operating construction plants (casting yard, hot mix plant, DG sets);
- Impact on land and water environment due to disposal of construction waste materials; and
- Impacts on community health and safety due to construction activities and transport activities.

386. The measures to mitigate these impacts are summarized in the following paragraphs.

i. Compensation for Loss of Land and Displacement of People

387. Phase 2A will require acquisition of about 53,475.27 m^2 of land of which 20,899.33 m^2 is private land and 32,575.94 m^2 is government land. 46 owners and 62 tenants are affected, especially at the proposed metro station locations. The affected people will be

compensated and assisted as per the provisions of Resettlement Plan (RP). Resettlement & Rehabilitation activities of proposed rail project will be governed by following general principles, which are based on The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013.

ii. Compensation for Loss of Trees

388. 1248 trees will be affected by the project. Many of the trees will be transplanted; trees cleared shall be replaced with minimum of 10 tree saplings per tree cut or according to conditions specified by Tree Committee or Forest Department. The saplings will be monitored for their survival for three years. Re-plantation shall be taken up every year with new saplings where saplings or transplanted trees fail to survive. Compensatory plantation will help the city to increase the green cover. Budget towards planting of trees have been included in the EMP cost.

389. In addition to the compensatory plantation, the median of the road under the elevated corridor will be developed using native shrubs, herbs and grasses. This green belt will provide aesthetic view of elevated track and also helps to serve as dust and noise absorbent barrier.

iii. Soil and Groundwater Pollution Control

390. Oil and grease generated from construction equipment must be collected and treated before discharged. Precautionary measures have been suggested to prevent these wastes moving in to ground or surface water bodies, as they are important sources of water for domestic use. Oil traps in the heavy machinery area are suggested to collect oil-based materials. Similarly, sedimentation basins would be erected prior to the water discharge point to reduce the sedimentation load in the storm water.

iv. Noise Pollution Control

391. For elevated corridors, ballast less track structure is supported on two layers of rubber pads to reduce noise and vibrations. In addition, baffle wall as parapets will be constructed up to the rail level so as reduce sound levels. Noise at source will be controlled or reduced by incorporating suitable feature in the design of structures and layout of machines and by use of resilient mounting and dampers etc.

392. To reduce the harmful effects, the Contractor shall ensure that all powered mechanical equipment used in the Works shall be effectively sound-reduced using the most modern techniques available including, but not limited to, silencers. The workers shall be provided with ear mufflers. The Contractor shall construct acoustic screens or enclosures around any parts of the Works from which excessive noise may be generated. The Contractor shall ensure that noise generated by work carried out by the Contractor and his sub-Contractors during daytime and nighttime shall not exceed the maximum permissible noise limits. In the event of a breach of this requirement, the Contractor shall immediately re-deploy or adjust the relevant equipment or take other appropriate measures to reduce the noise levels and thereafter maintain them at levels which do not exceed the said limits. Such measures may include without limitation the temporary or permanent cessation of use of certain items of equipment. Vehicles used for transportation of construction materials would be equipped with proper silencers. Careful planning has been made to operate the construction equipment to have minimal disturbances. The construction equipment would be run only during the daytime and their noise would be monitored as per CPCB standards. A comprehensive noise assessment should be carried

out prior to start of construction work to identify requirements of noise barriers and other mitigation measures at sensitive receptors along the alignment.

v. Vibration Control

393. The vibration is generally caused from rail-wheel interaction. This will be reduced by minimizing any surface irregularities on the wheel and rail. To minimize the vibration, shock absorbing pad has to be provided and there has to be a distance between rail seat assembly and concrete plinth.

394. During piling and other construction activities, there may be possibility of vibration occurrence and the monitoring shall be carried out for couple of readings and can be interpreted accordingly whether is there any adverse impact on the surrounding buildings and other structures. In this regard, any authorized monitoring agency shall be employed to carry out the set of analysis.

vi. Air Pollution Control

395. During the construction period, the impact on air quality will be mainly due to increase in PM10 along haul roads and emission from vehicles and construction machinery. Mitigation measures which shall be adopted to reduce the air pollution are presented below:

- The Contractor shall take all necessary precautions to minimize fugitive dust emissions from operations involving excavation, grading, and clearing of land and disposal of waste. He shall not allow emissions of fugitive dust from any transport, handling, construction or storage activity to remain visible in atmosphere beyond the property line of emission source for any prolonged period of time without notification to the Employer.
- The Contractor shall use construction equipment to minimize or control of air pollution. He shall maintain evidence of such design and equipment and make these available for inspection by Employer.
- Contractor's transport vehicles and other equipment shall conform to emission standards fixed by Statutory Agencies of Government of India or the State Government from time to time. The Contractor shall carry out periodical checks and undertake remedial measures including replacement, if required, so as to operate within permissible norms.
- The Contractor shall cover loads of dust generating materials like debris and soil being transported from construction sites. All trucks carrying loose material should be covered and loaded with sufficient free - board to avoid spills through the tailboard or sideboards.
- The temporary dumping areas shall be maintained by the Contractor at all times until the excavate is re-utilized for backfilling or as directed by Employer. Dust control activities shall continue even during any work stoppage.
- The Contractor shall place material in a manner that will minimize dust production. Material shall be minimized each day and wetted, to minimize dust production. During

dry weather, dust control methods must be used daily especially on windy, dry days to prevent any dust from blowing across the site perimeter.

- The Contractor shall water down construction sites as required to suppress dust, during handling of excavation soil or debris or during demolition. The Contractor will make water sprinklers, water supply and water delivering equipment available at any time that it is required for dust control use. Dust screens will be used, as feasible when additional dust control measures are needed especially where the work is near sensitive receptors.
- The Contractor shall provide a wash pit or a wheel washing and/or vehicle cleaning facility at the exits from work sites such as construction depots and batching plants. At such facility, high-pressure water jets will be directed at the wheels of vehicles to remove all spoil and dirt.

vii. Utility Restoration

396. The proposed alignment runs along major roads of the city, which serve Institutional, Commercial and Residential areas. A number of sub-surface, surface and overhead utility services, viz. sewers, water mains, storm water drains, telephone cables, electrical transmission lines, electric poles, traffic signals etc. exists along the proposed alignment. These utility services are essential and have to be maintained in working order during different stages of construction by temporary / permanent diversions or by supporting in position. As such, these may affect construction and project implementation time schedule /costs, for which necessary planning / action needs to be initiated in advance. Prior to the actual execution of work at site, detailed investigation of all utilities and location will be undertaken well in advance by making trench pit to avoid damage to any utility. Utility services shall be kept operational during the entire construction period and after completion of project. All proposals should, therefore, ensure their uninterrupted functioning.

viii. Development and implementation of Sub-plans

397. As part of the environmental management plan, contractors need to develop various sub-plans as discussed in the EMP. These plans are aimed at good environmental management practices and serve as guide documents. These sub-plans will form part of construction EMP be consistent with the contractor's SHE plan and will be included as part of the contractor's responsibilities in the bid documents. Table 7-1 present some of the key plans to be developed by contractor and responsible party for its approval.

Table 7-1: Contractors' Sub-plans and Approval Party

Plan	Description	Approval by	
		PIU	DE
Permits and Approvals Action Plan	An action plan to secure all permits and approvals needed as per EMP item 15	Yes	Yes
Waste and Debris Disposal Management Plan	The plan shall describe waste streams and amounts, describe recycling/reuse methods for each material, identify the waste destinations and transport modes, including what materials are being segregated on site for reuse or	Yes	Yes

Plan	Description	Approval by	
		PIU	DE
	recycling, specify responsibilities for managing and disposal of waste		
Construction Water Management Plan	Plan to describe the water sources, required permits and ways to minimize water wastage	Yes	Yes
Traffic Management Plans	The traffic management plans shall contain details of temporary diversions, traffic safety arrangements, details of traffic arrangement after cessation of work each day, safety measures for nighttime traffic and arrangement of flagmen.	Yes	Yes
Haul Road Network Plan	The routing, timing and logistics of the haul truck movement shall be planned including mitigation measures for air quality, noise, traffic and community H&S	Yes	Yes
Emergency Response Plan	This plan shall prescribe measures to prevent, mitigate, respond to and recover from emergency events that could occur due to project activities such as accidents, spills of hazardous substances, fire, extreme weather events, communicable disease outbreak, and others.	Yes	Yes
Construction and Labor Camp Plans	The plan will provide a layout map of the camp sites with entry and exit roads and different facilities inside the camp. Facilities may include contractor's office, residential quarters, toilets, health center, construction plants, storage areas etc. The plan will include information on hygiene, health and safety measures, waste management, supply of water for drinking and bathing, wastewater and drainage management, traffic movement routes etc.	Yes	Yes
Site and Camp Restoration Plan	Describes the clean-up and restoration operations to be implemented by the Contractor prior to demobilization including clearance of all temporary structures, disposal of all garbage, night soils and Petroleum, Oil and Lubricants wastes and filling and sealing of all disposal pits or trenches.	Yes	Yes

Table 7- 2: Environmental Management Plan Matrix

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
Pre-Construction Phase (Planning and design):								
1	Land Acquisition and resettlement	Social - Land is being acquired at all the Metro Stations along the Metro alignment. Total land to be acquired is 53,475.27 m^2 (Government land 32,575.94 $m^2$and Private land 20,899.33 m^2) and total of 108 properties.	– Land Acquisition will be carried out as per the provision of Govt. of India and ADB policies. – The acquisition of land and private properties will be done in accordance with Resettlement Plan and Entitlement Framework for the Project in line with the KIAD (Karnataka Industrial Areas Development) Act 1966 and Amendments.	The areas with additional land acquisition is proposed for the project.	Number of households and individuals affected.	Review of relevant documents, entitlement matrix and amount paid.	Land Acquisition Team, BMRCL through Revenue department of the state.	BMRCL, Karnataka State Government
2		Land use change - Change in land use is expected at station locations where the land is being acquired. The insignificant impacts on land use change are limited to a few of proposed metro stations.	The change in land use is insignificant as the proposed metro alignment is following the median of Outer Ring Road and most of the metro stations are proposed on vacant land without much impact on the existing structures. The Bengaluru Comprehensive Development Plan (CDP) and Bengaluru Revised Master Plan (RMP) 2031 both account for proposal of Phase 2A by BMRCL. Proper permissions will be ensured from competent authorities before construction.	Throughout the project alignment and station areas.	Area of land acquired for the project.	Review of records on permission received from authorities.	Land Acquisition Team, BMRCL with District Administration and State Authority	BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
3	Clearance of Encroachments / Squatters (Compulsory resettlement)	Social - There are 46 owners and 62 tenants within the Corridor of Impact (CoI) along the proposed metro alignment and metro stations of Phase 2A.	Advance notice, as per Resettlement Plan will be given to the encroachers and squatters present within in the Corridor of Impact, and they will be given the financial assistance as relocation allowances. R & R activities shall be undertaken as per BMRCLs Entitlement Framework and completed before construction starts.	Throughout the project alignment and station areas.	Area of land acquired for the project.	Review of records on permission received from authorities.	Land Acquisition Team, BMRCL with District Administration and state authority	BMRCL
4	Tree Cutting	Ecology – As per BMRCL survey approximately 1,248 trees are impacted by the project under Phase 2A. Out of total trees enumerated many of the trees are planned to be trans-located depending on the tree species, girth and health of the trees. The trees are located on the median of proposed route along the outer ring road impacting the ecology in the project vicinity. In addition to tree cutting, pruning of branches will be required at some locations.	Transplantation/felling of trees will be taken up according to the recommendations/ directions of the Tree Expert Committee (TEC) re-constituted by Government of Karnataka, as per the orders of Honorable High Court of Karnataka dated 20 August 2020. Every tree felled is compensated at the rate of ten trees or as per the direction of TEC or Forest Department. In addition, at-grade median plantation will be taken up all along the proposed alignment. The Environmental Specialist of DE and the Contractor shall carry out joint field verification to ascertain the possibilities of saving trees and trees to be	Throughout project corridor.	ROW width Number of trees to cut Compensatory plantation plan Number of trees replanted	Review of relevant documents – tree cutting permit, compensatory plantation plan Field observations	Relevant agency/Forest Department Specialized in afforestation	BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			removed shall be marked with paint. Contractor, under any circumstances shall not cut or damage trees unnecessarily. Trees identified under the project shall be cut only after receiving clearance from State Forest Department or per direction by the TEC and after receipt of BMRCL's written permission. Transplantation of trees shall be taken up on priority suiting to the tree species, age, size, and health condition of the tree. Compensatory plantation taken up will be monitored regularly for their survival. Vegetation with girth size of over 30 cm shall only be considered as trees and shall be compensated. The tree saplings which do not survive during the first year after replanting will be compensated immediately.					
5	Relocation of Utilities and Common Property Resources	Social - The proposed metro line interferes with community utilities like water pipes, sewers, OFCs,	Permission from all concerned departments and BBMP should be sought before commencement of utility shifting works.	Throughout the project alignment and station areas.	Area of land acquired and required for working	Review of records on permission received from authorities.	Agency engaged by BMRCL	BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
		telephone wires. Skywalks, etc. throughout the corridor. This will create nuisance to public and the commuters.	All community utilities i.e. water supply lines, sewer lines, electrical lines, telephone and OFC cables shall be planned and relocated suitably before the start of construction works. The Contractor will install signage consisting of information signs, construction signs and traffic signs 15 days before initiation of shifting works.		space for the project.			
6		Traffic flow – During relocation activities regular traffic flow will be impacted.	Permission from traffic police should be sought before commencement of utility shifting works. Traffic diversion plans shall be prepared, and detours should be properly planned and enacted during non-peak hours, if possible. Traffic marshals should be posted near such detours. Proper signage has to be posted informing motorists about detours to avoid congestion.	Traffic diversions and intersections locations	Approval from competent authority.	Checking of documentation.	Agency engaged by BMRCL	BMRCL
7		Air – Dust will be generated during utility shifting activities and pollutes the air.	Traffic shall be diverted away from the utility shifting sites to avoid re-suspension of dust from the road surface.					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			Dust suppression methods like water spraying shall be adopted during utility shifting to encapsulate the dust.					
8		Safety – Workers and public will be exposed to safety threat such as excavation related safety hazards such as falls into trenches or excavations; tripping over equipment, debris and spoil; exposure to underground services, electrocution, etc.	Barricades of at least 3 m height will be installed to mark the boundary of the areas where public utilities are to be relocated. Workers shall be provided with appropriate PPEs and ensure to operate equipment in a safe manner during shifting works Utility shifting shall be coordinated such that information on utilities' locations is obtained before digging. Concerned departments shall be requested either to shift their utilities or to strictly supervise the shifting works to avoid any unforeseen safety hazards. Vehicles used for transporting utility equipment will be tied firmly and covered with tarpaulin to prevent them from falling onto the road surface. Vehicle speeds shall not exceed 30 km/hour in construction areas. Restoration of road surface, footpaths, signboards that are	At locations of utilities shifting.	Approval from competent authority and site observations.	Checking of documentation.	Agency engaged by BMRCL	BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			damaged during relocation of public utilities immediately to the original conditions. The Contractor shall abide by the terms and conditions stipulated in Condition of Contract of Safety, Health & Environment Manual.					
9	Relocation of affected Cultural, Religious and demolition of private properties	Social – There is no major impact on the cultural and religious structures from the proposed metro alignments and 4 metro stations. However, there will be impact on 31 properties mostly at the proposed metro stations at Kodi beesanahalli Metro Station, Marathahalli Metro Station, ISRO Metro Station, Doddenakundi Metro Station, DRDO Sports Complex Metro Station, Saraswathi Nagar and KR Puram Metro Station, along the alignment.	Impact on any cultural and religious structure, if any will be relocated suitable location in consultation with public. Access to the religious centers in the vicinity of proposed construction zone shall be ensured by planning in advance. Public shall be consulted to inform such impact and address suitably in consensus with to mitigate adverse impacts. Owners of private buildings shall be compensated in line with Entitlement Matrix and KIADB Act, 1966. Unnecessary damage to the structure shall be avoided and the structures being impacted shall be suitably compensated on par with the applicable statutory requirements.	The areas with additional land acquisition is proposed for the project.	Number of structures affected.	Review of relevant documents, entitlement matrix and amount paid.	Contractor and agency engaged by BMRCL	BMRCL
10		Air – Dismantling of structures in the project location	Barricading to a height of 3 m will be provided to reduce dust generation.	Throughout project	$PM_{2.5}$ and PM_{10} level	Standards CPCB	Contractor and	BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
		generates fugitive dust during dismantling, loading, hauling and unloading of dismantled and excavated material.	Water sprinkling shall be done twice or thrice both at construction sites and haulage routes to encapsulate dust from the excavated heaps. Fugitive dust while loading and unloading should be controlled using water sprinkling. Trucks transporting dismantled debris and excavated soil to dump locations shall be covered with tarpaulins to prevent spillage of soil during transportation.	corridor with excavation activities.	measurements Dust pollution or complain of locals.	methods Site observations and Public consultation	agency engaged by BMRCL	
11		Noise – Dismantling of structures, loading, unloading and trucks carrying excavated material will result in noise (typically in excess of 57 dB(A) at 10 m distance). The adverse impacts of noise will be significant near noise sensitive receptors (Annex – 5) and proposed metro station locations where station areas spread into residential areas especially at Doddanekundi and Saraswathi Nagar station.	Barricade of GI sheet up to a height of 3 m will be erected on all sides of construction site to reduce the noise generated during loading and unloading being transmitted to the receptors. This will effectively cut down noise levels by 10-15 dB(A). Haulage of dismantled and excavated debris by trucks should be planned during non-peak hours.	Throughout project section especially at construction sites near identified sensitive receptor locations.	Noise levels measurements Complaints from local people.	As per Noise Rules,2000 Consultation with local people	Contractor and agency engaged by BMRCL	BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
12	Preconstruction activities	Aesthetics - Land acquisition, utility shifting activities and barricading of site will compromise the visual aesthetics temporarily.	Proper barricading ensures masking construction activities in addition to safety objectives. Residual aesthetic impact will remain until the construction is complete, which is difficult to mitigate.	At locations of utilities shifting.	Approval from competent authority and site observations.	Checking of documentation.	Agency engaged by BMRCL	BMRCL
13		Vibration – possible damage to sensitive buildings located near the alignment	Pre-construction survey in order to identify and classify any buildings or other structures that might be impacted by vibration if deemed necessary by the contractor to confirm or refine Building Condition Survey already conducted by BMRCL	Along the alignment	List of sensitive objects and buildings	Visit, photo/video recording	Contractor and agency engaged by BMRCL	BMRCL
14	Changes / Revisions / additions in the Project Work	New impacts - The changes or revisions in the project proposals may create the possibility of new impacts	The in-charge of Environment from BMRCL or the concerned consultant shall re-assess the possible impacts from the changes or revisions in the project proposals and revise / modify the EMP accordingly and addendum to the contract may be issued subsequently to see that the impacts are addressed properly.	At locations of changes proposed.	Approval from competent authority.	Checking of documentation.	Consultant	BMRCL

Pre-construction activities by the Contractor

Sl. No.	Environmental Issue/Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
15	Contractor Preparatory Works (Upon issuance of Notice to Proceed)	Non-compliance with contract conditions and regulatory requirements.	The Contractor will complete the following activities no later than 30 days upon issuance of Notice to Proceed 1) Appoint Contractor's Health and Safety Officer (HSO) and environmental focal person to EC, 2) HSO will engage with BMRCL -Environment Specialist to a meeting to discuss in detail the EMP, seek clarification and recommend corresponding revisions if necessary and submit contractor's EMP based on project EMP, impact assessmnent laid out in the EIA, and SHE Manual requirements 3) HSO will request BMRCL copy of monthly monitoring formats and establish deadlines for submission. 4) HSO will submit for BMRCL approval an action plan to secure all permits and approvals needed to be secured during construction stage which include but not limited to: i) operation of batching plants, ii) transport and storage of hazardous materials (e.g. fuel, lubricants, explosives), iii) waste disposal sites and disposal management plan, iv) temporary storage location, iv) water use, v) vegetation should	Throughout the project sections	Approval from competent authority.	Checking of documentation.	Contractor	BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			be removed from the construction zone after obtaining necessary permission, and vi) emission compliance of all vehicles. Arrangements to link with government health programs on hygiene, sanitation, and prevention of communicable diseases will also be included in the action plan. 5) HSO will submit for approval of BMRCL the construction camp layout before its establishment 6) HSO will prepare all necessary sub-plans as stipulated in the SHE Manual and EIA					
16	Identification of Quarry (If opened exclusively for metro project)	Selection and finalization of quarry is very important to avoid impacts arising out of location.	The Contractor will finalize the locations in consultation with DE and BMRCL. The Contractor shall establish a new quarry with the prior consent of DE only if, the lead from existing quarries is uneconomical and alternative material sources are not available. Contractor shall finalize quarry for procurement of construction materials after assessment of availability of sufficient quantity of materials, quality and the logistic arrangements. Contractor shall also work out haul road network and report to Environmental Specialist of DE	Location of quarry area.	Approval from competent authority.	Checking of documentation.	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			and DE shall inspect and in turn report to BMRCL before approval. All the required permissions / consents from SPCB shall be obtained, if it is new quarry. The Contractor shall prepare a reinstatement plan for the quarry site and get approved by the DE.					
17	Quarries &crushers (If established exclusively for metro project	Impacts from location - Selection of site for establishing quarries and crushers is very important to avoid impacts arising out of location.	Quarries and crushers shall be sited sufficiently (at least 500m) away from settlements and fertile agricultural lands preferably in the downwind direction. Quarries and crushers shall be located at a distance of 300 m from water bodies and sensitive ecosystems such as forests. Contractor shall submit a detailed layout plan for all such sites and approval from Environmental Specialist of DE shall be necessary prior to the establishment. Specifications for crushers and batching plants shall comply with the requirements of relevant emission control legislations. Consent for the	Location of quarry areas and crusher plant location.	Approval from competent authority.	Checking of documentation.	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			Establishment and Operation from KSPCB shall be obtained before establishment and operation respectively and a copy should be submitted to the DE and BMRCL.					
18		Air – Quarrying and crushing activities generate dust and pollute the air.	Arrangements to control dust pollution through provision of windscreens, water sprinklers, and dust extraction systems shall have to be provided at all such sites.					
19		Permissions and Consents – All required permissions and authorizations shall be obtained before operating the units and monitored regularly for their validity to prevent violation of statutory regulations.	Contractor shall obtain materials from quarries only after consent of the Department of Mines and Geology and Consent for Establishment & Consent for Operation from State Pollution Control Board. The crushers and all related activities shall be under taken as per the Policy guidelines for installation of stone Crushers. The general and specific conditions specified in the license and consents shall be strictly adhered and followed.					
20	Procurement of Construction Vehicles, Equipment and other Machinery	Air & Noise – If the proper vehicles, equipment and machinery to be used in construction of project are not	Vehicles, equipment and machinery procured for construction shall conform to the relevant Bureau of India Standard (BIS) norms. The discharge standards	Project area.	Certificate from manufacturer and approvals from	Checking of documentation.	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
		procured, will produce noise, pollute air.	prescribed under the Environment Protection Act, 1986 and Motor Vehicles Act, 1988 shall be strictly adhered. Noiseless equipment or equipment with the least noise emission available in the market shall be used as much as practicable in the construction (e.g. saws and high-pressure water jetting to cut pavement to ensure less noise levels) Contractor shall ensure regular servicing and maintenance of all vehicles and machinery used in construction. All vehicles and machinery should have a Pollution Under Control certificates which shall be sent to Environmental Specialist of DE and BMRCL's verification whenever required.		competent authority.			
21	Sourcing of Construction Water	Sourcing and Resource scarcity - Sourcing of construction water in Bangalore city is a big problem. Utilization of water resources available in the city may further worsen the problem of water scarcity. Hence it is very important to	Construction Water Management Plan shall be prepared and implemented after getting approval from Environmental Specialist of DE. Contractor shall arrange adequate supply and storage of water for whole of construction period at his own cost. The contractor shall submit a list of	Project site, camp areas and batching plants.	Approval from competent authority.	Checking of documentation.	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
		source water required for construction without affecting the existing users.	source/s from where water shall be used for the project to DE and BMRCL. The Contractor shall source the requirement of water preferentially by conjunctive use of Surface water and groundwater but with prior permission from the concerned Groundwater Authority. Copy of permission obtained shall be submitted to DE and BMRCL prior to initiation of construction. Contractor shall provide a list of locations and type of sources from where water for construction shall be extracted. Contractor shall extract water only from approved locations and consult Environmental Specialist of DE before finalizing locations to avoid disruption to other water users, The Contractor shall take all precaution to minimize the wastage of water during construction activities.					
22	Sourcing of Sand	Resource scarcity - Extraction of sand will destroy biodiversity on the riverbanks. In order to put an end to river sand mining, the state	Sand shall be procured from identified and approved sand mines only. If the sand is being procured from new sand quarry /	Location of sand quarry area.	Approval from competent authority.	Checking of documentation.	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
		government had banned sand to encourage use of manufactured sand.	supplier, it shall be ensured that requisite license / lease has been obtained from the concerned Authorities. Contractor shall enter into an agreement with land owner / supplier and submit to DE before procuring the sand. Permission for extraction of sand shall be obtained from Department of Mines & Geology. Government of Karnataka.					
23	Arrangement of Labors and siting of labor camps	Labor scarcity and establishment of new labor camp and associated issues.	The Contractor shall preferably use unskilled labor drawn from local communities to give maximum economic benefits to the local community. Labors shall be sourced from nearby locality to avoid establishment of labor camps and consequent impacts on the local resources and surrounding environment. If employment of migrant labor is deemed necessary, proper health screening will be done following local regulations, other applicable laws and guidelines, and international good practice Labor camps shall be sited at least 500 m away from major	All construction camps	Camp health records Existence of proper first aid kit in campsite Complaints from local people Availability of Safety gears to workers	Camp records Site observation Consultation with local people living nearby Interact with construction workers	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			settlements or villages; major surface water bodies and forests. All required consents / permissions shall be taken from State Pollution Control Board, District Health Department and Central Ground Water Authority (CGWA) to establish labor camps. Under SHE CoC, and under the Building & Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 the employer (contractor) is liable to arrange for health care facilities of labors, free of charge. Labor camps shall be constructed in semi urban / urban set-ups. Thus, sewage and other discharges from the labor camps can be discharged in public sewers. Refer to SHE Conditions of Contract (CoC). Labor camps are provided with canteen systems, so that the labors don't cook by themselves (as per BOCWR). Cooking shall be done with Commercial LPG gas cylinders (19.4 kg).					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
24	Siting of Batching plants, Casting Yard and Construction Camp	Location – Improper siting of batching plant, casting yards and construction camps will lead to issues related to resource sharing, air pollution, noise pollution, water pollution, soil pollution and other impacts in the vicinity.	As much as practicable, construction camps shall not be proposed within 500m from the nearest settlements to avoid conflicts and stress over resources and infrastructure facilities with local community. The batching plants, casting yards, construction camps for offices and construction plant sites shall be identified and located at a minimum distance of 500 m from any major surface water course or body. Contractor's camps shall be identified at least 2km away from the Forest Reserves. Consent to Establishment and Operate (CtE&CtO) shall be taken from State Pollution Control Board to establish batching plants, construction camps.	At the specific locations of plant established.	Approval from competent authority.	Checking of documentation.	Contractor	DE, BMRCL
25	Orientation of Implementing Agency and Contractors	Orientation to project implementing agencies and contractor will impart insight to the project features and guidelines to ensure minimum impact on the environment.	BMRCL shall organize orientation sessions and regular training sessions before the start of construction of project. This trailing shall include general as well as specific context of the project. These sessions shall involve all staff of BMRCL involved in implementation of EMP,	Throughout the project.	Training plan and records	Checking of documentation.	DE	BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			Environmental Specialists of DE and Contractors.					
Construction Phase:								
26	Excavations (Clearing, grubbing and levelling of site)	Soil and Surface drainage - Clearing and leveling alters the soil texture and compactness affecting the infiltration and soil ecology. Leveling of site also involves alteration of natural drainage. Clearing, grubbing and levelling activities are common all along the proposed metro alignment and metro station locations. Soil Debris - The estimated quantity of earth work excavation such as pile drilling muck, pile cap and open foundations and construction and demolition (concrete) waste will be approximately 64748 m3 & 3645 m3 respectively. (Source: Data provided by BMRCL)	Only ground cover / shrubs that impinge directly on permanent works or necessary temporary works shall be removed. A portion of this will be reused for backfilling. The remaining soil debris will be suitably disposed of to the pre-identified approved locations. Infiltration losses due to site leveling and could be countered by installing Rain Water Harvesting (RWH) pits at camp and plant sites.	Throughout the project areas and locations proposed for camps, plants and construction yards.	Presence of destroyed/ compacted agricultural land or land.	Site observations	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
27		Vegetation - Digging, borrowing, uprooting of vegetation from construction site before commencement of construction and surface.	All works shall be carried out such that the damage to flora other than those identified for cutting is minimum. Damage to trees other than marked trees shall be suitably compensated at the rate of 10 trees for one tree being impacted.	Throughout the project area.	Number of trees removed	Approvals from concerned authority.	Contractor	DE, BMRCL
28		Noise - Noise will be generated during clearing, grubbing and levelling activities. The impact from noise will be significant at noise sensitive receptors like schools, colleges and hospitals. There are education institutions which are sensitive to noise along the proposed metro route which are impacted temporarily by this activity.	Noise generated by these activities will be less. However, 3 m high barricade of GI sheet will be erected around the construction site which will effectively reduce transmission of noise to the receptors. Noise and vibration control and monitoring stipulated in the SHE manual shall be followed and project limits shall be observed.	Throughout the project areas.	Noise and vibration levels measurements	As per Noise Rule, 2000. Site observations and Public consultation	Contractor	DE, BMRCL
29		Air - Fugitive dust will be generated during these construction activities. There are hospitals along the proposed metro alignment which are impacted by air	Precaution shall be taken to reduce the level of dust from construction plants and construction sites involving earthwork by sprinkling of water. Water sprinkling will be carried out at regular interval, mutually decided by the contractor and BMRCL	Water sprinkling to be carried out as per SHE Conditions of Contract at regular interval (to be	Throughoutprojectcorridor with excavation activities.	$PM_{2.5}$ and PM_{10} level measurements Dust pollution or complaintof locals.	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
		pollution temporarily during construction phase.		mutually decided by the contractor and BMRCL)				
30		Aesthetics – Excavations will impact on the aesthetics of the area temporarily during construction stage.	Construction sites shall be covered with barricades on all sides and the construction activities shall be limited within these barricades.	Throughout the project areas with excavation activities.	Site specific plans, schedules and approvals.	Review of design documents and site observation	Contractor	DE, BMRCL
31	Mechanical piling and concrete pavement breaking	Noise and vibration - Mechanical piling operations, generates noise which may go up to 88-90 dB(A) at 5 m distance. During footing construction the expected noise increase will exceed the 3 dB(A) even with the use of the standard 3-meter noise wall due to the possible use of vibro-hammers and a backhoe equipped with pavement breakers.	Augur piling will be carried out in place of mechanical piling which will generate less noise (around 70-75 dB(A)). Barricade of GI sheet up to height of 3 m will be erected on all sides of piling operations. This could effectively cut down noise levels by 10-15 dB(A). Piling operations will be restricted during daytime hours only. Augur piling methods will be used to reduce the impacts of noise Noise and vibration control and monitoring stipulated in the SHE manual shall be followed and project limits shall be observed. Noisier construction and demolition activities that cannot	Throughout project section especially at construction sites, residential and identified sensitive locations.	Noise levels measurements Complaints from local people.	As per Noise Rules,2000 Consultation with local people	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			meet the project standards (annex 4) for nearby sensitive receptors are prohibited between 10PM and 6AM to reduce construction noise impacts during night hours. Continuous loud noises around noise sensitive receptors such as schools, hospitals, etc. that exceed the corresponding project noise limits for the specific receptor shall be avoided. Restriction of construction activity to limited time periods depending on applicable noise standards for sensitive receptors present in the area shall be observed. Impact pile driving shall be avoided in noise and vibration sensitive areas. Drilled piles or the use of sonic or vibratory pile driver are quieter alternatives where the geological conditions permit their use. Use of more quiet methods of pavement breaking like saws and high pressure water jetting to cut pavement particularly in residential and silence zone areas.					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
32		Health and Safety - Noise and vibration generated during piling will affect the health and safety of the workers Vibration may cause damage to adjacent sensitive structures	3 m tall screens of GI sheets will be installed between source (pile driver) and receptors (workers & nearby populations). Workers involved in piling will be provided with personal safety gears such as ear plugs, ear muffs. Vibration will be measured during the entire during piling and concrete pavement breaking activities on nearest structures to ensure that project limits are not exceeded. Vibration meters will be installed on the nearest and most fragile structures along the active construction front during piling and concrete paving operations.	Throughout project section especially at construction sites, residential and identified sensitive locations.	Noise and vibration levels measurements Complaints from local people.	As per SHE Manual, Noise rule,2000 Consultation with local people	Contractor	DE, BMRCL
33		Land - Piling will affect the structure and texture of soil.	Top soil of construction site up to a depth of 300mm will be excavated, piled and stored to conserve the top soil which can be used at BMRCL's tree plantation sites.	Location of excavation station area, yards and plant location	Top soil stockpile	Site observations	Contractor	DE, BMRCL
34	Loading/unloading and hauling of debris of excavations and dismantled structures	Air – Excavated material generates fugitive dust from road surface during loading, hauling and unloading of excavated material.	Barricading to a height of 3 m will be provided to reduce dust generation. Water sprinkling shall be done twice or thrice both at construction sites and haulage	Throughout project corridor with excavation activities.	$PM_{2.5}$ and PM_{10} level measurements Dust pollution or	Standards CPCB methods Site observations and	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			routes to encapsulate dust from the excavated heaps. Fugitive dust while loading and unloading should be controlled using water sprinkling. Trucks transporting excavated soil to dump locations shall be covered with tarpaulins to prevent spillage of soil during transportation.		complain of locals.	Public consultation		
35		Noise – Loading, unloading and trucks carrying excavated material will result in noise (typically in excess of 57 dB(A) at 10 m distance). The adverse impacts of noise will be significant near noise sensitive receptors and proposed metro station locations where station areas spread into residential areas especially at Doddanekundi and Saraswathi Nagar station.	Barricade of GI sheet up to a height of 3 m will be erected on all sides of construction site to reduce the noise generated during loading and unloading being transmitted to the receptors. This will effectively cut down noise levels by 10-15 dB(A). Haulage of excavated debris by trucks should be planned during non-peak hours. Noisier construction and demolition activities that cannot meet the standards for nearby sensitive receptors are prohibited between 10PM and 6AM to reduce construction noise impacts during night hours. Continuous loud noises around noise sensitive receptors such	Throughout project section especially at construction sites near identified sensitive receptor locations.	Noise levels measurements Complaints from local people.	As per Noise Rules,2000 Consultation with local people	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			as schools, hospitals, etc. that exceed the corresponding project noise limits for the specific receptor shall be avoided. Restriction of construction activity to limited time periods depending on applicable noise standards for sensitive receptors present in the area shall be observed. Noise and vibration control and monitoring stipulated in the SHE manual shall be followed and project limits shall be observed.					
36		Social - Frequent movement of trucks during debris disposal could create social issues. Often observed near proposed Metro station locations at Marathahalli junction, ISRO metro station and Doddanekundi metro station.	The local community has to be taken into confidence before the construction commences. Their advice has to be taken and incorporated in decision making. The routing, timing and logistics of the haul truck movement should be planned to have minimal impact son noise level. Strict speed limits should be followed at the settlement areas and on the haulage roads. Haulage of excavated materials should be planned during non-peak hours.	Throughout project corridor within construction zone.	Complaint of locals.	Public consultation	Contractor	DE, BMRCL
37		Traffic Congestion – Trucks hauling for	Movement of trucks transporting excavated debris					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
		disposal of debris will add to the existing traffic congestion woes, especially at Marathahalli junction, ISRO metro station and Doddanekundi metro station.	shall be planned during non-peak hours.	Throughout project corridor within construction zone.	Complain of locals.	Public consultation	Contractor	DE, BMRCL
38		Health & Safety - The movement of trucks will increase the safety concerns of the dwellers and commuters.	Movement of trucks shall be planned such that it causes least problematic and safer to the public. All required safety signboards precautions shall be erected along the haulage routes to ensure uninterrupted flow of traffic. Construction zone shall be separated from inhabited zones to avoid any unforeseen safety threats and consequences.					
39	Disposal of excavated materials	Social - Unscientific handling and disposal of debris from excavations and dismantling structures will lead to nuisance to public and the environment.	The debris generated from excavations and dismantling of structures shall be reused for back filling subject to structural suitability of materials and approval of Engineer concerned of DE. All waste debris shall be completely cleared from construction sites on regular basis and disposed of in approved disposal sites and	At all approved dumping sites	Location of dumping sites Public complaints	Field survey and interaction with local people	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			certified by Environmental Specialist of DE. Contractor shall prepare debris disposal plan to deal with surplus debris materials that are available after adjusting for all in-situ applications and submit it to Environmental Specialist of DE for approval. Waste debris shall be dumped in abandoned quarries or borrow pits in layers and compacted mechanically. Once the filling is complete, the entire debris disposal area shall be provided with a layer of good earth on the top and cover with vegetation. All arrangements for transportation during construction including provision, maintenance, dismantling and clearing debris, shall be considered incidental to the civil work and shall be planned and implemented by Contractor as approved and directed by the Environmental Expert of DE. Contractor at his cost shall resolve any claim, arising out of waste disposal or any non-compliance that may arise on					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			account of lack of action on his part.					
40		Land – Dumping may cause change in the topography and affect the natural drainage pattern in the area.	The construction and demolition waste generated during the construction phase should be managed in accordance with the C&D Waste Management Rules, 2016. Contractor shall suitably dispose of unutilized debris materials either through filling up of borrows areas located in wasteland or at pre-designated disposal locations, subject to the approval of the Environmental Expert of DE. Disposal sites shall be identified out of BBMP approved land fill sites as per Construction & Demolition Waste Management Rules, 2016. Location of disposal sites shall be finalized prior to initiation of construction works on any corridor of the project. Environmental Specialist of DE shall approve the disposal sites after conducting a joint inspection of site with Contractor.	Throughout project corridor within construction zone.	Location of dumping sites	Field survey and interaction with local people	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
41		Soil erosion – Unconsolidated debris generated from pile driving or other construction activities may be eroded and silt up the nearby water bodies. The susceptible locations for disposal of debris and siltation are identified as Stream at Ch 10+050 (both sides), Pond at Ch 14+700 (LHS), Mahadevapura Lake at Ch 14+950 (RHS), Pond at 15+600 (RHS), Pond at 15+800 (LHS), Pond at Ch 16+300 (RHS), B Naranyanpura Lake at 16+350 (LHS), and Benniganahalli Lake at Ch 18+200 (RHS).	Debris generated from piling or other construction activities shall be disposed such that it does not flow into nearby surface water bodies or agricultural land in the area.	Throughout project corridor within construction zone.	Location of site and drainage plan	Field survey	Contractor	DE, BMRCL
42		Air - The dumping operation of excavated material will generate fugitive dust in the nearby areas.	Sprinkling of water to suppress the fugitive dust emission from the heaps of debris shall be carried out.	Throughout project corridor within construction zone.	$PM_{2.5}$ and PM_{10} level measurements as compared with project	Standard CPCB methods Site observations and	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
					standards (annex 4) Dust pollution or complain of locals.	Public consultation.		
43	Accessibility	Social - Construction activities may restrict the movement of public to access the roads especially at the Metro Station construction locations. Accessibility issues may be significant at Marathahalli junction, ISRO metro station and Doddanekundi metro station.	Contractor shall provide safe and convenient passage for vehicles, and pedestrians to and from roadsides and property. Contractor shall also ensure that the existing accesses shall not be undertaken without providing adequate alternative provisions.	Nearhabitation on both sides of schools,temples,hospitals, graveyards, construction sites, haulage roads, diversionsites.	Road signage & drainage as per IRC guideline Complaints from local people	Field observation Interaction with local people	Contractor	DE, BMRCL
44		Safety - Movement though confined space may cause inconveniences and potential safety issues amongst pedestrians and residents.	Construction sites shall be properly barricaded to ensure the safety of public residing near the construction sites. Safe passage for pedestrians with proper fall protection arrangements and caution signboards shall be planned and provided. HSE officials of contractor shall ensure this.					
45	Planning for traffic diversions and detours	Social - Traffic diversions will create inconvenience to the public and commuters.	Detailed Traffic Control Plans shall be prepared by Contractor and approved by Environmental Specialist and Engineer concerned of DE prior	Throughout the project corridor especially at	Traffic Management plan	Review traffic management plan Field	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			to commencement of works on any section of Metro works. The traffic control plans shall contain details of temporary diversions, traffic safety arrangements during peak traffic hours; details of traffic arrangement after cessation of work each day, safety measures for night time traffic and arrangement of flagmen. Permission from BBMP and Traffic police shall be sought before commencement of construction works. Contractor shall ensure that the diversion/detour is always maintained in running condition, particularly during the monsoon to avoid disruption to traffic flow. Contractor shall inform local community of the changes to traffic routes; conditions and pedestrian access arrangements with assistance from DE and BMRCL.	diversion and intersections	Safety signs on site Number of traffic accidents	observation of traffic management and safety system Interaction with people in vehicles using the road		
46		Traffic Congestion - Construction sites will be restricted for human and vehicular movements. This will result in detour of vehicles especially at	The temporary traffic detours shall be kept free of dust by sprinkling of water three times a day and depending on weather conditions, construction in the built-up areas and volume of traffic).					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
		busy commercial areas along Outer Ring Road. This results in traffic congestion						
47		Air - Air pollution from vehicular congestion along the outer ring road during construction phase. Major pollutants like PM_{10}, $PM_{2.5}$, NOx, SO_2, CO, NMHC, Lead and VOCs are released.	Traffic diversions shall be properly planned and implemented during peak hours. Traffic marshals shall be posted near such detours. Proper signage shall be posted informing motorists about detours.				Contractor	DE, BMRCL
48		Noise – Restrictions on vehicular movement near the construction sites by barricading & detours may result into traffic congestion along outer ring road at Marathahalli junction, ISRO metro station and Doddanekundi metro station. This will result in noise from vehicular movement and honking due to congestion.	Traffic diversions shall be planned properly with prior permission from traffic police. Sign boards shall be displayed properly on prohibition of use of horns particularly at noise sensitive receptor locations like schools, colleges and hospitals. Traffic marshals shall be posted at the construction sites and near busy intersections like Marathahalli junction, Doddanekundi Road junction, KR Puram Bridge junction, etc. to oversee the smooth flow of traffic.				Contractor	DE, BMRCL
49		Travel time cost / Resource consumption - Detouring of traffic during construction will	The detour shall be planned with traffic department such that road length to be optimum.				Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
		increase the road length to be travelled by vehicles. This essentially increases the overall fuel consumption and travel time of road users.	The faster completion of works will also tend to reduce fuel consumption. Congestion cost will be minimized by providing alternate route for traffic in peak hours.					
50	Construction of raft foundation	Land - Construction of raft foundation will generate concrete spoils. This will have adverse effects on land.	Concrete spoils shall be collected and disposed of in the pre-identified and approved disposal grounds.	Throughout the project corridor.	Method and location of construction site	Contractor records Field observation	Contractor	DE, BMRCL
51	Steel structure preparation	Land - Steel structure preparation will create steel scraps (approx. 5% of total BOQ steel requirement; as per CPWD standard estimate)	Steel scrap shall be collected, sorted by diameter and sold to approved scrap dealers/vendor on alter date.	At construction yards and work zones	Method and location of construction site	Contractor records Field observation	Contractor	DE, BMRCL
52		Health & safety - Bar bending & other activities (including working at heights) might pose a health & safety risks to workers	(a) Workers shall be provided with appropriate hand gloves. (b) Workers working at height or doing hot work shall seek permission from site HSE manager and shall be provided with rigs, safety harness & safety belts (Please refer to SHE Manual, BMRCL)	Construction sites	Availability of Safety gears to workers Safety signage Training records on safety Number of safety related accidents	Site observation Review records on safety training and accidents Interact with construction workers	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
53	Transporting construction materials and haul road management	Air pollution - During transportation of construction material, fugitive dust will be generated from re-suspension of dust from road surface and from the spillage of construction materials from a moving vehicle.	All vehicles delivering fine materials to the site shall be properly covered with tarpaulins to avoid spillage of materials. All existing roads used by vehicles carrying construction materials, shall be kept clear of all dust/mud or other extraneous materials dropped by such vehicles. Contractor shall arrange for regular water sprinkling as necessary for dust suppression of all such roads and surfaces.	Throughout project corridor within construction zone.	$PM_{2.5}$ and PM_{10} level measurements Dust pollution or complain of locals.	Standard CPCB methods Site observations and Public consultation.	Contractor	DE, BMRCL
54	Stacking & warehousing of raw material	Surface Water – The stacked earth or raw materials will be washed out and pose serious impacts on surface water bodies, If not managed properly. Water bodies like Stream at Ch 10+050 (both sides), Pond at Ch 14+700 (LHS), Mahadevapura Lake at Ch 14+950 (RHS), Pond at 15+600 (RHS), Pond at 15+800 (LHS), Pond at Ch 16+300 (RHS), B Naranyanpura Lake at 16+350 (LHS), and Benniganahalli Lake at	Contractor shall construct silt fencing around the stockpiles at the construction sites including ancillary sites close to water bodies. Contractor shall ensure that construction materials containing fine particles are stored in an enclosure such that sediment-laden water does not drain into nearby watercourses. Small dikes and garlanding drains shall be constructed along the periphery of the raw materials yard and boundary shall be constructed.	At construction yards and work zones	Method and location of construction site	Contractor records Field observation	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
		Ch 18+200 (RHS) are located along the proposed metro corridor are vulnerable to siltation.						
55		Land - Spillage of materials / mix products on the ground could pollute land	Proper care shall be taken such that the spills will be cleared regularly by scraping and disposing the products.	At construction yards and work zones	Method and location of construction site	Contractor records Field observation	Contractor	DE, BMRCL
56		Health & Safety - Fine dust particles like cement / silt / sand could cause harm to respiratory system.	Cement and sand shall be stacked under tarpaulin and protected from spillage by GI sheet barricading. Workers shall be provided with suitable respiratory PPEs.					
57		Aesthetics - Stacking of raw material will cause aesthetic issues located nearby residential areas	The height of barricade walls between the residential area and raw material yards / construction areas shall be raised using GI sheets to mask the view.					
58	RCC pouring (using concrete pump) and setting of concrete (using needle vibrator)	Noise & vibration - RCC pouring using concrete pump generates low frequency rumbling noise. Though pump noise is not excessively loud, it is tonal and perceptible. This will be more perceived and irritating for noise sensitive receptors such as schools, colleges and hospitals and residential areas.	Timing of using RCC pumps shall be planned and specified. RCC pumps shall be housed in small mechanical closets. Bends and excessive head will be avoided. Consistency of concrete shall be altered, to reduce the need for use of vibrator. Damping could be used to reduce high frequency noise and thereby reducing the noise levels.	Throughout project section especially at construction sites, residential and identified sensitive locations, refer to noise and vibration level	Noise and vibration levels measurements	As per Noise Rules,2000 and Public consultation.	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
		Needle vibrators generate low frequency noise when dipped in concrete but high frequency noise when raised. Sound level vary between 82-93 dB(A).	The Contractor shall abide by the terms and conditions stipulated in Condition of Contract on Safety, Health & Environment and Project Safety, Health & Environment Manual on noise and vibration monitoring and observe project limits.	prediction study report.				
59		Land - Spillage from concrete pouring may contaminate land. During setting, spillage from cast could take place.	Efforts shall be made to avoid spillage of concrete to prevent wastage of concrete and resources. The spoils from pouring concrete shall be collected and reused as sub-grade material in road restoration works.	At construction yards and work zones	Method and location of construction site	Contractor records Field observation	Contractor	DE, BMRCL
60		Aesthetics - Spoils from concrete pouring will create unpleasant visuals	After each pouring cycle, the spoils will be manually collected and reused as sub-grade material in road restoration works.				Contractor	DE, BMRCL
61	Curing of concrete (use of water)	Source scarcity – Bangalore city is facing the scarcity of water resources. Use of fresh water for curing of concrete will further lead to depletion of water resources.	Treated sewage water (treated to secondary level) shall be used for curing purpose. Curing both by sprinkling and dipping may be adopted, where a limited amount of water is sprinkled slowly at regular intervals for curing concrete. These methods save water by reusing and recycling, energy, labor, time and cost.	At construction yards and work zones	Approved layout for drainage of construction yards.	Field observation	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			Moisture retaining fabric coverings saturated with water shall be used for curing. Wet coverings such as wet gunny bags, hessian cloth, jute matting, straw etc., shall be wrapped to vertical surface for keeping the concrete wet. For horizontal surfaces saw dust, earth or sand are used as wet covering to keep the concrete in wet condition for a longer time. All the required permissions from the concerned local authorities shall be procured before use of water resources for construction and curing.					
62		Surface water – Excess of curing water will drain to the low-lying areas stagnate making it as mosquito breeding places and pollute water courses	Proper drainage shall be ensured to guide the curing water to the nearby drains. Garland drainage is proposed to be constructed around the construction yard. This will intercept the runoff generated from site.	At construction yards and work zones	Method and location of construction site	Site observations and relevant records	Contractor	DE, BMRCL
63		Ground water - Hydrating water requirement @ 0.38:1 water: cement + curing will require @ 0.06 kg/m2/hr. of water, most of it will be supplied from	Groundwater from Central Ground Water Authority designated safe areas shall be used after procuring permissions from concerned authorities.	At construction yards and work zones	Permission from authority.	Site observations and relevant records	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
		approved groundwater sources (through tankers) as per the Central Ground Water Board norms.	Water can be harvested and made to percolate into the recharge pits (as a compensatory measure) should be practiced.					
64		Aesthetics – Curing water impounding may lead to inconveniences to local public and stagnation promotes vector propagation.	Garland drain shall be constructed around the construction area. The curing water impounded can be collected and reused for curing.					
65	Use of Crane & Launchers	Noise - Operation of launchers and cranes generate noise which goes up to 85-90 dB(A).	Cranes and launchers shall be serviced and maintained regularly to prevent them making noise. Tall GI sheets of 3 m height barrier around the construction area shall be erected to control the noise transmission from the source where the cranes and launchers are used. The construction workers working near construction equipment shall be provided with PPEs like ear plugs / muffs complying with relevant standards. Noise emitting crane and launching works at noise sensitive receptors like schools, colleges and hospitals shall be scheduled properly to	Throughout project section especially at construction sites, residential and identified sensitive locations.	Noise and vibration levels measurements	As per Noise Rules, 2000 and Public consultation	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			avoid or reduce impact on them. The Contractor shall abide by the terms and conditions stipulated in Condition of Contract on Safety, Health & Environment and Project Safety, Health & Environment Manual on noise and vibration monitoring and observe project limits.					
66		Health & Safety - Cranes and launchers are a major safety concern during construction.	Contractor shall engage only qualified & trained crane/ launcher operators. Contractor shall ensure regular servicing and maintenance of cranes and launchers to avoid malfunction of equipment. Proper training shall be given to crane & launcher operators and labors before the commencement of work. Operation of launchers and cranes shall be done only under the strict supervision of a qualified engineer and a safety supervisor. The operating personnel should follow the operating and maintenance manuals supplied along with the cranes & launchers to understand the	Construction sites	Availability of Safety gears to workers Safety signage Training records on safety Number of safety related accidents	Site observation Review records on safety training and accidents Interact with construction workers	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			crane and operate the crane efficiently and safely. Instructions in Safety, Health & Environment Manual shall be followed. The Contractor shall abide by the terms and conditions stipulated in Condition of Contract on Safety, Health & Environment and Project Safety, Health & Environment Manual.					
67	Construction camps and Labor camp(s) and associated environmental issues	Impacts related to location – Selection of labor camp location is important as it adversely impacts from the discharge of sewage and solid waste from labour camps.	Contractor shall obtain permission from District Health Officer before establishing labor camps. Contractor shall follow all relevant provisions of the Building and the other Construction Workers (Regulations of Employment and Conditions of Service) Act, 1996 for construction and maintenance of labor camp, BMRCL Construction SOP on COVID 19, and SHE Manual. The location, layout and basic facility provision of each labor camp shall be submitted to DE and BMRCL to obtain their approval prior to their establishment.	All construction camps	Camp health records Existence of proper first aid kit in campsite Complaints from local people Availability of Safety gears to workers	Camp records Site observation Consultation with local people living nearby Interact with construction workers	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
68		Resource scarcity – Establishment of labor camps requires resources like water thus increasing pressure on local resources. Water required for domestic uses in labor camps and workers if drawn from existing community bore wells and nearby surface water resources may deplete groundwater. Dependency of laborers on fuel wood for cooking and	The Contractor shall provide potable water facilities for drinking & cooking and uncontaminated water for washing in the labor camps as per standards set by the Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996. The Contractor shall also guarantee the following: a) Supply of sufficient quantity of Potable Water in every workplace / labor camp (Site at suitable and easily accessible places and regular maintenance of such facilities. b) If any water storage tank is provided that shall be kept such that the bottom of the tank at least 1 m above the surrounding ground level. c) If water is drawn from any existing well, which is within 30 m proximity of any toilet, drain or other source of pollution, the well shall be disinfected before water is used for drinking. d) All such wells shall be entirely covered and provided with a trap door, which shall be dust proof and waterproof.					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
		heating purposes will result in cutting of trees in and around labor camp.	e) A reliable pump shall be fitted to each covered well. The trap door shall be kept locked and opened only for cleaning or inspection, which shall be done at least once in a month. f) Analysis of water shall be done every month as per parameters prescribed in IS 10500-1991. Environmental Specialist of DE shall be required to inspect the labor camp once in a week to ensure the compliance of the EMP. Contractor shall provide sufficient quantity and timely supply of liquid petroleum gas to the laborers to discourage cutting of trees and vegetation.					
69		Sanitation and Sewage System – Wastewater generated at the construction camps and labor camps will pollute the soil, surface and ground water if disposed untreated. Impacts from storing, treating and disposing the sewage waste and solid wastes increases breeding sites of mosquitoes in turn	Contractor shall follow all relevant provisions of the Building and the other Construction Workers (Regulations of Employment and Conditions of Service) Act, 1996 for construction and maintenance of labor camp as well as BMRCL Construction SOP on COVID 19, and SHE Manual. The location, layout and basic facility provision of each labor camp shall be submitted to DE					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
		increases the risk of vector borne diseases such as malaria. Supply of non-potable water will not only cause communicable diseases to laborers but also act as potential centers for spreading diseases There is also a possibility of spreading diseases such as HIV, COVID 19, and others by having contact with local population.	and BMRCL prior to their construction. The construction shall commence only upon the written approval of the DE. The Contractor shall maintain necessary living accommodation and ancillary facilities in functional and hygienic manner and as approved by the DE. The Contractor shall maintain sufficient and appropriate sanitary facilities available and maintain hygienic conditions functional in the labor camps. Necessary living accommodation and ancillary facilities shall be provided in labor camps as approved by the DE. The Contractor shall ensure that - Wastewater treatment plants shall be constructed at labor camps to treat the sewage to the prescribed standards before disposing it on the land or water in such a manner that no contamination of soil, ground water or water courses take place.					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			- Separate toilets / bathrooms, for men and women are to be provided. (marked in local and English language) - Adequate water supply is to be provided in all toilets and urinals The Contractor shall arrange for – A readily available first aid unit including adequate supply of sterilized dressing materials and appliances as per the Factories Rules in every work zone. - Arrangement for availability of suitable transportation at all times to take injured or sick person(s) to the nearest hospital. Contractor should ensure to conduct HIV and other communicable diseases awareness programs.					
70		Solid Waste - Poor sanitation and solid waste disposal in labor camps and work sites and possible	Domestic solid waste from construction and labor camps shall be segregated into biodegradable and non-biodegradable before being					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
		transmission of communicable diseases from workers to local populations.	sent to treatment. Biodegradable wastes are treated by composting and non-biodegradable wastes are either recycled or disposed of to authorized land fill site. The Contractor shall provide garbage bins in the camps and ensure that these are regularly emptied and disposed of in a hygienic manner as per the Comprehensive Solid Waste Management Plan approved by the Environmental Specialist of DE.					
71	Use of batching plant and casting yard	Air – Handling of cement, sand and gravel materials into batching plant will generate fugitive dust and ambient air quality will be adversely affected.	Batching plants shall be sited at least 1 km in the downwind direction from the nearest human settlement. Vehicles delivering raw materials like sand and fine aggregates shall be covered to reduce spills on the roads. Water shall be sprayed on haulage roads within the premises of batching plants on a regular basis. The batching plants shall be fitted with dust extraction units and collectors to reduce exhaust dust. Batching plants / casting yards shall be barricaded and	At Batching plant sites	$PM_{2.5}$ and $PM_{10,}$ Noise level measurements, Compliance on terms and conditions in given permission for batching plant	Standards CPCB methods for air quality monitoring, relevant records on permission from authorities	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
		Use of DG - The batching plant will get its power backup from DG sets. In most cases DG sets of 100 – 250 kVA) is required to run the batching plant & ancillary facilities. Thus, the diesel required will range from 30 – 45 L/hr (at 100% load).	designated as a compulsory PPE zone to effectively reduce the impact from fugitive dust emissions. Required permissions for electrical connection and supply must be obtained from BESCOM by the Contractor. DG sets, if used, shall: (a) conform to height of stack norms as per CPCB rules; (b) conform to emission norms as per Environment (Protection) Act, 1986; (c) noise level at 1 m distance from enclosure shall not be >75 dB(A). Diesel storage if done beyond threshold limit (1000 L) permission from CCOE should be obtained. Diesel should be stored on pukka platforms and spillages should be avoided.					
72		Noise and vibration - Batching plants will generate noise and vibration during operation	Batching plants / casting yards shall be barricaded and designated as a compulsory PPE zone. Workers working in close proximity of the batching plants shall be provided with suitable PPEs like earmuffs & plugs reduce the impacts of noise.					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			Contractor to conduct noise and vibration monitoring as stipulated in the SHE manual and following project limits.					
73		Land - Soil compaction and contamination are envisaged at concrete batching plant and along access roads to these construction establishments.	As part of mitigation measures topsoil shall be preserved and back filled. The site shall be rehabilitated to the original geographical contours and natural landscape or as per the contract agreement with the landowner.					
74		Water - Batching plant will use water for concrete mixing. In most cases water will be supplied from groundwater.	Permission from CGWA must be obtained before digging and operating bore wells. Water abstracted must be measured/ recorded periodically.					
75		Permissions from Authorities	Consent to Establish (CtE) and Consent to Operation (CtO) shall be obtained for construction establishments such as batching plants from the SPCB. All project activities are adhered to the contractual obligations under clearances and approvals					
76	Curing of concrete segments & I beams	Water requirement - Curing will require a significant amount of water, which will mostly be supplied from groundwater.	Wastage /excess from curing could be collected separately and if possible reused. Stagnation of water (and resultant vector propagation) should be avoided.	At casting yards	Method and approved drainage plan	Site observations and relevant records	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
77	Hauling of concrete castings to construction site	Air - Transportation of concrete castings on the roads generates fugitive dust from road surface in addition to the obnoxious gaseous emissions from trucks used for hauling.	Truck tyres shall be washed to remove soil clinging to it near the exit points of the casting yards. Water sprinkling along the hauling route shall be undertaken. Trucks shall have PUC certificates and conform to the prescribed emission norms.	Throughout project corridor.	$PM_{2.5}$& PM_{10} level and Noise level measurements & checking PUC certificates Dust pollution or complain of locals	Standards CPCB methods Observations Public consultation	Contractor	DE, BMRCL
78		Noise – Transporting vehicles carrying concrete castings results in high noise (typically in excess 57 dB(A) at 10 m distance). The adverse impacts of noise will be significant at the residential areas and the noise sensitive receptors.	The routing, timing and logistics of the haul truck movement shall be planned to have minimal impacts on the ambient noise levels.					
79		Social - Continuous movement of haul trucks could create social issues in the form of obstruction to movement of commuters and traffic congestion.	The routing and timing of haul trucks shall be planned to take the local community into confidence. They should be informed in advance on the routing and approximate timing after considering their advice.					
80		Safety - The movement of trucks will increase the risk of accidents to the commuters.	Safety sign boards shall be displayed all along the haul routes to sensitize the public.					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
81	Use of DG sets at construction sites	Air - Air pollution from emissions of DG sets	Contractor shall prefer to utilize power from BESCOM as primary source and DG sets shall be used only as power back-ups to conserve the diesel which is a non-renewable resource. (a) Emissions from DG shall adhere to CPCB prescribed norms (b) Stack height of DG sets shall be as per CPCB requirement (stack height= 0.2* (rating in kVA) 0.5] (c) Low Sulphur diesel shall be used in the DG sets.	At installation location of DG sets	Monitoring of ambient air quality and Noise and Vibration levels Measurements as stipulated in the SHE Manual, compliance with consent taken from SPCB	Standards CPCB methods and as per Noise Rules,2000	Contractor	DE, BMRCL
82		Noise - Noise & vibration will be generated from the use of DG sets	DG sets shall be insulated type to mitigate noise at source itself. DG sets shall be mounted on damping skids to reduce the vibration generated from DG sets. Project limits and monitoring requirements set out in the SHE manual shall be followed					
83	Storage of fuel and lubricants	Surface and Groundwater - Spillage of fuel from underground storage	Spillage of fuel from underground storage facilities shall be avoided by taking required precautions during	Fuellingstation, construction	Quality of soil	Site	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
		or above ground storage facility will adversely affect the quality of ground and surface water respectively	installations. Spillages reaching the soil from above ground storage facilities shall be avoided by storing on the concrete impervious platforms and installing oil interceptors at the outlet drains. The vehicle and construction equipment shall be properly maintained and refueling / maintenance of vehicles shall not be done near the water bodies to avoid contamination from fuel and lubricants. Diesel Generator sets shall be placed on a cement concrete platform with oil and grease trap to control the oil ingress into soil/water bodies. A Contingency Plan shall be prepared by the Contractor to face and act immediately on spillage as per Petroleum Rules, 2002 and Petroleum (Amendment) Rules, 2018.	sites, andconstructioncamps and disposal location.	nearStorage area Presence of spilled oil project area	Observation and check of records		
84		Health & safety - Storage of fuel and lubricants will attract the provisions of Hazardous Chemicals (Management & Handling) Rules and Petroleum Rules as amended to date. It	Proper onsite emergency plan shall be prepared by the Contractor and get approved through BMRCL. If the diesel storage crosses the threshold limits permissions from Chief Controller of Explosives (CCoE).					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
		could cause serious damage to health & safety of workers / property.	Proper fire protection norms have to be undertaken as per National Building Code, 2016 (for buildings) / Oil Industry Safety Directorate Standard 117 (for installations).					
85	Construction activities near water bodies	Construction works near water bodies especially Stream at Ch 10+050 (both sides), Pond at Ch 14+700 (LHS), Mahadevapura Lake at Ch 14+950 (RHS), Pond at 15+600 (RHS), Pond at 15+800 (LHS), Pond at Ch 16+300 (RHS), B Naranyanpura Lake at 16+350 (LHS), and Benniganahalli Lake at Ch 18+200 (RHS) are susceptible for impact from construction activities.	While working close to water bodies, contractor shall not obstruct / prevent the inflow of water. Construction close to water bodies shall be avoided in monsoon and may be undertaken in the dry season. Chute drains with sediment trap or silt fence and garland drains shall be planned at erosion susceptible areas to avoid ingress of silt into the water bodies. Vehicles and construction equipment shall not be parked near water bodies. The construction vehicle parking locations, fuel / lubricants storage sites, vehicles, machinery and equipment maintenance and refueling sites shall be located at least 500 m away from water bodies and storm water drainages. The Contractor shall submit the locations and layout plans of such sites prior to their	At construction work zones, plants, constructions yards and camp areas.	Method and location of construction site	Contractor records Field observation	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			establishment and shall be approved by the Environmental Specialist of DE. The Contractor shall take necessary precautionary measures to prevent wastewater construction sites, construction and labor camps entering water bodies or storm water drainages during construction. Operation, maintenance and refueling of all vehicle / machinery and equipment shall be carried out in such a manner that spillage of fuels and lubricants does not contaminate the ground. Wastewater from vehicle parking, fuel storage areas, workshops, wash down and refueling areas shall be treated in an oil interceptor before discharging it on land or into water bodies or into other treatment system. Arrangement shall be made for collection, storing and disposal of oily wastes to the pre-identified disposal sites approved by the Environmental Specialist of DE. All spills and collected petroleum wastes shall be disposed of in					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			accordance with Petroleum Rules and Pollution Control Board guidelines.					
86	Drainage and flood control	Drainage – Drainage of construction site shall be ensured at all time during construction such that the area is drained to nearby drains. Blocks in the drainage will cost inundation and flooding in the area.	It shall be ensured that no construction materials like earth, stone, or appendage disposed of in a manner that block the inflow of water to water bodies and cross drainages. All necessary measures shall be taken to prevent blockage to the water flow. In addition, the Contractor shall take all required measures as directed by the Environmental Specialist of DE to prevent temporary or permanent flooding near the construction site and adjacent area.	At construction yards and work zones	Approved layout for drainage of construction yards.	Field observation	Contractor	DE, BMRCL
87	Siltation of water bodies and degradation of water quality	Soil erosion and siltation - Soil erosion from construction site and siltation of sediments in to water body will impact aquatic ecosystem and silt up the nearby water body.	Beds nearby water bodies shall not be excavated for borrowing earth for construction. Silt fencing shall be constructed around the stockpiles at the construction sites including ancillary sites close to water bodies. Construction materials containing fine particles are stored in an enclosure such that sediment-laden water does	Throughout the entire project alignment especially along water bodies cutting/excavation is required.	Occurrence of slope failure or erosion issues	Review of design documents and site observation	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			not drain into nearby watercourses.					
88	Construction Vehicles, Equipment and Machineries	Emission from Construction Vehicles, Equipment and Machineries – Fugitive emissions from vehicles and equipment used in construction of project will pollute the air.	All the vehicles, equipment and machinery used in construction are regularly maintained to comply with the relevant statutory standards of CPCB and Motor Vehicles Rules. Noise limits for equipment set out in the SHE manual shall be followed Redundant vehicles shall not be used in construction and Pollution Under Control (PUC) certificates for all vehicles / equipment / machinery used in the Project shall be ensured.	Throughout project section especially at construction sites, residential and identified sensitive locations.	$PM_{2.5}$ and $PM_{10,}$ and Noise level measurements. Complaints from local people	Standards CPCB methods for air quality monitoring, relevant records on permission from authorities , Consulation details	Contractor	DE, BMRCL
89		Noise - Construction vehicles and construction equipment will generate noise during construction. The noise will be more if the vehicles are not regularly serviced and maintained.	All Construction plants and equipment used in construction shall strictly conform to the MoEF&CC/CPCB noise standards. All Vehicles and equipment used in construction shall be fitted with exhaust silencers. The effectiveness of exhaust silencers shall be regularly checked and if found defective shall be replaced. Servicing of all construction vehicles and machinery shall be done regularly and during routine servicing operations.				Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			Maintenance of vehicles, equipment and machinery shall be regular and up to the satisfaction of the Environmental Specialist of DE to keep noise levels at the minimum.					
90	Personnel Safety Measures for Labor	Workers working at construction sites and construction establishment sites are exposed to occupational safety risks.	Contractor shall provide: ➢ Protective footwear, protective goggles and nose masks to the workers employed in concrete works, crushers, etc. ➢ Welder's protective eye-shields to workers who are engaged in welding works ➢ Earplugs to workers exposed to loud noise, and workers working in crushing or compaction ➢ Safety harness to workers working at height and shall comply with all regulations regarding safe scaffolding, ladders, working platforms, gangway, stairwells, excavations, trenches and safe means of entry and egress. The Contractor shall comply with all the precautions as required for ensuring the safety of the workmen as per those applicable to the contract.	Construction sites	Availability of Safety gears to workers Number of safety related accidents	Site observation Review records on accidents Interact with construction workers	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			The Contractor shall not employ any person below the age of 14 years for any work and no woman shall be employed on the work of painting with products containing lead in any form. The Contractor shall also ensure that paint containing lead or lead products is used except in the form of paste or readymade paint. The Contractor shall make sure that during the construction work all the relevant provisions of Building and other Construction Workers (regulation of Employment and Conditions of Services) Act, 1996 are adhered to. Contractor is obligated to follow BMRCL's Safety, Health and Environment Manual which defines the principal requirements of the Employer on Safety, Health and Environment (SHE) associated with the Contractor / Sub-contractor and any other agency to be practiced at construction work sites at all time, including SOP related to COVID 19					

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
91	Traffic and Safety	Traffic disruption – Construction works of metro disrupts traffic and exposes to traffic safety risks all along the proposed metro alignment and metro stations.	The Contractor shall take all necessary measures for the safety of traffic during construction and provide and maintain signs, barricades, markings, flags, lights and flagmen for information of road users and protection of traffic approaching or passing through the section of any existing cross roads as proposed in the Traffic Control Plans / Drawings. Traffic Control Plan shall be devised and implemented to the satisfaction of the Environmental Expert of DE.	At locations of traffic diversions and intersections .	Approval from competent authority.	Checking of documentation.	Contractor	DE, BMRCL
92	Risk from electrical equipment		The Contractor shall take all required precautions to prevent danger from electrical equipment and ensure that. ➢ No material shall be so stacked or placed as to cause danger or inconvenience to any person or public. ➢ All necessary fencing and lighting shall be provided to protect the public from electrical hazards in construction zones. All equipment to be used in construction shall conform to the relevant Indian Standards (IS) codes, shall be free from defect; kept in good working	At Project site.	Specifications of electrical items.	Checking of documentation.	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			order; regularly inspected and properly maintained as per IS provision and to the satisfaction of the Environmental Expert of DE.					
93	Risk force measure		Contractor shall take reasonable precautions to prevent danger to the workers and public from emergency spillage, fire, flood, etc. resulting from construction activities. Contractor shall make required arrangements so that in case of any mishap all necessary steps can be taken for prompt first aid treatment. Construction Safety Plan prepared by the Contractor shall identify necessary actions in the event of an emergency.	The project.	Conditions on contractors' contract.	Checking of document.	Contractor	DE, BMRCL
94	First Aid		The Contractor shall arrange for – A readily available first aid unit including an adequate supply of sterilized dressing materials and appliances as per the Factories Rules in every work zone. Availability of suitable transport at all times to take injured or sick person(s) to the nearest hospital.	Construction sites	Availability of first aid boxes Number of safety related accidents	Site observation Review records on accidents Interact with construction workers	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
95	Informatory Signs and Hoardings		The Contractor shall provide, erect and maintain information / safety signs, hoardings written in English and local language (Kannada), wherever required or as suggested by the Environmental Specialist of DE.	Construction sites	Installation of project informatory boards.	Site observation.	Contractor	DE, BMRCL
96	Notified Archaeological Property and Chance Found Archaeological property	There is no archaeological monument notified under the Ancient Monuments and Archaeological Sites and Remains (Amendment and Validation) Act, 2010. However, during excavation for metro project the possibility of chance found article, structure or monument is not ruled out and suitable precaution and mitigation measures shall be taken to protect and conserve the structure or site of archaeological importance.	All fossils, coins, articles of value of antiquity, structures and other remains of archaeological interest discovered on the site shall be the property of the Government and shall be dealt with as per provisions of the relevant legislation. The Contractor shall take reasonable precautions to prevent his workmen or any other persons from removing and damaging any such article or thing. He shall, immediately upon discovery thereof and before removal acquaint the Environmental Specialist of DE of such discovery and carry out his instructions for dealing with the same, waiting which all work shall be stopped. The DE shall seek direction from the Archaeological Survey of India (ASI) before instructing the Contractor to recommence the work in the site. The	Throughout the project construction zones.	Ancient Monuments and remains during excavation.	Site observations.	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			Archaeological structures identified along the project sites should be protected/ preserved or enhanced as per the law.					
97	Contractor's Demobilization	Environmental condition – The construction activities of metro works will cause environmental pollution. It is required to monitor the environmental attributes regularly to keep a tab on effectiveness of the mitigation measures.	The BMRCL shall undertake seasonal monitoring of air, water, noise and soil quality through an approved monitoring agency. The parameters to be monitored, frequency and duration of monitoring as well as the locations to be monitored shall be as per the Monitoring Plan prepared. Project Standards for Air, Noise and Water given in Annex - 4.	The project sites.	Baseline monitoring and monitoring during works.	Monitoring reports.	Contractor	DE, BMRCL
98		Continuous Community Participation	The Environmental Specialist of DE shall have continuous interactions with local people around the project area to ensure that the construction activities are not causing undue inconvenience to the locals residing in the vicinity of project site under construction due to noise, dust or disposal of debris etc. Access to GRM shall be ensured through provision of drop boxes in construction sites and provision of contact information and access in the BMRCL website.	The project sites.	Community engagement plan	Communication policy and engagement plan.	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
99		Clean-up operations, restoration and rehabilitation	Contractor shall prepare site restoration plans, which shall be approved by the Environmental Specialist of DE. The clean-up and restoration operations are to be implemented by the Contractor prior to demobilization. The Contractor shall clear all temporary structures; dispose all garbage, night soils and Petroleum, Oil and Lubricants wastes as per waste management plan and as approved by DE. All disposal pits or trenches shall be filled in and effectively sealed off. Residual topsoil, if any shall be distributed on adjoining/proximate barren land or areas identified by the Contractor and approved by the Environmental Specialist of DE in a layer of thickness of 75 mm – 150 mm. All construction zones and construction establishments including proposed metro alignment, camps, batching plants, crushers, and any other area used / affected due to the project operations shall be left clean and tidy, at the Contractor's expense, to the entire satisfaction to the	The project sites.	Site closure plans	Approval of site closure plan.	Contractor	DE, BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			Environmental Specialist of DE.					
Operation Phase:								
100	Operation of metro trains	Air – Implementation of metro project will have a positive impact on the ambient air quality as the public use metro in place other modes of transportation which otherwise known for emitting air pollutants.	Public should be made aware and attracted to use metro more and more. BMRCL should plan for integrating other modes of transport to achieve last mile connectivity to attract public to use metro.	Project alignment.	Air quality and noise level monitoring during operational stage.	Monitoring reports.	BMRCL	BMRCL
101		Noise& vibration - The most significant source of noise during operation of metro is generated from contact between rolling wheel and rail and contact between the brake pad and wheel, followed by engine noise and aerodynamic noise.	The metro train generates rolling noise of approximately 85 dB(A) at a ht. of 8-12 m, the effective noise levels perceived at at-grade roads will be approx. 55 - 60 dB(A) which is less than the monitored baseline noise levels along the alignment. Construction of parapet wall as mitigation measure to reduce noise level generated from metro operations. As per preliminary noise modeling study, the design height of 1070 mm is adequate to keep the noise levels within the prescribed values for noise for commercial zones as the	Project alignment.	Noise level prediction modelling results.	Assessment reports.	BMRCL	BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			background noise level in these areas is already on higher side. Use of vibration resilient pads in tracks will absorb vibration. Hence, the increase in noise levels at the road level will be insignificant and will be marginally different from baseline ambient noise generated from traffic. Since the train coaches are enclosed and air conditioned, the impacts of noise on the travelers will be insignificant.					
102		Social – Implementation of metro will have a positive impact on the livelihood of society in terms of employment, commutability, improved access, comfortable travel and decreased travel time.	The employment generation capacity has to be extended to the needy and underprivileged people. This positive impact should be enhanced to larger canopy of people by integrating with other modes of transportation to establish last mile connectivity. Metro services should be extended to support disabled, students, senior citizens through special programmes. Parking facilities for private vehicles shall be planned and provided to attract users of metro.	Working areas/offices, stations and depot	Number of Eemployment generated.	Check of relevant documents.	BMRCL	BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
103		Resources – There will be a positive impact on the conservation of resources.	This positive impact should be enhanced to larger canopy of people by integrating with other modes of transportation to establish last mile connectivity.	Development in the areas along the alignment.	Consultation with community in the locality. SOP developed and revised as necessary	Site observations and survey.	BMRCL	BMRCL
104		Health & Safety – Operation of metro rail will have significant benefit on the health due to reduced air pollution and on the safety due to reduced risk of exposure to accidents. However, in light of COVID 19 pandemic, risks for disease transmission must also be addressed.	This positive impact should be enhanced to larger canopy of people by integrating with other modes of transportation to establish last mile connectivity. SOP on communicable diseases, particularly COVID 19 shall be prepared and reviewed and revised as necessary					
105		Ancillary development - Ancillary developments will take place along with metro corridor.	Ancillary development should be monitored and only specific types of developments should be encouraged. A stringent land use policy should be developed & followed. There should be balanced and sustainable developments along the metro corridor.	Feeder route and connected stations.	Commuter satisfication and complaints.	Site observations and consultation with users.	Appointed agency.	BMRCL
106		Aesthetics – Implementation of metro rail will enhance the aesthetics in the vicinity after completion.	Aesthetics of metro structure should be regularly maintained and monitored for proper housekeeping landscaping underneath metro line, vertical gardens on the piers and				Facility Contractor	BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			upkeep of metro coaches & metro stations.					
107		Water pollution – Washing of metro coaches in metro workshops will have oil & grease in the wastewater which contributes for Chemical Oxygen Demand (COD) & Total Suspended Solid content if disposed into the nearby water bodies.	Effluent Treatment Plants (ETPs) shall be designed and planned in the workshops to treat the wastewater and then dispose it suitably.	Stations and Depot locations.	Water quality paramters.	As per CPCB requirements	BMRCL	BMRCL
108	Use of DG sets	Air – Use of DGs will release air pollutants to the environment.	It shall be preferred to use power source from BESCOM and DGs shall only be used as power backups. Emissions from DG shall conform to CPCB norms and height of the stacks of DG shall be as prescribed by CPCB. High Speed Diesel containing low Sulphur content shall be used to run DGs.	Stations and Depot locations.	Air quality and noise level parameters. Conditions mentioned in consent letter for DG sets	As per CPCB requirements .	BMRCL	BMRCL
109		Noise - Noise & vibration will be generated from the use of DG sets	DG sets should be noiseless type and DG sets shall be provided with enclosures and mufflers to reduce the noise transmission.	At location of installations at stations or power back-up.	Air quality and noise level paramters	As per CPCB requirements	BMRCL	BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
			The DG sets shall be mounted on damping skids to reduce the vibration from DG sets.					
110	Storage of Diesel	Water Pollution – Spillage of diesel from storage facility will pollute nearby surface water bodies and groundwater quality adversely	Storage of diesel shall be done in designated areas paved with concrete floors and with an arrangement of oil interceptors to prevent oil entering the water stream. Precautions shall be taken to avoid any spillage of diesel.	Storage facility and filling facility.	Presence of spilled oil at facility. Emergency response planning and equipments. Approval from competent authority.	Site observation and compliance check on given permission.	BMRCL	BMRCL
111		Health & safety – Accidental spillage of diesel could cause serious fire hazards and affect the health of workers and damage to properties.	As the storage of diesel attracts the provisions of Hazardous Chemicals (Management & Handling) Rules and Petroleum Rules; as amended to date, required permission shall be obtained. Proper on-site emergency plan shall be prepared and get the BMRCLs approval. If the diesel storage crosses the threshold limits permissions from Chief Controller of Explosives (CCoE), proper fire protection norms shall be undertaken as per National Building Code, 2005 (if applicable).					
112	Monitoring Operation Performance	Non-compliance – Failure to monitor operation performance will lead to non-	The BMRCL shall monitor the operational performance of the various mitigation / enhancement measures	Metro operations	Commuter satisfication	Site observations and	BMRCL	BMRCL

Sl. No.	Activity	Impact	Mitigation Measures	Location	Monitoring		Responsibility	
					indicators	Method	Implementation	Supervision
		compliance of statutory requirements of project.	carried out as a part of the project.		and complaints.	consultation with users.		
113	Maintenance of Drainage along the metro corridor	Flooding – Non maintenance of drains to ensure the flow of surface run off will lead to flooding which may create problem to access metro services.	BBMP shall ensure that all drains (side drains, median drain and all cross drainages) are periodically cleared especially before monsoon season to facilitate the quick passage of rainwater and avoid flooding.	Project alignment	Drainage layout	Site observations	BBMP	BMRCL
114	Environmental Monitoring	Construction of metro project and associated works may impact air quality, noise levels, surface and ground water quality and soil quality.	The periodic monitoring of the ambient air quality, noise level, water (both ground and surface water) quality, soil quality in the selected locations shall be done as suggested in environmental monitoring plan through the approved monitoring agency.	Project alignment	Environmental parameters monitoring	Reports on monitoring	Approved Monitoring Agency	BMRCL
115	Tree Plantation	Tree transplantation and compensatory tree plantation in lieu of trees impacted by metro project will help to maintain green cover in the city and helps to ameliorate cities weather conditions and environment.	The survival rates and success of the transplanted and compensatory planted trees under metro project shall be monitored and ensured by State Forest Department on behalf of BMRCL.	Plantation at median &station areas	Survival rates	Site observations and reports.	State Forest Department	BMRCL

E. Environmental Monitoring Plan

398. Environmental monitoring is an essential component for sustainability of any developmental project. It is an integral part of environmental management plan. Any infrastructure development project involves complex inter-relationships between people, natural resources, biota and other developing forces creating a new environment. It is very difficult to predict with complete certainty the exact post-project environmental scenario. Hence, monitoring of critical environmental parameters is essential for project implementation and post implementation phase.

399. The monitoring programme consists of performance indicators to be monitored, location, sampling and analysis methods, frequency compared to standards; reporting formats and necessary budgetary provision. Out of this, the budgetary provisions are confidential and are not supposed to be part of the disclosure statement. The budgetary statements are provided for the purpose of evaluation of the EMP. The Contractor's monitoring plan should be in accordance with the baseline environmental monitoring locations provided in the environmental impact assessment report.

400. For each of the environmental condition indicators, the monitoring plan specifies the parameters to be monitored, location of the monitoring sites, frequency and duration of monitoring. The monitoring plan also specifies implementation and supervising responsibilities. The monitoring plan and details of monitoring locations for environmental condition indicators of the project during the construction and operation stage are presented in Table 7-3. The monitoring will be carried out by BMRCL through the approved agency and will be supervised by Environmental Expert of Designated Engineer s and BMRCL.

401. The objectives of the EMoP are:

- Ensure that impacts do not exceed the established legal standards;
- Check the implementation of mitigation measures in the manner described in the EIA report;
- ensure timely and effective implementation of the EMP;
- Provide an early warning of potential environmental damages so that mitigation measures may be modified or additional measures may be implemented;
- Check whether the proposed mitigation measures have been achieved the intended results, and or/ other environmental impacts occurred.

402. The monitoring plan will be used for performance monitoring of the project. A monitoring plan defining all parameters to be monitored, with tentative location, project stages for measurements, implementation and institutional responsibility for different environmental components is prepared for all stages of project and presented in Table 7-3.

Table 7- 3: Environmental Monitoring Plan Matrix*

Attribute	Parameters to be monitored	Locations and Frequency	Frequency	No of samples	Implementation
Ambient Air	PM_{10}, $PM_{2.5}$, SO2, NOx, CO and Pb using High volume sampler to be located within 50m from project area in the down wind direction.	**Three** locations at representative air sensitive receptors (schools & Hospitals) along the Metro alignment + **One** location at each metro station + **One** location each at casting yard & Batching plant + **One** location at Construction camp.	(1 sample/ season for three seasons (excluding monsoon) during two years of construction stage and one-year operation stage)	**225 Nos.** ((3+13+2+1) *3*3)	BMRCL / Contractor through an approved Independent Agency
Ambient Noise levels	Noise levels as per National Ambient Noise Standards and WBG IFC Standards on db(A) scale (Equivalent noise levels Leq, L10, L50, L90 of 24-hourly noise samples at each location during day time and night time.	**Three** locations at representative noise sensitive receptors (schools & Hospitals) along the Metro alignment + **One** location at each station + **One** location each at casting yard & Batching plant + **One** location at Construction camp.	1 sample/ season for three seasons (excluding monsoon) during two years of construction stage and one-year operation stage	**225 Nos.** ((3+13+2+1) *3*3)	BMRCL / Contractor through an approved Independent Agency
Vibration	PPV mm/s (Federal Transit Administration Guideline standards)	**Three** locations at sensitive structures along the metro route and**one** location each at all proposed metro stations.	2 samples / year during two years of construction stage and one year of operation stage	**114 Nos.** ((3+13) *2*3)	BMRCL/ Contractor through an approved Independent Agency
Surface Water Quality	pH, temperature, EC, Turbidity, Total Suspended Solids, Total Dissolved Solids, Calcium, Magnesium, Total Hardness, Chlorides, Sulphates, Nitrates, DO, COD, BOD, Iron, Zinc, Manganese	One sample each at Agara Lake, Bellandur Lake, Ibbalur Lake, Stream at Ch 10+050, Mahadevapura Lake, B Naranyanpura Lake, and Benniganahalli Lake, located along the proposed metro corridor including one sample each at construction camp and labor camp.	Once in every four months (Excluding monsoon) during two years of construction stage and one year of operation stage.	**99 Nos.** ((7+2) *3*3)	BMRCL / Contractor through an approved Independent Agency

Attribute	Parameters to be monitored	Locations and Frequency	Frequency	No of samples	Implementation
Ground Water Quality	Water quality parameters as per IS for drinking water (IS: 10500-1991)	One location each at the proposed metro stations, one sample each at construction camp and labor camp.	Once in every four months (Excluding monsoon) during two years of construction stage and one year of operation stage.	**153 Nos.** ((13+2) *3*3)	BMRCL / Contractor through an approved Independent Agency
*Soil	Monitoring of pH, Nitrogen, Phosphorus, Potassium, Sodium, Chloride, Organic Carbon and Lead analyzed using absorption spectrometer	One sample each at the proposed metro stations, casting yards/batching plant, construction camp and labor camp.	Two samples per year (One in pre-monsoon and one in post-monsoon) during two years of construction stage and one year of operation stage.	**144 Nos.** ((13+3) *2*3)	BMRCL / Contractor through an approved Independent Agency
Occupational Health and Safety	As specified in project SHE plan prepared by Contractor following BMRCL's SHE Manual and IFC EHS Guidelines	Project site	Weekly	**-**	BMRCL / Designated Engineer / Contractor

***Applied Standards.** During the design, construction and operation the project will apply pollution prevention and control technologies and practices consistent international good practice, as reflected in internationally accepted standards such as the World Bank Group's Environmental, Health, and Safety (EHS) Guidelines (IFC, 30 April 2007). When state or national regulations differ from these guidelines the most stringent measures will be applied. (Annex – 4)

F. Environmental Management Budget and Resources

403. The cost of all compensation and rehabilitations works will be an integrated part of the overall project cost, which will be borne by the project. The preliminary estimated cost of the environmental management plan including implementation and monitoring is detailed in Table 7-4. This cost estimate is exclusive of land acquisition and resettlement & resettlement cost.

Table 7- 4: Cost of EMP Implementation*

Sl. No.	Item	Cost in Lakhs (INR)
1	Compensatory afforestation	88
2	Green Belt Development beneath elevated track	49
3	Translocation of trees	81
4	Disposal of excavated soil	200
5	Shifting of civil/electrical utilities	10,571
6	Rain water harvesting	18
7	Water Quality	40
8	Air & Noise monitoring	35
9	Establishment of Environmental Management Cell	50
Total		**11,132**

Note: Cost estimate is tentative and subject to change following detailed design provisions. EMP costs are taken as lump sum, which should cover health and safety provisions such as PPE and those related to disease prevention and hygiene.

G. Reporting system

404. Environmental monitoring involves regular checking of the environmental management issues detailed in the EMP to ascertain whether the mitigation measures are achieving their objectives, according to the EMP, with the progress of the construction works. Reporting system ensures and provides the necessary feedback for the PIU to keep the monitoring programme on schedule and achieve the expected outcomes.

405. The Contractor, Designated Engineer (DE) and BMRCL operate the reporting system for monitoring environmental conditions and environmental management indicators. Reporting formats for Contractor and DE have to be prepared and finalised, which shall be implemented by the Contractor and monitored by DE and BMRCL.

406. The reporting system will start with the Contractor who executes project works. The Contractor reports to DE who in turn reports to BMRCL PIU. The Contractor shall formally submit monthly and quarterly environmental compliance reports to the DE. The DE shall submit separate quarterly environmental monitoring reports to the BMRCL PIU in addition to submission of the summary of the activities for the month in the formal monthly report including any deviations and corrective actions. BMRCL shall be responsible for ensuring compliances and preparation of targets for identified non-compliances with respect to EMP.

407. A full record of construction activities shall be kept as a part of normal contract monitoring system. Reporting and monitoring systems for various stages of project implementation and related activities have to be proposed to ensure timely and effective implementation of the EMP. The operation stage monitoring reports shall be biannual,

provided the Project Environmental Completion Report shows that the implementation is satisfactory.

408. The reporting system shall be as follows:

- Contractor reporting to DE
- DE reporting to BMRCL
- BMRCL reporting for the information of all interested parties, including but not limited to a biannual Environmental Report to ADB.

Table 1- 5: Reporting System during construction

Item	Contractor	Designated Engineer (DE)		BMRCL to oversee compliance monitoring
		Supervision	Reporting to BMRCL	
Construction Stage				
Monitoring of construction site and construction camp	Before start of construction work	Regular	Monthly	Regular
Environmental monitoring	As required per EMoP	As required	Monthly	Quarterly
Debris disposal area	Weekly	As required	Quarterly	Quarterly
Monitoring Enhancement sites	Implementation	Regular	Quarterly	Quarterly
Erosion control & topsoil preservation	Weekly	Weekly	Monthly	Quarterly
Quarry areas / Crushers / Debris disposal areas	Regular	Weekly	Monthly	Quarterly
Tree cutting	Weekly	Weekly	Monthly	Quarterly
Tree transplantation /compensatory plantation	Monthly	Monthly	Monthly	Quarterly
Operation stage				
Rehabilitation of Quarry site / debris disposal site / batching plants /labor camps /construction camps / Project sites	One time	As required	One time	As required
Environmental monitoring	Quarterly	Quarterly	Quarterly	As per monitoring plan

VIII. CONCLUSION AND RECOMMENDATIONS

409. The Environmental Impact Assessment exercise provides a full description of the project corridor environment, and significant positive and negative environmental and social impacts due to the proposed project. The proposed Phase 2A ORR alignment will not pass through any environmentally sensitive areas as the entire alignment is located within a highly urbanized area.

410. The proposed metro project has the potential to cause significant adverse impacts during pre-construction, construction and operational phases. In order to avoid, minimize or mitigate the identified adverse impacts an environmental management plan for the various phases of project implementation containing detailed mitigation and management measures has been prepared. In addition, environmental enhancement works like landscaping and rainwater harvesting along the alignment; beautification of parks; restoration of water bodies and harvesting and utilization of solar energy in metro stations taken up as a corporate social responsibility will make the proposed metro project viable and beneficial to the public of Bengaluru city.

411. It is estimated that a total of 53,475.27 m2 needs to be acquired for stations and viaduct of the metro project of which 20,899.33 m2 is private land and 32,575.94 m2 is government land.

412. Approximately 123,709 m3 of excavated earth and 7,822 m3 of concrete debris would be generated from the excavations for piles and pile cap. As far as possible, demolition and construction waste should be segregated and recycled. The unserviceable waste left after recycling should be dumped in pre-identified and pre-approved pits as per Construction & Demolition Waste Management Rules.

413. There are 6 major water bodies in the vicinity of project corridor of which the quality could be impacted by the project. However, appropriate mitigation measures such as proper sewerage systems for the stations will be taken up to avoid and reduce the impact. Waste water generated at construction camps and labor camps will be treated to the standards prescribed by CPCB before disposal.

414. Disruption of city traffic during the construction phase of the project is unavoidable, however all efforts should be made to limit the extent of the impact. Effective pre-approved traffic management and diversion plans that adhere to the Guidelines on Traffic Management in Work Zones will be prepared and communicated to local public and commuters in advance.

415. Generation of dust by the construction activities and the hauling of materials and debris is the main air quality issue associated with construction of metro project. Proper dust mitigation measures are proposed in the EMP to handle the dust during various phases of project implementation.

416. 29 air and 124 noise sensitive receptors were identified along the project corridor alignment. Dust mitigation by regular sprinkling of water and noise mitigation measures such as provision of barricades and noise barriers during construction will be made at all the identified air and noise sensitive receptors to reduce the impact.

417. After implementation of the project the air pollutants emission is likely to come down to a greater extent with extensive savings on consumption of fuel because of shift of commuters to metro system from other modes of vehicular traffic on Outer Ring Road.

418. An estimated number of 1248 trees are impacted by the project. Sincere efforts shall be made to transplant many of the trees. Every impacted tree will be compensated at the rate of 1 to 10 as per the direction of Tree Committee or Forest Department. In addition, at-grade median plantation will be taken up all along the proposed alignment.

419. There are no notified archaeological structures along the proposed project corridor.

420. The project has a potential temporary impact on the livelihood, public services, health and safety of community and laborers during construction of the project. All necessary safeguards should be taken to ensure the safety, welfare and good health of all personnel and public near the construction sites.

421. In light of the COVID-19 pandemic, measures for communicable disease prevention and control have been strengthened or added where necessary in pertinent management plans such as the emergency response plan. BMRCL has also prepared the SOP for works during the lockdown period which will serve as the main guidance document for contractors and will be updated from time to time as the situation evolves.

422. Noise and vibration will be generated from construction activities and equipment temporarily during construction phase and noise mitigation measures such as provision of barricades and noise barriers during construction will be made at all the identified noise sensitive receptors to reduce the impact. Impact from noise and vibration are also known during operation of metro trains particularly at curves due to friction of wheels and tracks. The vibration impact can be mitigated or reduced by using resilient wheels, ballast mats, resiliently supported ties; rail grinding on a regular basis; wheel turning or wheel truing to re-contour the wheel; vehicle reconditioning and others.

423. Recommendations:

- BMRCL will conduct additional consultations with residents living along the proposed alignment with particular attention to vulnerable groups as soon as COVID-19 situation in Bengaluru allows this;
- BMRCL having one of the larger metro networks in the country should strengthen its capacity to monitor and manage social, environmental and health & safety issues of projects being implemented;
- Commissioned metro projects should be subjected to annual environmental audits as a part of corporate social responsibility;
- Develop the Environmental and Social Management Framework (ESMF) with specific environmental quality objectives as well as targets and deadlines with respect to sustainable development strategy;
- Felling of trees for metro project is one of the significant impacts. A separate cell consisting of officials from Forest Department should be set up to tackle all the issues related to tree cutting, tree transplantation, compensatory plantation and regularly monitor and report survival of planted trees;
- High priority should be given to maintaining the safety and health of both laborers as well as the general public in all phases of the project;
- Stringent mitigation measures and monitoring requirements for various phases of metro project implementation are included in the EMP. The BMRCL shall ensure that site specific EMP together with the Safety, Health and Environment (SHE) guidelines forms a part of bid document and civil works contract. The same shall be revised if

necessary, during project implementation or if there is any change in the project design and with approval of ADB.

ANNEXURES