

Environmental Impact Assessment

October 2020

India: Bengaluru Metro Rail Project

Phase 2A (Outer Road Ring Metro Line)

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 |
| BMRL | Bangalore Metro Rail Corporation Ltd |
| BMTCL | 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.

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EXECUTIVE SUMMARY

A. Introduction

1. Bengaluru is one of the fastest growing cities in India with unpredicted and uncontrolled growth of population and traffic, forcing city to face tough challenges in providing and extending basic infrastructure and services. Bengaluru roads are too narrow and most of these roads are bordered with ribbon development of thick built-up sections all along the roads, making widening of these roads to cater to the growing numbers of vehicles an unviable option. Bengaluru's vehicle population has been growing rapidly, choking the city roads with frequent traffic jams and making them prone to road accidents. Further, the public is using the independent modes of transportation for commuting on existing limited road network adding to the congestion, accidents, noise and air pollution. Volume demand to capacity ratios on most of the roads are more than 1. Overall average traffic speed is about 13.5 kph in peak hour. Traffic composition on roads indicates very high share of two wheelers and growing share of cars. This not only indicates the need for augmenting road capacity but also to optimize the available capacity by adopting alternative public transport system. Rapid development of IT industries in Electronic City and Whitefield areas of Bengaluru, has contributed to the phenomenal growth all along Outer Ring Road (ORR) between Central Silk Board (CSB) and KR Puram. The existing ring road having 6 lane main carriage way with service roads is not able to cater to the needs. It is estimated that about half a million IT professionals are employed on this corridor. The biggest challenge these people are facing is the long commuting time thereby bringing down their efficiency and also affecting the overall economic efficiency in this corridor. Hence, it is proposed for construction of ORR Metro line along the ORR starting from CSB to KR Puram.

B. Project Description

2. The present proposal is for the implementation of Phase 2A Metro Line on the ORR and will be an elevated standard gauge corridor with double line section for a route length of 17.130 km (line length of 19.75 km) up to the depot. The corridor proposed is from terminal station at CSB to terminal station at KR Puram and further up to Baiyappanahalli Depot, the other stations being HSR Layout, Agara Lake, Ibbalur, Bellandur, Kadubeesanahalli, Kodibeesanahalli, Marathahalli, ISRO, Doddenakundi, DRDO Sports Complex and Saraswathi Nagar.
3. The project proposals involve construction of elevated viaduct generally passing on median of the road and the stations proposed above the road with entries planned from both sides of the road beyond the existing service road. The proposed stations will have two side platforms and the access to the platforms is through staircases, escalators and elevators housed in the paid area of concourse.
4. Total 13 stations are proposed along the ORR line and 7 stations out of 13 stations have been planned for commercial development for an area of about 1000 Sqm at each station at concourse level. The area at ground level will be used for intermodal transit and parking.
5. Provision of 6m wide service road has been proposed around the stations for integration with BMTC buses to ensure last mile connectivity for commuters. A provision for pocket track of 300m length at Kodibeesanahalli station and cross overs at Ibbalur-Bellandur-Kadubeesanahalli and Marathalli-ISRO-Doddenakundi stations are made for facilitating smooth train operations and to help in easy turnaround of trains during emergency.
6. For the convenience of implementation, the proposed Phase 2A metro project corridor has been divided into two different Contract Packages as given in Table E-1. The work includes road widening, utility diversion and allied works and construction of loops,

ramps for road flyover at CSB junction of approximate length of 2.84 km including road widening and allied works in Reach-5 line (R5/P4).

Table E- 1: Package wise details of Proposed Phase-2A metro project

| Sl. No. | Package No. | General Description | Length (M) | Number of Metro Stations |
|---------------------------|-------------|---|--------------|--|
| 1 | P1 | Construction of elevated structure (Viaduct & Stations) from Central Silk Board to Kadubeesanahalli | 9859 | 6 Nos. of elevated metro stations (Central Silk Board Station, HSR Layout Station, Agara Station, Ibbalur Station, Bellandur Station and Kadubeesanahalli Station) |
| 2 | P2 | Construction of elevated structure (Viaduct & Stations) from Kodibeesanahalli to KR Puram | 9774 | 7 Nos. of elevated metro stations (Kodibeesanahalli Station, Marathahalli Station, ISRO Station, Doddenakundi Station, DRDO Sports Complex Station, Saraswathi Nagar Station and KR Puram Station) |
| Phase 2A Total (M) | | | 19633 | 13 Stations |

7. **Project Categorization** - Phase 2A ORR metro line and Phase 2B metro line from KR Puram to Kempegowda International Airport (KIA) are proposed for funding from the Asian Development Bank (ADB). Rail-based systems have been excluded from the scheduled list under the Environmental Impact Assessment (EIA) Notification of 2006 and its subsequent amendments under the Environment (Protection) Act, 1986. Therefore, the proposed Phase 2A Metro Project is not required to secure environmental clearance in the form of an approved EIA from the Ministry of Environment, Forest and Climate Change (MOEFCC) per national policies and regulations. Similarly, the metro stations and depots proposed along the metro rail corridor being part of Metro rail project do not attract EIA Notification prescribing environmental clearance.
8. A preliminary screening of the project was done using Rapid Environmental Assessment (REA) Checklist for environmental categorization as per the ADB's SPS considering the aspects of project location and potential environmental impacts during various stages of project implementation (Annexure – 1).
9. The project, being located in a highly urbanized area, has been assessed to have very minimal impacts on biodiversity and will not affect environmentally sensitive areas. However, the scale of the civil works will require a great number of workers and entail movement of large quantities of materials and operation of heavy machinery in a largely populated urban area, including several congested segments. As such, community and occupational, health and safety risks during the construction stage are considered significant. Therefore, the proposed lines have been classified as Category 'A' as per Safeguard Policy Statement (SPS), 2009. This EIA has been prepared and will be disclosed at least 120 days prior to board consideration of the project in compliance with ADB SPS requirements.

C. Policies, Regulatory Framework and Its Applicability

10. The Constitutional Provisions like Article 48 and 51-A (g) and 74th Amendment to the Constitution serve as principle guidelines of environmental protection. Further Regulations, Acts, Policies applicable to sustainability and environmental protection are as follows:

- *EIA Notification, September 2006 & subsequent Amendments*
- *The Environment (Protection) Act, 1986*
- *The Water (Prevention and Control) Act, 1974*
- *The Air (Prevention and Control) Act, 1981*
- *The Hazardous Waste (Management and Handling) Rules, 1989*
- *The Wildlife Protection Act, 1972*
- *The Karnataka Preservation of Trees Act, 1976*
- *The Indian Forest Act, 1927*
- *The Forest (Conservation) Act, 1980 (as amended in 1988)*
- *National Green Tribunal (NGT) Order*
- *The Right to Fair Compensation and Transparency in Land Acquisition and Rehabilitation and Resettlement Act, 2013 (RFCTLARR Act 2013)*
- *Karnataka Industrial Area Development Board Act*
- *The Ancient Monuments and Archaeological Sites and Remains Act 1958*
- *Public Liability Insurance Act, 1991*

11. After reviewing the various applicable acts and statutes mentioned above, it is determined that clearances and permission are required for the project. A summary of clearances required for the proposed project is shown in the Table E-2.

Table E- 2: Clearances required for the proposed project

| Sl. No. | Subject | Authority Granting Clearance | When required | Responsibility | Applicability |
|---------|---|------------------------------|---------------------|----------------------|---------------|
| 1 | Permission for cutting of trees and transportation | State Forest Department | Before Construction | BMRCL | Applicable |
| 2 | Elevated Metro Corridor Crossing Indian railway lines | Indian Railways (SWR) | Before Construction | BMRCL | Applicable |
| 3 | No Objection Certificate (NOC) for Construction and labor camp, Crushers, Batching, wet mix macadam, hot mix plants | KSPCB, Karnataka | Before Construction | Contractor/ Supplier | Applicable |
| 4 | Employing Labour/ Workers | District Labor Commissioner | Before Construction | Contractor | Applicable |
| 5 | Rehabilitation & Resettlement of Displaced families | Government of Karnataka | Before Construction | BMRCL | Applicable |
| 6 | Permission for withdrawal of groundwater for construction | Central Ground Water Board | During Construction | Contractor | Applicable |
| 7 | Installation of Generators | KSPCB | Before Installation | Contractor | Applicable |
| 8 | Storage, handling and transport of hazardous materials | KSPCB, Karnataka | During Construction | Contractor | Applicable |

| Sl. No. | Subject | Authority Granting Clearance | When required | Responsibility | Applicability |
|---------|---|--------------------------------|---------------------|----------------|---------------|
| 9 | Traffic Management and Regulation during operation | Traffic Police Department | During Construction | Contractor | Applicable |
| 10 | License for storing Diesel/Fuel | Commissioner of Explosives | During Construction | Contractor | Applicable |
| 11 | Location/ layout of workers camp, equipment and storage yards | KSPCB, District Health Officer | During Construction | Contractor | Applicable |
| 12 | Disposal of Construction and Demolition wastes | BBMP, Bangalore | During Construction | Contractor | Applicable |

D. Description of Environment

12. Baseline information on environment was collected from secondary sources of data for the macro environmental parameters like climate, physiography (geology and geomorphology), biological and socio-economic environment of the project influence area. The corridor specific environmental details have been collected from primary source of data such as reconnaissance survey, baseline environmental surveys on ambient air quality, ambient noise levels, surface and underground water quality, soil quality vibration survey, tree enumeration, etc. along the project area.
13. The atmospheric concentration of air pollutants has been monitored at 7 representative air pollution sensitive locations such as schools, colleges, hospitals, hostels and libraries adjacent to the proposed Phase 2A metro alignment in November 2019. Air Monitoring was carried out for parameters PM_{2.5}, PM₁₀, NO_x, SO₂, CO and Pb. The results show that the average concentrations for PM₁₀ were within the prescribed CPCB limit of 100 µg/m³ but exceeded the WBG guideline value of 50 µg/m³ at all monitored locations. The concentrations of PM_{2.5} were all within the prescribed CPCB limit of 60 µg/m³ but exceeded the WBG guideline value of 25 µg/m³ at 5 locations. The concentrations of all other monitored parameters were within the prescribed CPCB limit and WBG guideline values. The survey for ambient noise levels has been conducted at seven representative locations sensitive to noise pollution along the alignment and an additional 30 locations in between. The results indicate that the lowest recorded ambient noise levels during both day and night time exceed the project limits for silence, residential as well as commercial areas (limits applied as prescribed by CPCB and WBG, whichever is more stringent).
14. To know the impact of vibration due to construction activities and metro train operation, the study was conducted at five locations along the proposed metro alignment. Threshold limit (upper Limit) has been set to 0.5 mm/s which refers the event has been captured above 0.5mm/s. The vibration of 1.22 mm/s has been recorded at one location out of five monitored locations. Surface water, ground water and soil samples have been collected from the water bodies, borewells and parks located adjacent to the proposed alignment respectively and analysed to establish the baseline conditions.

The tree enumeration survey has been carried out along the alignment, and station locations to capture. The species, girth, trunk height of impacted trees has been recorded during survey. Total of 1,248 trees are observed along the alignment and station locations.

E. Environmental Impacts and Mitigation Measures

15. The implementation of proposed metro project from Central Silk Board to KR Puram (ORR Line) 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.
16. It is estimated that a total of 53,475.27 m² of land needs to be acquired for stations viaduct of the metro project, Multi-level Parking and Bus stand at Central Silk board of which 20,899.33 m² is private land and 32,575.94 m² is government land.
17. 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.
18. 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. Wastewater generated at construction camps and labor camps will be treated to the standards prescribed by CPCB before disposal.
19. 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.
20. 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.
21. 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.
22. 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.
23. As per BMRCL survey approximately 1,248 trees are impacted by the project under Phase 2A. 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.
24. There are no notified archaeological structures along the proposed project corridor.

25. 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.
26. Noise and vibration will be generated from construction activities and equipment temporarily during construction phase and noise mitigation measures such as provision of barricades, noise barriers, the timing of works and the use of specialist equipment 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; etc.

F. Information Disclosure, Consultation, and Participation

27. Consultations during environmental and social impact assessment have been conducted with project affected people (PAPs) and stakeholders. Suggestions and options given during consultations improve technical and economic efficiency of the project. Execution of suggestions from stakeholders creates the sense of ownership among the communities of the region and eases the implementation process. Consultations are usually conducted with a sample section of the community with a good representation from the affected communities. Public consultation was conducted at Higher Primary School, Outer Ring Road, Ibbalur to elicit the concerns of project affected public and stakeholders. As per SPS, 2009 of ADB the draft EIA report has been made publicly available at least 120 days before board consideration of the project.

G. Environmental Management Plan

28. Environmental Management Plan (EMP) deals with the implementation procedure of the guidelines and mitigation measures recommended to avoid, minimize, and mitigate foreseen environmental impacts of the project. The implementation of environmental management plan needs suitable organization set up and the success of any environmental management plan depends on the efficiency of the group responsible for implementation of the programme. It is proposed to carryout regular environmental monitoring to provide information to the management for periodic review and alternation of the environmental management plan as necessary so as to ensure that environmental protection is optimized at all stages of the project implementation.
29. Environmental monitoring is an essential component for sustainability of any developmental project. It is an integral part of any environmental assessment process. The monitoring programme consists of performance indicators, reporting formats and necessary budgetary provision. 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 the applicable standards, implementation and supervising responsibilities. The monitoring will be carried out by PIU through an independent external monitoring the approved agency as per the requirements of ADB's Safeguard Policy Statement for Category 'A' projects and will be supervised by the Environmental Experts of the Designated Engineer, External Independent Monitoring Agency and PIU.
30. The contractor is primarily responsible for daily onsite implementation environmental monitoring and management works during implementation of road improvement project to ensure high level of safety and quality and that all statutory requirements are

met during the project implementation. The PIU will provide overall management and monitoring of EMP implementation as supported by the Designated Engineer (DE). An external monitor will be engaged to conduct third party monitoring of EMP implementation.

31. The staff of PIU, DE, independent external monitoring agency and the Contractor who would be responsible for the implementation of the EMP, need to be trained on environmental issues specific to project. Suitable training programmes have been worked out for the project as well as capacity building needs. The programme consists of several training modules specific to target groups. The training would cover the basic principles and postulates of environmental assessment and mitigation plans, implementation techniques, monitoring and management methods and tools.
32. The budgetary provision of INR 11,132 Lakhs for the implementing EMP of the project has been made.

H. Conclusion and Recommendations

33. The project will potentially cause negative impacts during construction phase. However, adequate mitigation measures have been recommended to avoid, minimize and reduce the impacts of project during design, construction and operation phases of project implementation.
34. 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.

I. INTRODUCTION

A. Background

35. Bengaluru is one of the fastest growing cities in India. The city is also known as Silicon Valley of India. It is in forefront supporting the growth of Information Technology (IT) and several other service-based industries attracting people and business from across the nation. This has led to the unpredicted and uncontrolled growth of population and traffic leading to challenges in providing and extending basic infrastructure and services. Road transport has been facing severe stress in the recent past. Bengaluru as a multi-nodal city lacks road connectivity and suffers from traffic congestion due to narrow roads. There are no good transit corridors between different parts of the city and connectivity to airport. Bengaluru roads are too narrow and most of these roads are bordered with ribbon development of thick built-up sections all along the roads, making widening of these roads to cater to the growing numbers of vehicles an unviable option. Widening of these narrow roads requires more land to be acquired and demolition of structures which will causes significant social and environmental impacts. Further, widening of roads is not a complete solution as the number of vehicles is increasing uncontrollably, adding to city's problems such as congestion, air pollution, noise pollution and associated social problems.
36. Bengaluru's vehicle population grows at roughly 500,000 vehicles every year leading to frequent traffic jams and makes the road prone to accidents. As per the Comprehensive Traffic and Transportation Plan for Bengaluru, 2011¹, an average Bangalorean spends more than 240 hours stuck in traffic every year resulting in loss of productivity, in addition to deterioration of air quality, reduced quality of life, and increase in costs for services and goods. Volume demand to capacity ratios on most of the roads are more than 1. Overall average traffic speed is about 13.5 kmph in peak hour. Traffic composition on roads indicates very high share of two wheelers and growing share of private cars. This not only highlights the need of augmenting road capacity but also optimizing available capacity by adopting alternative public transport system. The household travel surveys indicate high share of work trips. This segment of travel demand needs to be mostly satisfied by public transport system. Considering the large employment centres being planned in the Bangalore Metropolitan Area (BMA), the public/mass transport system like metro rail network needs to be expanded substantially.
37. Rapid development of IT industries in Electronic City and whitefield areas of Bengaluru, has contributed to the phenomenal growth all along Outer Ring Road (ORR) between Central Silk Board and KR Puram. With these developments, traffic on this road has unmanageably increased. It is estimated that about half a million IT professionals are employed on this corridor of ORR between Central Silk Board and KR Puram. In addition to IT professionals, this corridor is known for housing various support services and indirect employment thus providing employment to one million people overall. The biggest challenge these people are facing is the long time spent during transportation thereby bringing down their efficiency and also affecting the overall economic efficiency in this corridor. The Phase 2 Metro Line passes through these two extremities of this corridor, one at Central Silk Board and other at KR Puram.
38. Though Phase1of the Metro network has been completed and Phase2 has been planned, this crucial corridor has been left untouched by both developments. Hence, the construction of Phase 2A ORR Metro Line starting from Central Silk Board (CSB) to KR Puram with a route length of 17.130 km (line length of 19.633 km) up to the depot has been proposed. The DPR for this line was prepared by BMRCL in October 2016 and updated during January 2019 incorporating the requirements prescribed in

¹Comprehensive Traffic and Transportation Plan for Bengaluru, 2011; Karnataka Urban Infrastructure Development Finance Corporation (KUIDFC), Government of Karnataka.

the Metro Rail Policy, 2017 issued by Ministry of Housing and Urban Affairs (MOHUA), Government of India (GOI). The route is an extension of the already sanctioned Phase 2 of BMRCL and named as ORR (Phase 2A) Metro Line.

B. Objective of the Project

39. The proposed Phase 2A ORR Metro line meets the objectives and norms set out in the Metro Rail Policy 2017. The proposed line seeks to provide efficient, effective sustainable mode of mass public transport for the business corridor having economic activities for 12% the country's IT exports. The project aims to support the goals of Comprehensive Mobility Plan (CMP) for complementing economic activities and increasing the share of public transport to 70% of all motorized trips. It also plans to facilitate systemic changes in road usage by incentivizing efficient, equitable and sustainable mobility options through economic and regulatory measures, while discouraging inefficient and unsustainable options through imposition of cost of negative externalities. This project will play a key role in mitigating the mobility-related binding constraints to IT eco-system in Bengaluru, which accounts for 40% of revenues of IT companies in India.
40. Phase 2A Outer Ring Road Metro Line and Phase 2B Airport Metro Link Line from KR Puram to Kempegowda International Airport (KIA) are proposed for funding from the Asian Development Bank (ADB).
41. For the convenience of implementation, the proposed Phase 2A Metro Project has been divided into two different contract packages as given in Table 1-1. The work includes road widening, utility diversion and allied works of Phase2A Metro Project and construction of loops, ramps for road flyover at CSB junction of approximate length of 2.84 km including road widening and allied works in Reach-5 line (R5/P4) of Bengaluru Metro Rail Project, Phase 2.

Table 1- 1: Packagewise details of Proposed Phase-2A metro project

| Sl. No. | Package No. | General Description | Length (M) | Number of Metro Stations |
|---------------------------|-------------|---|--------------|--|
| 1 | P1 | Construction of elevated structure (Viaduct & Stations) from Central Silk Board to Kodibeesanahalli | 9859 | 6 Nos. of elevated metro stations (Central Silk Board Station, HSR Layout Station, Agara Station, Ibbalur Station, Bellandur Station and Kadubeesanahalli Station) |
| 2 | P2 | Construction of elevated structure (Viaduct & Stations) from Kodibeesanahalli to KR Puram | 9774 | 7 Nos. of elevated metro stations (Kodibeesanahalli Station, Marathahalli Station, ISRO Station, Doddenakundi Station, DRDO Sports Complex Station, Saraswathi Nagar Station and KR Puram Station) |
| Phase 2A Total (M) | | | 19633 | 13 Stations |

C. Project Proponent

42. MOHUA is the executing agency (EA) acting through the Bangalore Metro Rail Corporation Limited (BMRCL) of the project. The EA will facilitate loan disbursement and ensure timely release of counterpart funding. I will be responsible for overall compliance with national and/or state-level environmental policies and ADB's

Safeguard Policy Statement including and EA level grievance redress mechanism (GRM), overall coordination of project implementation, and interagency coordination as needed. Recruitment of consultant for contract supervision, nongovernment organization, monitoring and evaluation, community and occupational safety, gender equality and social inclusion, environmental sustainability, and institutional development support and procurement of contractors will also be the responsibility of the EA.

43. The Project Implementation Unit (PIU) in BMRCL is the implementing agency (IA) of the project which will conduct preconstruction activities and monitor project activities and outputs, including periodic review, preparation of review reports reflecting issues and plans of action. The PIU will be responsible in ensuring the involvement of beneficiaries and/or representatives in all stages of project development and implementation and ensure quality of works and services of consultants and counterpart staff.

D. Environmental Categorization

44. The Environmental Impact Assessment (EIA) Notification of 2006 and its subsequent amendments under the Environment (Protection) Act, 1986 provides for the requirement of prior environmental clearance for specified projects/activities from concerned regulatory authority. Rail-based systems have been excluded from the scheduled list and therefore the proposed Phase 2A Metro Project is not required to secure environmental clearance in the form of an approved EIA from the Ministry of Environment, Forest and Climate Change (MOEFCC) per national policies and regulations.
45. A preliminary screening of the project was done using Rapid Environmental Assessment (REA) Checklist for environmental categorization as per the ADB's SPS considering the aspects of project location and potential environmental impacts during various stages of project implementation (annexure – 1).
46. The project, being located in a highly urbanized area, has been assessed to have no impacts of biodiversity and environmentally sensitive areas. However, the scale of the civil works will require a great number of workers and entail movement of large quantities of materials and operation of heavy machinery in a largely populated urban area, including several congested segments. As such, community and occupational, health and safety risks during the construction stage are considered significant. Therefore, the proposed lines have been classified as Category 'A' as per Safeguard Policy Statement (SPS), 2009. This Environmental Impact Assessment has been prepared and will be disclosed at least 120 days prior to board consideration of the project in compliance with ADB SPS requirements.

E. Scope of the Study

47. The main scope of the study is to assess significant environmental impacts related to location, design, construction and operation stages of project and preparation of environmental mitigation and management plans for the identified adverse impacts by the proposed Phase 2A metro project stretch from CSB to KR Puram per ADB Safeguard Policy Statement, 2009. Alternatives to the project's location, design, technology, and components that would avoid, or minimize adverse environmental impacts and risks have also been examined. In absence of feasible alternatives, mitigation measures are framed to avoid or minimize the intensity of impacts. Impacts were assessed both within area of impact of 50 meter either side of the alignment and project's area of influence up to 10 km. This area of influence encompasses project associated facilities, construction camps, labour camps, access roads, borrow pits and disposal areas.

F. Approach and Methodology

48. The methodology adopted for the Environmental Impact Assessment is as follows:

- Review of the proposed project activity: This includes review and assessment of the project such as transportation scenario, design, location and alignment, proposed construction such as erection of viaducts, stations and depot, road widening, etc., and operation.
- Assessment of baseline environment: This includes the baseline information of environment such as physical parameters (e.g. air, water, soil and noise), biological components along with socioeconomic scenario of the project area and environmental valued components of the selected corridor through primary and secondary data collection.
- Assessment of environmental Impact: The main objective of this study is to examine the potential environmental impacts during different stages of the project. Based on primary and secondary information collected, the positive and negative environmental impacts are assessed.
- Stakeholder Consultation: This includes formal and informal unstructured stakeholder consultation ranging from Government officials to the public stakeholders. In these consultations, stakeholders are briefed about the various details of the project and their opinions and concerns are elicited.
- Environmental Management Plan (EMP) and mitigation measures: Based on degree of environmental impacts, mitigation measures are proposed. These mitigation measures are also presented to the decision-makers for the alternative designs and other modifications of the project. Critical environmental and social impacts are identified and given due focus in the environmental monitoring plan (EMOP).
- Capacity building and institutional arrangements: Existing capacity building and institutional arrangements are examined and additional measures are proposed for the proper implementation of the EMP.

II. PROJECT DESCRIPTION

49. The Detailed Project Report (DPR) for constructing and commissioning of Phase 2A Metro Line was prepared by BMRCL in October 2016 based on the experience it gained while implementing the Phase1 Metro project. The DPR was revised during January 2019 incorporating the requirements prescribed in the Metro Rail Policy 2017 issued by MOHUA, GOI. During the preparation of updated DPR, there was continuous interaction with government agencies like Directorate of Urban Land Transport (DULT), Bangalore Development Authority (BDA), Bruhat Bengaluru Mahanagara Palike (BBMP), Bangalore Metropolitan Transport Corporation (BMTc) and Transport Department responsible for development of Bengaluru city to come up with the most feasible design and alignment for the proposed project.

A. Proposed Project

50. The present proposal is for the implementation of Phase 2A Metro Line on the ORR and will be an elevated standard gauge corridor with double line section for a route length of 17.130 km (line length of 19.75km) up to the depot. It includes a 300m pocket track at Kodibeesanahalli Station for turning back, emergency stabling facility and operational convenience. The corridor proposed is from terminal station at CSB to terminal station at KR Puram and further up to Baiyappanahalli Depot. Other stations are HSR Layout, Agara Lake, Ibbalur, Bellandur, Kadubeesanahalli, Kodibeesanahalli, Marathahalli, ISRO, Doddenakundi, DRDO Sports Complex and Saraswathi Nagar. The alignment of proposed Phase 2A Metro Line with metro stations and some photos of the ORR are given in Figure 2-1 and Figure 2-2.

51. The project proposals involve construction of elevated via duct generally passing on median of the road and the stations proposed above the road with entries planned from both sides of the road beyond the existing service road. Provision of 6m wide service road has been proposed around the stations for integration with BMTc buses to ensure last mile connectivity for commuters. The proposed stations will have two side platforms and the access to the platforms is through staircases, escalators and elevators housed in the paid area of concourse. 7 out of 13 stations have been planned for commercial development for an area of about 1000 sqm at each station at concourse level. The area at ground level will be used for intermodal transit and parking.

52. The 13 Stations include two interchange stations at CSB Junction and K R Puram providing connectivity to Reach 5 and Reach 1 extension of Phase 2. The line has provisions to extend towards Hebbal along the ORR and further to Kempegowda International Airport as Phase 2B. For ease of operation, this metro corridor will be served by the existing Baiyappanahalli Depot for stabling and coach maintenance.

B. Alignment of the Proposed Metro

53. Horizontal Alignment: The Phase 2A Metro alignment generally follows median of the ORR from Central Silk Board to KR Puram. The ORR alignment is generally straight with no sharp curves. This alignment requires minimum land to be acquired and trees to be cut for construction of viaduct structures and stations. Since the ORR is a wide road the aesthetic impact of the alignment will be limited. There are a total of 43 curves in the alignment, ranging from 193m to 8000m. Check rails are not required for any of the curves on this corridor as no curves have radius below 190m.

54. Design Speed - The maximum sectional Design speed will be 90 km/h. Safe speed on curves of radii of 400 m or more is 80 km/h while 55 km/h shall be permitted for curves with radius of 193 m. Simulation studies of alignment, vertical profile and station locations will be used to determine the applied cant, and length of transition in relation to normal speeds at the different locations to minimize wear on rails on curves.

Figure 2-1: Proposed Phase 2A Metro line and Metro Stations

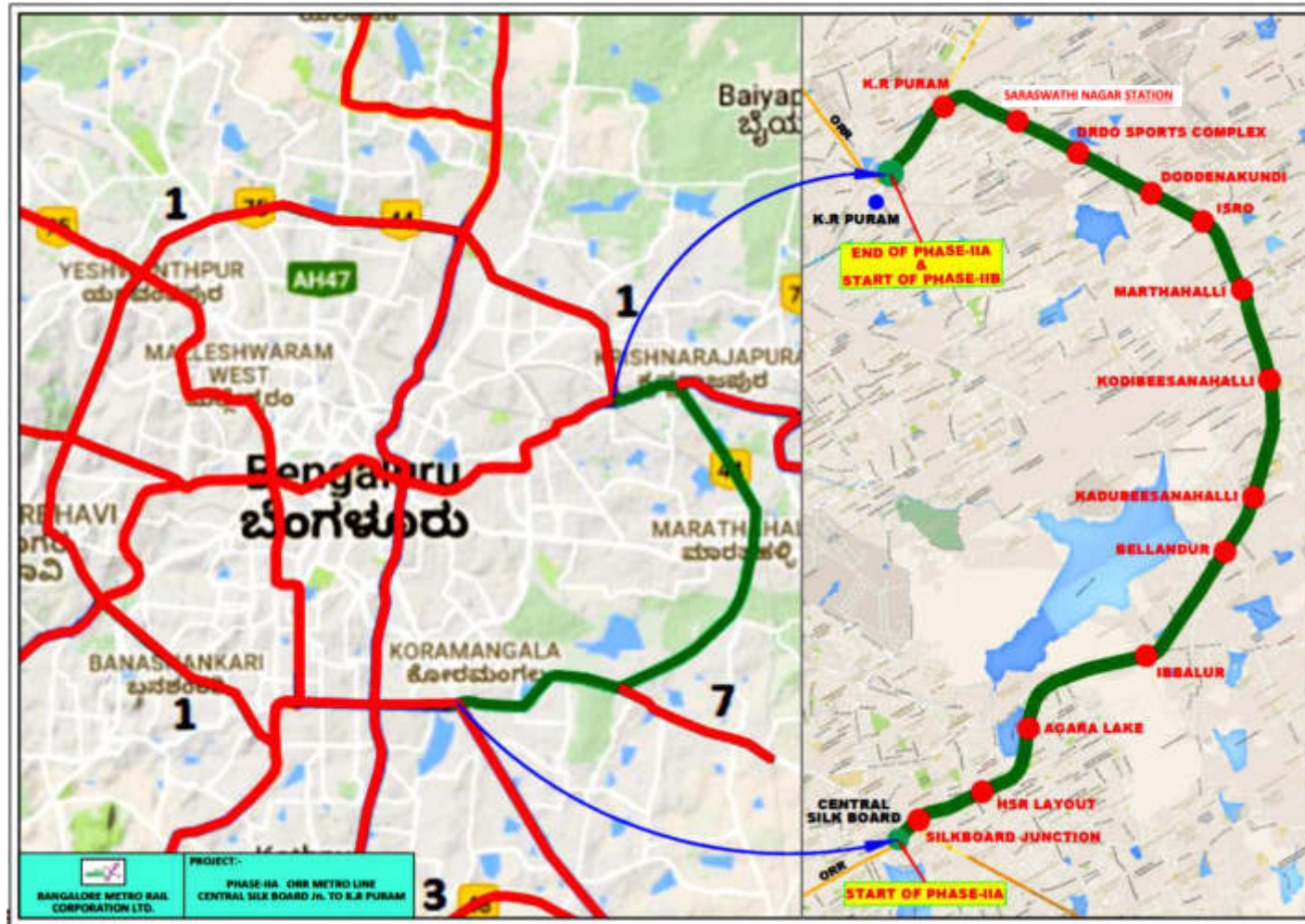


Figure 2- 2: Photos of Outer Ring Road along the proposed corridor



55. Vertical Alignment - A vertical clearance of 5.50m above road level shall be maintained by track supporting structures on elevated sections for movement of vehicular traffic. The rail level is planned to be generally 13.5 m above the road level to meet this requirement with the box girder design. This will also permit construction of elevated pedestrian walkways and footbridges (connecting bridges) for platform interchange for commuters at stations below the viaduct.
56. Viaduct - The most widely used precast segmental box girder/U-girder with post tensioning superstructure was selected for this project considering ease of construction and standardization of the formwork for wide span ranges. In this approach, segments are casted in a casting yard and then transported and assembled on site. This will be supported on single cast-in-situ reinforced concrete cement piers. Circular pier design with pier cap to support the bearings under the box girders will be adopted for this corridor.
57. Track Spacing- Track spacing on the viaduct through the stations shall be 4.2m providing for the extra clearance required due to end throw/mid throw and lean on curves of radius up to 120m while it will be changed beyond 4.2m in depots per provisions of the schedule of dimensions (SOD) of BMRCL 2015 for curves less than 120 to 100m.
58. Track Structures: UIC-60 (60 kg/m) rail section has been proposed considering the axle load frequency of train operation, maintainability, international practice. Rail grade on main lines should be 1,080 head hardened to accommodate sharp curves and steep gradients while 880 grade may be used for the depot lines.
59. Plinth type ballast-less track structure with RCC derailment guards integrated with the plinths is proposed on viaducts along with a suitable fastening system with a base plate to base plate spacing of 70 cm. The fastening systems for ballast less track should satisfy performance criteria issued by Government of India, Ministry of Railways in December 2015. Ballast-less track is also proposed for inspection and washing lines, and the workshop while ballasted track may be used for the rest of the line inside the depot.
60. The track structure is proposed to be joint-less even through the turnouts ensuring durability, minimum maintenance, and at the same time, having the highest level of safety, reliability and comfort, with minimum noise and vibrations.
61. Gauge - Standard gauge (1435mm) is commonly used for metro railways worldwide. 1 in 7 and 1 in 9 turnouts, which occupy lesser length, are feasible for this gauge, making it more suitable in the alignment which passes through heavily built-up areas as compared to 1 in 8 ½ and 1 in 12 turnouts required for broad gauge. The operational Phase 1 of Bengaluru Metro and Phase 2 which is under implementation are also adopting standard gauge. Given these, the standard gauge was also determined to be the best option for this alignment.

C. Depot Planning

62. At present, Baiyappanahalli Depot serves the East-West (E-W) corridor catering to the maintenance needs of trains. It is housed with 16 Stabling Bay Lines (SBL), 3 Inspection Bay Lines (IBL) and 4 Repair Bay Lines (RBL). The Baiyappanahalli Depot will be used for the train maintenance for the Phase 2AMetro Line. Once the planned depot at Kadugodi is developed, the existing Baiyappanahalli Depot, with additional stabling lines and required remodelling, will be utilised exclusively for the proposed Phase 2A and Phase 2B Metro Lines.
63. Phase 2A requires 29 rakes with 2.5 minutes headway to cater to the traffic requirement of year 2041. These trains are planned to be stabled and maintained at

Baiyappanahalli Depot. A full-fledged facility for maintenance of Communication Based Train Control (CBTC) equipped trains shall be planned at Baiyappanahalli in a phased manner such that it will not affect either the train operations on purple line or the rolling stock maintenance. The transition of the Baiyappanahalli Depot from distance-to-go (DTG) signalling to complete CBTC system involves an overlapping period during which some depot line will cater exclusively to CBTC equipped trains and balance meeting the requirements of DTG system. Once alternative arrangements for DTG equipped trains is established, Baiyappanahalli Depot will be fully converted to service CBTC equipped trains only.

64. Phase 2B from KR Puram to Kempegowda International Airport is sanctioned for a length of about 38.00km. As such, the depot facilities are necessary at either end of the corridor to ensure seamless operation during any eventuality. Hence, to ensure feed from KR Puram end to Airport line, additional stabling and inspection facility at Baiyappanahalli Depot is proposed, necessitating remodelling of the facility. Considering the total length of Phase 2A and Phase 2B metro lines (56 km), a full-fledged depot at the end of Phase 2B is also proposed. Remodelling of Baiyappanahalli depot will also augment its capacity to cater for the complete operational needs of Phase 2B from either end.
65. A separate traction sub-station (TSS) shall be provided for depots to facilitate isolation of depot traction supply from mainlines in order to prevent the leakage of return currents to depot area. Tracks of depot areas shall also be isolated from main line through insulated rail joints (IRJ). Remote operated disconnection/sectionalizing switches shall be provided to feed power from depot to mainline and vice-versa in case of failure of depot TSS and nearest mainline TSS.

D. Rolling Stock, Traction and Signaling

66. The rolling stock for this metro line is planned as per MOHUA guidelines except with following deviations:
 - Minimum coach width is planned 2880 mm against MOHUA specification of 2900 mm, with axle load of 15 tonnes against MOHUA specification of 16 tonnes.
 - In place of front evacuation, side evacuation has been planned. This is being proposed for the following reasons:
 - a. BMRCL Rolling Stock in Phase 1 and Phase 2 has a minimum coach width of 2880 mm and axle load 15 tonne. Thus, any change in the coach width will lead to change of SOD;
 - b. Fifteen (15) tonne train is more energy efficient in comparison to 16 tonne train;
 - c. With the Phase 1 experience, side evacuation is preferred option from the view of ease of maintenance and operation.
 - Baiyappanahalli depot has been constructed with SOD of Phase 1 and Phase 2. Since this depot will be utilized for maintenance of trains of Phase 2A and 2B corridors, the SOD has to be retained.

E. Ridership on Proposed Metro Corridor

67. Ridership is the number of passenger trips. From the traffic study in the DPR² it is estimated that the daily ridership of this Metro corridor will be 3,38,466 in 2024, when the project is planned to be completed. It is projected to rise to 4,49,990 by 2031 and to 5,82,912 by 2041. Similarly, the Peak Hour Peak Direction Traffic (PHPDT) will be 19,573 by 2024 which is projected to increase to 26,023 by 2031 and to 33,704 by 2041. The ridership on the proposed metro corridor is important to assess the modal

²DPR for Phase 2A of Bangalore Metro, Volume 1 prepared by Bangalore Metro Rail Corporation Ltd. October 2019 (Updated)

shift from individual mode of transportation to public transportation which contributes to the reduction in air pollution and in addition to other social and economic benefits.

68. The travel model generated for Revised Master Plan (RMP) 2031³ has been used for the estimation of ridership for the proposed metro corridor from Silk Board to KR Puram. This metro line has been incorporated in the model. That assessment was complemented by a subsequent study done by Rail India Technical and Economic Service (RITES) in 2016 for demand assessment of metro lines up to year 2041. The total station-wise ridership is tabulated in Table 2-1 below.

Table 2- 1: Station-wise Daily Ridership for Phase 2A

| Sl. No. | Stations | 2024 | 2031 | 2041 |
|---------|---------------------|----------------|----------------|----------------|
| 1 | Central Silk Board | 59,320 | 78,866 | 102,162 |
| 2 | HSR Layout | 12,056 | 16,029 | 20,764 |
| 3 | Agara | 7,423 | 9,868 | 12,784 |
| 4 | Ibbalur | 32,716 | 43,496 | 56,344 |
| 5 | Bellandur | 14,898 | 19,807 | 25,658 |
| 6 | Kadubeesanahalli | 16,865 | 22,422 | 29,045 |
| 7 | Kodibisanahalli | 22,500 | 29,913 | 38,750 |
| 8 | Marathahalli | 40,724 | 54,143 | 70,136 |
| 9 | ISRO | 16,480 | 21,911 | 28,383 |
| 10 | Doddanekundi | 20,207 | 26,866 | 34,801 |
| 11 | DRDO Sports Complex | 14,400 | 19,144 | 24,799 |
| 12 | Saraswathi Nagar | 13,045 | 17,344 | 22,467 |
| 13 | KR Puram | 67,831 | 90,181 | 116,819 |
| | Total | 338,466 | 449,990 | 582,912 |

Source: DPR for Phase 2A of Bengaluru Metro, October 2019

F. Passenger Carrying Capacity

69. In order to maximize the passenger carrying capacity, longitudinal seating arrangement shall be adopted. The whole train shall be vestibuled to distribute the passenger evenly in all the coaches. Criteria for the calculation of standing passengers are 4 persons per square meter of standing floor area in normal state (AW2) and crush load 6 persons standee per sq. meter (AW3) and exceptional dense crush load of 8 persons/sq. meter (AW4).
70. Therefore, for the rail vehicles with 2.88 m maximum width and longitudinal seat arrangement, conceptually the exceptional dense crush capacity (AW4) of 43 seated, 273 standing thus a total of 316 passengers for a driving motor car (DMC), and 50 seated, 293 standing thus a total of 343 for a trailer car (TC) and motor car (MC) is envisaged. The seating and standee capacity of DMC, MC and TC in the unit of “DMC–TC–MC–MC–TC–DMC” with external sliding door are given in Table 2-2 below.

Table 2- 2: Carrying Capacity of Mass Rail Vehicles Crush@6 P/sqm

| | Driving Motor car | | Trailer car / Motor car | | 6 Car Train | |
|----------|-------------------|-------|-------------------------|-------|-------------|-------|
| | Normal | Crush | Normal | Crush | Normal | Crush |
| Seated | 43 | 43 | 50 | 50 | 286 | 286 |
| Standing | 137 | 204 | 147 | 220 | 862 | 1288 |
| Total | 180 | 247 | 197 | 270 | 1148 | 1574 |

Normal (AW2) -4 P/sqm of standee area. Crush (AW3) -6 P/sqm of standee area.

³Revised Master Plan (RMP) for Bengaluru - 2031 (draft) prepared by Bangalore Development Authority. The master plan has been developed before the COVID-19 pandemic and therefore does not consider any operational modifications due to this pandemic. However, under the assumption that COVID-19 is under control by the time of completion of the metro and that it does not lead to permanent changes in carrying capacity of metro carriages the numbers of the master plan can be used for the purpose of this EIA.

G. Power Requirements

71. The proposed metro line requires high level of reliable and good quality of power supply. To ensure this, discussions with the state electricity authority were held and the 220/66 kV input sources from grid sub-stations (GSS) are chosen. Technology for power supply, rolling stock, traction system, CBTC-based signalling system and other system facilities of both Phase 2A and Phase 2B metro lines are planned for seamless extension from Phase 2A to 2B without operational constraints. Standby diesel generator sets shall also be provided to provide power to essential facilities such as lifts, lighting, ventilation, signages, etc., in the event of simultaneous tripping of two receiving subs-stations (RSS) or total grid failure.
72. The proposed power supply scheme detailed in the DPR is expected to ensure minimal interruptions during operations, optimum safety, reliability, and responsiveness to emergency situations. Information on power requirement both for traction and station as detailed in the DPR is given in Table 2-3.

Table 2- 3: Power Requirements for ORR Line between CSB and KR Puram

| Sl. No. | Description | Values | | | Units |
|----------|---|-----------|-----------|-----------|----------------|
| | | Year 2024 | Year 2031 | Year 2041 | |
| A | Traction power requirements | | | | |
| 1 | No of cars per rake | 6 | 6 | 6 | (2DMC+2TC+2MC) |
| 2 | Tare weight of train | 222 | 222 | 222 | T |
| 3 | Passenger weight | 130 | 130 | 130 | T |
| 4 | Total Train weight | 352 | 352 | 352 | T |
| 5 | Length (Route km) | 17.00 | 17.00 | 17.00 | km |
| 6 | Headway (during peak hours) | 5 | 3 | 2.5 | m |
| 7 | Specific Energy Consumption (SEC) | 75 | 75 | 75 | KWH/1000 GTkm |
| 8 | Power demand from one train set | 0.79 | 0.79 | 0.79 | MW |
| 9 | No. of train sets in operation during peak hour | 12 | 20 | 24 | Train sets |
| 10 | Total traction demand | 9.48 | 15.80 | 18.96 | MW |
| 11 | Less Regeneration @20% | 1.90 | 3.16 | 3.79 | MW |
| 12 | Depot traction power requirement | 1.0 | 1.0 | 1.0 | MW |
| 13 | Net traction power requirement | 8.58 | 13.64 | 16.17 | MW |
| 14 | Total traction power requirement (MVA) assuming 5% energy losses and .95 pf for traction loads. | 9.49 | 15.08 | 17.87 | MVA |
| B | Station auxiliary power requirement | | | | |
| 1 | Elevated station load | 0.25 | 0.25 | 0.25 | MW |
| 2 | Property development load | 0.10 | 0.10 | 0.10 | MW |
| 3 | Total elevated station auxiliary load | 0.35 | 0.35 | 0.35 | MW |
| 4 | No. of elevated stations | 13 | 13 | 13 | |
| 5 | Total auxiliary power requirement | 4.55 | 4.55 | 4.55 | MW |
| 6 | Depot auxiliary power requirement | 1.0 | 1.5 | 1.7 | MW |
| 7 | Total auxiliary power requirement | 5.55 | 6.05 | 6.25 | MW |
| 8 | Total auxiliary power requirement (MVA) assuming 5% energy losses and .85 pf for auxiliary loads. | 6.86 | 7.47 | 7.72 | MVA |
| 9 | Total traction & aux power requirement (MW) | 14.13 | 19.69 | 22.42 | MW |

| Sl. No. | Description | Values | | | Units |
|---------|--|-----------|-----------|-----------|-------|
| | | Year 2024 | Year 2031 | Year 2041 | |
| 10 | Total power requirement (MVA) assuming 5% energy losses and .95 & .85 pf for traction & aux loads respectively | 16.34 | 22.55 | 25.59 | MVA |

Source: DPR for Phase 2A of Bengaluru Metro, Annexure 12.1, October 2019

H. Sub Stations

73. Total 6 TSSs are estimated and the precise requirement of TSSs will be determined during detailed engineering stage. The TSS along with Auxiliary Sub-Stations (ASS) will be located at the station building itself at concourse level inside a room. Self-cooled, cast resin dry type rectifier-transformer is proposed, suitable for indoor application. From the traction sub-stations, 750 V DC cables will be laid up to third rail and return current cables will be connected to running rails. Electric Power requirement for this line is likely to be 23.25 MVA approximately in year 2024 and which is likely to increase to 36.69 MVA by the year 2041. All the ASS and TSS of mainline are unmanned and to be Supervisory Control and Data Acquisition (SCADA) compatible, to be integrated with Operations Control Centre (OCC) of Phase 2.

I. Analysis of Alternatives

74. Various alternatives were explored by the BMRCL to arrive at the preferred mode of transport and technical design.

“No Project” Scenario”

75. Travel demand forecasts detailed in the DPR show that all major work zones in the city are congested, with no room for further expansion. Volume to capacity ratio is forecasted to be above 1 for nearly all road network links. This level of congestion is projected to hamper bus operations such that trip frequency will drop even if the number of buses is doubled. Public transport share is also projected to drop from 48% in 2015 to 36% by 2031 in the “do nothing” scenario.
76. Whether public transport system on a corridor in the city should be road-based or rail-based will depend primarily on the traffic density during peak hours on the corridor. Experience has shown that in mixed traffic conditions, comprising slow- and fast-moving traffic prevailing in most of our cities, road buses can optimally carry 8,000 peak hour peak direction traffic (PHPDT). When traffic density on a corridor exceeds 8,000 PHPDT, average speed of buses decreases, journey time and air pollution increase, and inconvenience to commuters is compounded. Thus, when the traffic density during peak hours exceeds this, rail-based mass transport, i.e. metro system should be considered.
77. Moreover, the metro system becomes an inevitable option when the traffic density on a corridor reaches 15,000 PHPDT. The growing economy and inadequate public transport services may cause the public to shift to private modes, as seen in the high vehicle ownership trends in the region. This would not only aggravate the congestion on the streets but also increase the pollution, highlighting the need to plan and provide for a medium capacity metro system in Bengaluru.
78. Traffic and transportation surveys like screen line volume count, turning volume count at junctions, road inventory survey etc., were carried out to assess the traffic and transport characteristic of the study area. The maximum PHPDT on Central Silk Board to K R Puram corridor has been assessed as 19,573 for 2024, 26,023 for 2031 and is likely to increase to 33,709 by 2041. Therefore, road based public transport will not be able to meet the demand.

Advantages of a Metro System

79. Metro systems are superior to other modes of public transport because of their higher carrying capacity, providing faster, smoother, and safer travel, occupying less space, are non-polluting and energy efficient. To summarise, a Metro system:

- Requires 1/5th energy per passenger km compared to road-based system
- Causes no air pollution in the city
- Causes lesser noise level
- Occupies no road space if underground and only about 2 metres width of the road if elevated
- Carries same amount of traffic as 5 lanes of bus traffic or 12 lanes of private motor cars (either way), if it is a light capacity system.
- Is more reliable, comfortable and safer than road-based system
- Reduces journey time by anything between 50% and 75% depending on road conditions.

Types of Metros and their Capacity

80. Rail based mass transport in cities can be categorized as follows:

| Mode | Carrying capacity (passengers/hour) PHPDT |
|--------------------------------|---|
| Light Rail Metro System (LRTS) | Up to 15,000 |
| Medium Capacity Metro System | 15,000-40,000 |
| Heavy Capacity Metro System | 40,000-60,000 |

81. Since the Light metro system accommodates a lower number of commuters, its trains consist of 3 coaches (which can be increased to 6 coaches in the future) and require smaller infrastructure.

82. Trains for medium capacity metro systems generally comprises 3 to 6 coaches with ultimate train headway of about 3 minutes around which related infrastructure, e.g., civil works, stations, passenger-handling equipment etc. are planned.

83. Heavy capacity metro systems have to deal with large traffic densities and have trains that have 6 to 9 coaches. Related infrastructure is also of large size. Beyond the traffic level of 60,000 PHPDT, additional parallel lines are normally planned.

Metrolite

84. MOHUA notified the standard specifications of Light Urban Rail Transit, "Metrolite" in July 2019. Thus, the adoption of this system for this corridor has been specifically examined. Considering the geographical location and the present conditions and future development of the corridor, it was determined that the Metrolite system will not be suitable for the following reasons:

85. Metrolite was recommended by MOHUA primarily as an at-grade system. It has been discussed earlier that an at-grade system is not feasible for this corridor where the road traffic is already past the saturation level. There are several important crossroads leading to major commercial and residential conglomerations. Provision of a dedicated path on this road along this ORR will make these junctions totally unmanageable as these points are already very congested. An at-grade metro corridor will split this highly developed corridor. With no parallel roads along this corridor, it will not be feasible to provide even a single lane on each road.

86. In terms of cost, an elevated Metrolite will not result in significant cost reduction since the savings in civil engineering cost will be offset by the higher cost for rolling stock as it would require higher number of coaches which also have to be imported. The cost of other systems will also be the same to maintain close headway.
87. Metrolite system is to be adopted for passenger PHPDT envisaged from 2000 to 15000. The PHPDT of the Phase 2A corridor is at 19,573, 26,023 and 33,709 in 2024, 2031 and 2041 respectively while on Phase 2B corridor, it is 21,112, 35,705 and 46,252 in 2024, 2031 and 2041 respectively. With a PHPDT range at 2,000 to 15,000, adopting the Metrolite system already poses serious constraints at present and will become more serious impediment in the near future.
88. The corridor from Phase 2A to 2B will cover a total distance of 56km. Metrolite is planned with maximum operation speed of 60KMPH. The maximum operational speed of 60kmph for Metrolite system will restrict the average train speed to about 23 KMPH, increasing travel time and defeating the purpose of the project.
89. Because of the aforementioned reasons, Metrolite is determined to be unsuitable for the corridor as it is grossly inadequate to cater to the traffic demand. Instead, a medium capacity metro system was determined more suitable for the Phase 2A metro line.

Alignment Alternatives

90. The alternative alignments were evaluated considering the principal objective of the Comprehensive Mobility Plan of providing public transportation to the Bengaluru City public, particularly to the IT community congregated all along the Outer Ring Road, Electronic City, white field and Kempegowda International Airport, and addressing traffic congestion issues. Environmental issues such as the air pollution, noise pollution and safety issues along the outer ring road and airport roads were also considered. The existing traffic congestion due to due concentration of IT industries and IT professionals in the region and their dependence on the individual mode of transportation is the major cause of traffic congestion, air pollution, noise pollution, increased fuel consumption, etc. Social concerns such as increased travel time, ease of access to basic amenities, safety issues were also considered in choosing the alignment.
91. Alignment alternatives other than the proposed alignment are not feasible as the construction of both viaduct structures and metro stations requires large area of land. The cost of land in Bengaluru city is high and there is no land available to accommodate the viaduct structures and metro stations unlike the available space along the median and sufficient width of ORR. Another important factor to prove that the proposed alignment is best among any other alternative is the connectivity of ORR in the region.

Analysis of the Corridor Options for Elevated/ Underground or at Grade

92. The ORR from CSB junction and K.R. Puram Station is with 6-lane carriageway and service roads on either side, with a total road width of about 45m throughout. This wide road width makes it ideal for an elevated metro. The width of the median is about 1.5m and construction of the metro piers along it will not impinge on the existing road width. An additional feature of this corridor is that road flyovers are split at the major road intersections at HSR Layout, Agara, Bellandur, Kodibeesanahalli, Kadubeesanahalli, Doddenakundi and Saraswathi Nagar, and two road under bridges (RUB) are available at Marathahalli and Kadubeesanahalli. The split flyovers were planned for the future public transport system on this corridor. The piers of the elevated metro may be provided in the space of about 8m available between the two arms of the split flyover. Even at the underpasses, the metro piers can run at the middle.

93. If the metro were to pass underground, it will have structural implications as it will pass below the flyovers and RUB. Apart from this, underground metro takes longer to construct and entails barricading of wider road width for construction of the underground stations. Moreover, the cost of construction and operation of underground metro is much higher compared to an elevated metro and is preferred only where elevated metro is not feasible.
94. Construction of at-grade Metro on this corridor is ruled out as two lines of metro will occupy about 10m of the road width making the remaining road grossly inadequate for the flow of road traffic on this important ring road. Also, an at-grade metro corridor along the road splits the city into two and a number of underpasses/over bridges will have to be constructed for movement of people and vehicles from one side to the other side of the Metro Corridor.
95. The location of the stations is planned with the following considerations:
- The stations are planned close to the commercial and residential establishments to facilitate the commuters and increase the ridership;
 - The stations are planned close to important crossroads for ease of commuters from these roads to reach the stations. This will also make operation of feeder services more convenient;
 - To reduce the cost of land acquisition and to make it less cumbersome the stations are generally planned in vacant lands and preferably in Government lands wherever possible.
96. Considering all the above aspects, elevated metro with elevated stations is proposed as the most suitable option for this corridor.

III. POLICIES AND THE REGULATORY FRAMEWORK AND ITS APPLICABILITY

A. Constitutional Provisions

97. Article 48, of Directive Principles of the State of the Constitution of India states that “the State shall endeavour to protect and improve the environment and to safeguard forests and wildlife of the country”. Further Article 51-A (g), of fundamental duties, emphasizes that, “It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures”. These two provisions of the constitution form the guiding principles for the environmental legislation in India. The Government of India has laid down various policy guidelines, regulations, acts and legislations pertaining to sustainability and protection of the environment and its various components.

B. The Environment (Protection) Act & Rules, 1986

98. The Environment (Protection) Act, popularly known as EP Act, is an umbrella legislation that supplements existing environmental regulations in India. Empowered by the EP Act, MOEFCC, the Government of India has issued the EIA Notification, 2006 regulating the siting of industry and operations, procuring clearances to establish industries and development of projects with appropriate EIA studies, coastal zone regulations, and other aspects of environment protection. This Act empowers the Government of India (section 6) to formulate rules to regulate environmental pollution by stipulating standards and maximum allowable limits to prevent air, water, noise, soil and other environmental pollutants; prohibits operations that emit pollutants in excess of standards (section 7); regulates handling of hazardous substances and identifies persons responsible for discharges and pollution prevention (section 9); and Section 17 deals with offences committed by Government Departments.

C. Environment Impact Assessment Notification and its applicability to the project:

99. As per the EIA Notification, 2006, by MOEFCC, Environmental Clearance (EC) is required for projects specified in the notification. However, all railways and metro rail projects in India are exempted from requirements of preparing EIA, therefore environmental clearance for the proposed Metro rail project under Phase 2A is not required. Similarly, other metro structures such as metro stations and depots proposed along the metro rail corridor do not attract EIA notification prescribing environmental clearance.

D. Water (Prevention and Control of Pollution) Act, 1974

100. The Water Act is the first environmental regulation that was brought to the state and central levels, with pollution control boards to control / regulate environmental pollution in India. The Act vests regulatory authority on the State Pollution Control Boards and empowers them to establish and enforce, standards for industries and local authorities discharging effluents. This Act provides for the prevention and control of water pollution and maintaining and restoring of wholesomeness of water. This act resulted in the establishment of Central and State level Pollution Control Boards (C/SPCB), whose responsibilities include managing water quality and effluent standards, monitoring water quality, prosecuting offenders and issuing licenses for construction and operation of certain facilities, among others. Under this act, the proposed metro project requires getting consent to establish and operate for batching plants, construction camps, labour camps, etc. from the SPCB. SPCB reviews and accords consent for establishment by stipulating specific and general conditions after accepting the application for the project. The Water (prevention and pollution control) Rules, 1975 prescribes consent form (Form XIII) for consent for establishment/expansion/ diversification and consent for operation of construction establishments of the proposed metro project.

E. Air (Prevention and Control of Pollution) Act, 1981

101. Similar to the Water Act, the Air Act vests regulatory authority on the CPCB and SPCB and empowers them to enforce air quality standards to prevent air pollution in the country. Section 21 of the act requires an application to be made to the state board to establish or operate any industrial operation and project activity. Under the act, its 1987 amendment, and the Air (Prevention and Control of Pollution) Rules of 1982 the project requires getting consent from the SPCB. As in the case of the Water Act, the SPCB reviews and accords consent for establishment by stipulating certain specific and general conditions after accepting the application for the project. This act is applicable as the consent to establish and operate for construction camp, labour camp, crusher, batching plant, etc. are required under this act.

F. Noise Pollution (Regulation and Control) Amendment Rules, 2017

102. Government of India has notified the Rules in exercise of the powers conferred by sub-section (2) of section 3 and section 25 of the Environment (Protection) Act, 1986. The ambient air quality standards in respect of noise for different areas / zones is specified in the Schedule annexed to these rules. The respective State Governments shall categorize the areas into industrial, commercial, residential or silence areas/zones for the purpose of implementation of noise standards for different areas. The State Government shall take measures for abatement of noise and ensure that the existing noise levels do not exceed the ambient air quality standards specified under these rules. While planning developmental activity or carrying out functions relating to town and country planning, all development authorities, local bodies and other concerned authorities shall take into consideration all aspects of noise pollution as a parameter of quality of life to avoid noise and achieve the objective of maintaining the noise standards. An area comprising not less than 100 metres around hospitals, educational institutions and courts may be declared as silence area/zone for the purpose of these rules. The respective State Pollution Control Boards in consultation with the Central Pollution Control Board shall collect, compile, and publish technical and statistical data relating to noise pollution and measures devised for its effective prevention, control and abatement. These rules apply to the metro project as it will generate noise both during construction and operation.

G. The Karnataka Ground Water (Regulation and Control of Development and Management) Act, 2011 and Rules 2012

103. The Karnataka State has enacted Karnataka Ground Water Act, 2011 (Regulation and Control of Development and management) and Rule 2012 to regulate the exploitation of ground water in the state. The state Government has established the Karnataka Groundwater Authority to implement the act and rules in the state. On the advice of the Authority, the Government may, by notification in the Official Gazette, declare any such area to be a notified area. As per the Act and Rules, it is mandatory to apply for permit to dig new borewells in the notified areas. The Authority has notified taluks in 12 districts as 'overly exploited'. These include all the taluks in Bengaluru Urban and Bengaluru Rural districts.

H. Hazardous and other Waste (Management and Transboundary Movement) Rules, 1989 (As amended in 2016)

104. The Government of India has formulated these rules under the Environment (Protection) Act, 1986. Under these rules, the operator or occupier of a facility dealing with hazardous waste is required to ensure that the hazardous waste is safely contained for storage and transportation and the labelling and packaging are visible and able to withstand physical conditions and climatic factors. Packaging, labelling and transport of hazardous wastes shall be in accordance with the provisions of the rules

and other guidelines issued from time to time. These Rules also require that in case of an accident during transportation of hazardous wastes, the operator or occupier of a facility shall immediately report to the State Pollution Control Board in the prescribed form. This statute applies to the metro project as it involves handling, storing and transshipment of hazardous materials such as bitumen for restoration of roads after completion of Metro project works. It also applies to the construction materials resulting in hazardous leachate percolating into ground water, dumping of used water from the RMC plant, and oils and greases from construction sites and labour camps.

I. Petroleum Rules, 2002 (as Amended in the year 2011)

105. The Rules consolidate the law relating to the import, transport, storage, production, refining and blending of petroleum. No one shall import, transport or store any petroleum except in accordance with the rules made under Section 4. Contravention of any of the provisions of any of the rules made there under or rules made under section 4 or 5 is a punishable offence. As per the Rules, transport of petroleum by tank lorry, storage of petroleum class A in barrels up to 300 L, storage of petroleum class B in barrels, storage of petroleum in tanks in installations, and others, require license or approval from licensing or approving authority. These Rules are applicable if the construction contractor transports, stores petroleum in the construction camps to refuel transportation vehicles and construction equipment.

J. Wildlife Protection Act, 1972

106. This Act is promulgated to provide for the protection of wild animals, birds and plants and for matters connected therewith. The act is not applicable to the proposed metro project as the proposed project does not pass through or located adjacent to the wildlife sensitive areas.

K. The Indian Forest Act, 1927

107. This Act prohibits clearing, tree felling, lopping, burning, grazing, quarrying, manufacturing activities, hunting, shooting, etc. in the forest. Violation of provisions of Section 26 specifically with regard to creating fire, felling, girdling, lopping, etc. of trees, quarrying and manufacturing operations or clearing up of any forest land for construction projects are punishable by imprisonment with a fine. This Act is not applicable to the project as the proposed metro corridor is not passing through or located adjacent to the forest land.

L. Forest (Conservation) Act, 1980 (as Amended in 1988)

108. As per Section 26 of the Indian Forest Act, 1927 a number of activities are prohibited in forest areas, and prior approval is required from the Central Government to use /divert forest land for non-forest purposes. The proposed metro corridor is not passing through or located adjacent to forest land.

M. The Karnataka Preservation of Trees Act, 1976

109. The act provides for the preservation of trees in the State by regulating the felling of trees and for planting of adequate number of trees to restore ecological balance and for matters connected therewith. The Act defines a 'tree' as any woody plant whose branches spring from and are supported upon a trunk or body and which trunk or body is not less than five and a half cm in diameter and not less than one meter in height from the ground level and includes palms, bamboos, stumps brushwood, canes and seedlings of such tree but does not include sandal and rosewood trees. The Act also explains the restriction on felling of trees and liability for preservation of trees. Section 8(2) of the Act specifies that "Any person desiring to fell a tree, shall apply in writing to the concerned Tree Officer for permission in that behalf. The application shall be accompanied by a site plan or survey sketch clearly specifying

the site or survey number, the number, kind and girth of tree sought to be cut and the reasons therefore along with the consent of the owner or occupant". The act is applicable to the project as the proposed alignment and proposed stations requires trees to be felled or transplanted.

N. The Ancient Monuments and Archaeological Sites and Remains Act, 1958 (as amended in the year 2010)

110. The archaeological sites, remains, or monuments in the country are protected by ASI (Archaeological Survey of India) or the State Directorate of Archaeology. Under the Act, areas within the radii of 100m and 200m from the protected property are designated as 'Prohibited areas' and 'Regulated areas' respectively. Development activities (including building, mining, excavating, blasting) likely to damage the protected property are not permitted in these areas without prior permission from the National Monument Authority (NMA). There are no notified archaeological sites or monuments in the vicinity of proposed metro corridor. However, this act is applicable if any antiquities are discovered during excavation in the project area.

O. Guidelines for Construction and Demolition Waste Management, 2016

111. In exercise of the powers vested under section 256 of Karnataka Municipal Corporation Act, 1976 (Karnataka Act, 14 of 1977) the public is notified with regard to Collection and Delivery of Municipal Solid Waste (Construction and Demolition Waste) within the Bruhat Bengaluru Mahanagara Palike (BBMP) area. According to these guidelines, no waste of any kind shall be deposited at any time by occupiers on street or beside the streets, pavements, drains, public spaces or vacant sites or any location which will lead to nuisance to the public. No waste of any kind shall be deposited at any time in any low-lying areas other than those notified by BBMP for each zone after KSPCB approval as it would affect movement of surface water, ground water recharge. Violation will result to fines as specified by the competent authority. These guidelines are applicable to metro project as it involves construction and demolition waste generated during construction of project.

P. Karnataka Tank Conservation and Development Authority Act, 2014 and amendment Act, 2018

112. Subsequent to quashing of National Green Tribunal's Order on "No-development Buffer Zone" by the Supreme Court, Karnataka Government has issued Government Order No. UDD 11 BMR 2017, Bangalore dated 20.07.2019 stipulating the 'Buffer Zones' from the water bodies (Lakes and Rajakaluves) for taking up construction activities as below.

- A buffer zone of 30 m from the periphery of water body or Lakes;
- A buffer zone of 30 m from the edge of the primary Rajakaluves (Natural drains);
- A buffer zone of 15 m from the edges of the secondary Rajakaluves and
- A buffer zone of 10 m from the edges of the tertiary Rajakaluves

113. Examining the proposed metro project in this context, it is found that small stretches of the proposed alignment pass within the prescribed buffer zones of lakes. However, the alignment of proposed metro line is on the median of ORR which is an existing major road having comparatively wider right of way (ROW). Further, the metro alignment is restricted mostly within the existing road without infringing into the lakes or Rajakaluves except near Benniganahalli Lake where it passes outside the ROW of the ORR. Clearance from the Lake Development Authority has been obtained (Annexure - 2).

Q. Biological Diversity Act 2002

114. The conservation and sustainable use of biological resources is critical to meet food, fodder, fibre, health, water and other needs of the for the benefit of present and future generations, for which purpose, access to and sharing of both genetic resources and technologies are essential. The GOI has enacted the Biological Diversity Act, 2002 to regulate access to biological resources of the country, ensure equitable share in benefits arising out of the use of biological resources, to conserve and ensure sustainable use of biological diversity, to conserve and develop important areas for biological diversity by declaring them as biological diversity heritage sites, and to protect and rehabilitate of threatened species, to mention a few. In case of persons intending to apply for any form of Intellectual Property Right in or outside India for any invention based on any research or information on a biological resource found in India, prior permission of the National Biodiversity Authority (NBA) constituted under this act is required. This act is not applicable to the proposed metro project.

R. Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996; Central Rules, 1998 and Karnataka Rules 2006

115. The GOI enacted the Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 and the Building and Other Construction Workers' (Regulation of Employment and Conditions of Service) Central Rules, 1998 and Karnataka Rules, 2006 apply to the building or other construction works relating to any establishment and aims to provide for the safety, health, and welfare measures related to workers engaged in building and construction activities across the country. This rule is applicable to the project as substantial labour is required in the construction. As per Section 46 of Chapter IX of the act, an employer shall send the Notice of Commencement, at least thirty days before the start of any building or other construction work to the Inspector having jurisdiction in the area where the proposed building or other construction work is to be executed.

S. The Right to Fair Compensation and Transparency in Land Acquisition and Rehabilitation and Resettlement Act, 2013 (RFCTLARR Act 2013)

116. This is an act which replaces both the Land Acquisition Act 1894 and National Resettlement and Rehabilitation Policy 2007. This is an Act to ensure, in consultation with institutions of local self-government and Gram Sabhas established under the Constitution, a humane, participative, informed and transparent process for land acquisition for development of essential infrastructural facilities, industrialisation and urbanisation with the least disturbance to the owners of the land and other affected families and provide fair compensation to the affected families whose land have been acquired or proposed to be acquired or are affected by such acquisition and make adequate provisions for such affected persons for their rehabilitation and resettlement. Government of Karnataka has issued Rules as provided in Section 109 of RFCTLARR Act 2013 namely "The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement (Karnataka) Rules, 2015". Chapter II of the rules deals with matters pertaining to Social Impact Assessment (SIA) Study including its publication, (Rules.3 to 13); Chapter III deals with the Process of Obtaining the Prior Consent (Rules 16-19); Chapter IV deals with the Preliminary Notification For Acquisition (Rule 20); Chapter V deals with the Rehabilitation and Resettlement Scheme and matters relating thereto (Rules 21- 38), and Rule 40 empowers the government for removal of difficulties, either in the interpretation of the provisions of the Rules and implementation of the provisions. This act is applicable for the proposed project as it involves land acquisition and demolition of properties thus affecting families and industries adjacent to proposed alignment.

T. Karnataka Industrial Area Development Board (KIADB) Act

117. The project will adopt the KIADB Act for implementation. Salient Features of the Section 28 of KIADB Act include the notification process for land acquisition, determination of appropriate compensation and payment of such compensation for people whose land and/or properties will have to be acquired by the KIADB.

U. Other applicable statutory requirements

118. Other statutory requirements applicable for the project include Public Liability Insurance Act, 1991, The Motor Vehicles Act, 1988, Minimum Wages Act, 1948; Contract Labour Act, 1970; Child Labour (Prohibition and Regulation) Act 1996 along with Rules, 1988; etc.

V. ADB's Safeguard Policy Statement and its applicability to the project:

119. The Asian Development Bank (ADB) has defined its Safeguard requirements under its Safeguard Policy Statement 2009 (SPS 2009). The prime objectives of safeguard policy are to: (i) avoid adverse impacts of projects on the environment and affected people, where possible; and (ii) minimize, mitigate, and/or compensate for adverse project impacts on the environment and affected people when avoidance is not possible. ADB uses a classification system to reflect the significance of a project's potential environmental impacts. Project's category is determined by the category of its most environmental sensitive component, including direct, indirect, cumulative and induced impacts in the project's area of influence. Projects are scrutinised as to its type, location, scale, sensitivity and the magnitude of its potential environmental impacts. This policy requires assessment, mitigation and commitment towards environmental protection. The extent of assessment depends on the category of the project. ADB's SPS 2009 classifies an infrastructure investment project depending on following three categories:

Category A: A proposed project is classified as category A if it is likely to have significant adverse environmental impacts that are irreversible, diverse, or unprecedented. These impacts may affect an area larger than the sites or facilities subject to physical works. An environmental impact assessment is required.

Category B: A proposed project is classified as category B if its potential adverse environmental impacts are less adverse than those of category A projects. These impacts are site-specific, none or very few of them are irreversible, and in most cases mitigation measures can be designed more readily than for category A projects. An initial environmental examination is required.

Category C: A proposed project is classified as category C if it is likely to have minimal or no adverse environmental impacts. No environmental assessment is required although environmental implications need to be reviewed.

120. **Applied Standards.** During the design, construction and operation the project will apply pollution prevention and control technologies and practises consistent with 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. Applicable standards are summarized in Annex 4.

W. Clearances required for the Metro project

121. After reviewing various applicable acts and statutes mentioned above, it is understood that following clearances or permissions are required. A summary of clearances required for the project is shown in table 3-2.

Table 3- 1: List of Clearances Required for the Project

| Sl. No. | Subject | Relevant Act | Authority Granting Clearance/ In charge | When required | Responsibility | Remarks |
|---------|---|---|---|---------------------|---------------------|---|
| 1 | Permission for cutting of trees and transportation | Karnataka Preservation of Trees Act, 1976 | State Forest Department | Before Construction | BMRCL | Exact number and location of trees are to be submitted |
| 2 | Elevated Metro Corridor Crossing Indian railway lines | | SWR, Indian Railways | Before Construction | BMRCL | |
| 3 | No Objection Certificate (NOC) for Construction camp, Labor camp, Crushers, Batching Plants, Wet Mix Macadam plants, Hot mix plants | Air (Prevention and Control of Pollution) Act, 1981; Water (Prevention and control of Pollution) Act, 1974 and Noise Pollution (Regulation and Control) Rules, 2000 | KSPCB, Karnataka | Before Construction | Contractor/Supplier | Appropriate forms, (Form I & Form XIII) with requisite fees, to be completed |
| 4 | Employing Labour/ Workers | The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996; Central Rules, 1998 and Karnataka Rules, 2006 | District Labor Commissioner | Before Construction | Contractor | |
| 5 | Rehabilitation & Resettlement of Displaced families | KIADB Act with compensation at par with RFCTLARRA 2013. | GoK | Before Construction | BMRCL | The project will adopt the KIADB Act for acquisition and compensation will be paid at par with RFCTLARRA 2013 |
| 6 | Permission for withdrawal of groundwater for construction | Environment (Protection) Act, 1986 | Central Ground Water Board | Before Construction | Contractor | |
| 7 | Installation of Generators | Air (Prevention and Control of Pollution) Act, 1974 Noise Pollution (Regulation and Control) Amendment Rules, 2017 | KSPCB | Before Installation | Contractor | |
| 8 | Storage, handling and transport of hazardous materials | Hazardous and other Waste (Management and Transboundary Movement) Rules, 1989 (as amended in the year 2016) formulated under | KSPCB, Karnataka | During Construction | Contractor | If bituminous is used for rehabilitation of roads or any other hazardous wastes |

Environmental Impact Assessment Study for Central Silk Board to KR Puram Section of BMRCL

| Sl. No. | Subject | Relevant Act | Authority Granting Clearance/ In charge | When required | Responsibility | Remarks |
|---------|---|---|---|---------------------|----------------|--|
| | | Environment (Protection) Act, 1986 | | | | |
| 9 | Traffic Management and Regulation during operation | Local Traffic Police instructions/Regulations | Bengaluru Traffic Police, | During Construction | Contractor | Prior permission from Bengaluru Traffic Police |
| 10 | License for storing Diesel/Fuel | Petroleum Rules, 2002 (as amended in the year 2011) of the Petroleum Act, 1934. | Commissioner of Explosives | During Construction | Contractor | |
| 11 | Location/ layout of workers camp, equipment and storage yards | Environment Protection Act, 1986 The Building and Other Constructions Workers' (Regulation of employment & Conditions of Service) Act, 1996. | KSPCB, District Health Officer | During Construction | Contractor | |
| 12 | Disposal of Construction and Demolition wastes | Karnataka Municipal Corporation Act 1976 (Karnataka Act, 14 of 1977) | Bruhat Bengaluru Mahanagara Palike (BBMP) | During Construction | Contractor | By the contractor approved by BBMP |

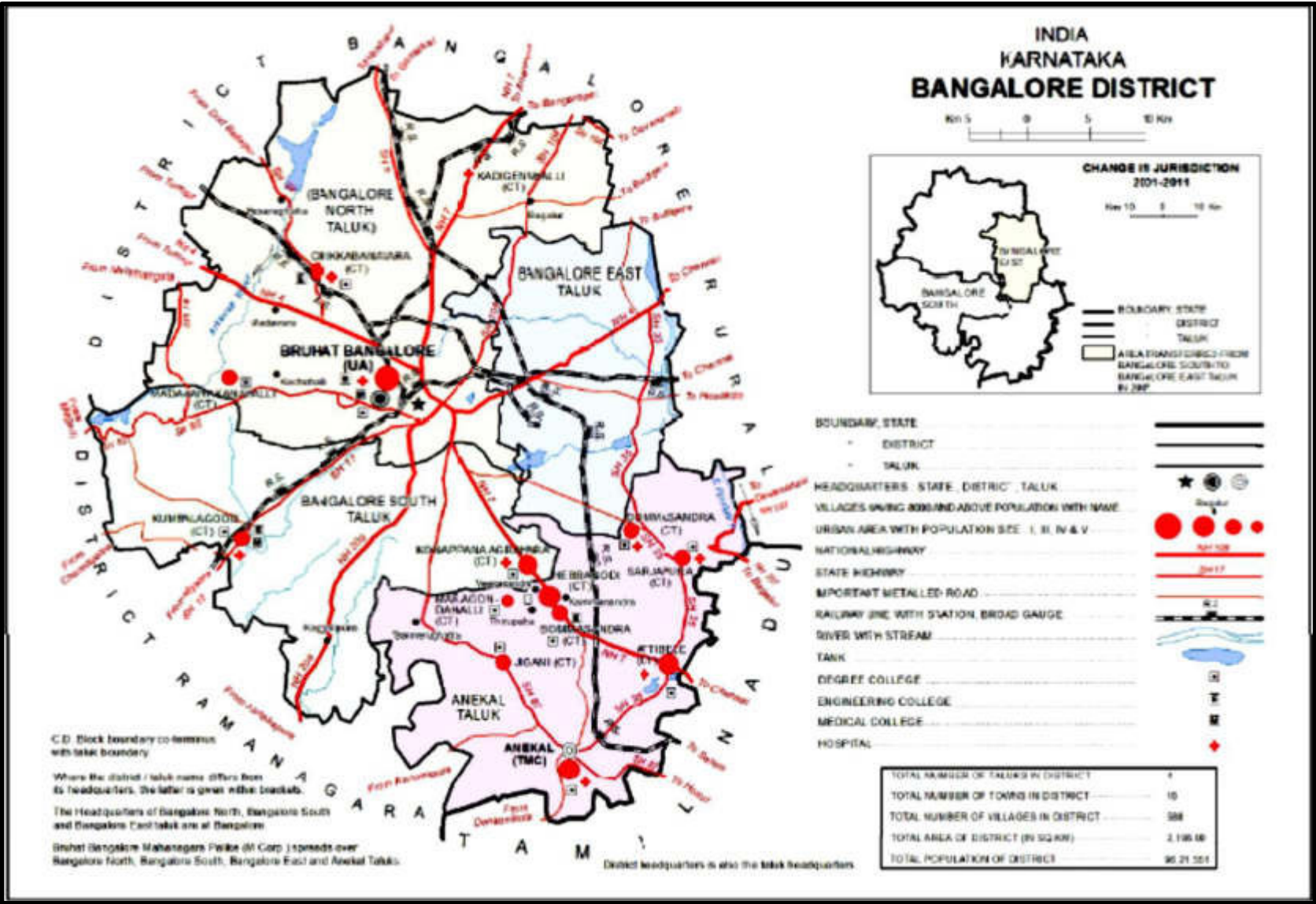
IV. DESCRIPTION OF ENVIRONMENT

122. Assessment of the impacts of the proposed ORR metro project through actual site visits, review of secondary data and information on the environment including biophysical attributes and other relevant aspects, and obtaining baseline data on the environmental condition of the study area with respect to physical and biological environment along the proposed alignment. Discussion on the environmental attributes considers the proposed alignment of ORR metro project located within the limits of Bengaluru city and broadly within Bengaluru Urban District.

A. Location

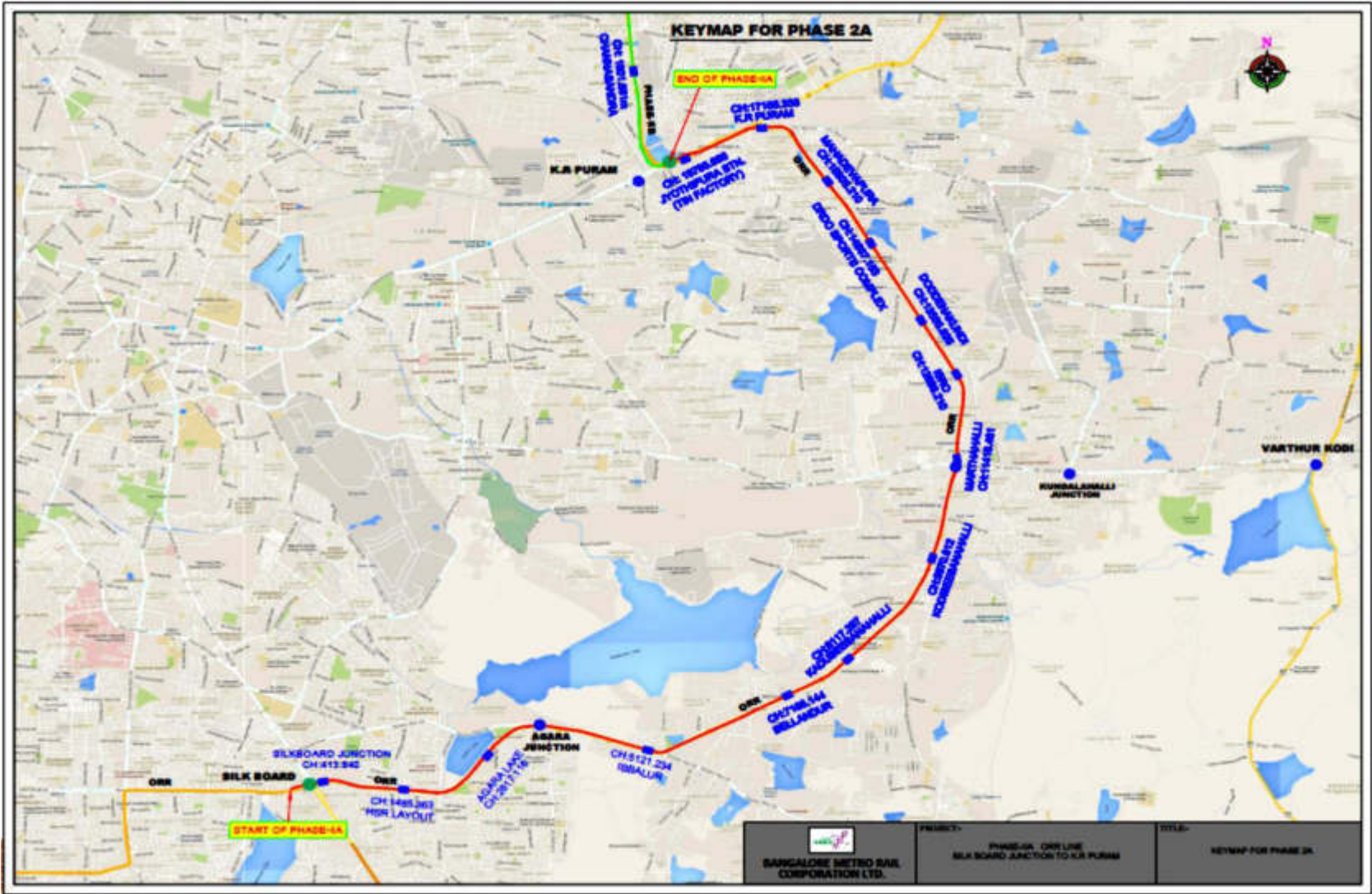
123. The proposed Phase 2A project starts from Central Silk Board to KR Puram and follows the median of Outer Ring Road. The complete alignment is located within the limits of Bengaluru Urban district.
124. Bengaluru Urban District is located in the south eastern portion of Karnataka State with geographical area of nearly 2190 sq. km. It is bounded by Bengaluru Rural District on the south-western, western, northern and north-eastern sides and bordered by Tamil Nadu State on the south-eastern direction. The district lies between 12° 39' to 13° 14' N Latitude and 77° 19' to 77° 51' E Longitude. Greater Bengaluru is a metropolitan area consisting of the metropolis of Bengaluru and its neighbouring regions. In January 2007, the Karnataka Government issued a Notification to merge 100 wards of the erstwhile Bengaluru Mahanagara Palike with seven City Municipal Councils (CMC), one Town Municipal Council (TMC) and 111 villages around the city to form a single administrative area. The administrative map of Bengaluru Urban District is presented in Figure 4-1. Figure 4-2 illustrates the proposed ORR metro alignment along the ORR.

Figure 4- 1: Administrative map of Bengaluru Urban District



Source: District Census Handbook, Bengaluru, 2011

Figure 4- 2: Proposed Phase 2A Metro line and Metro Stations



Note: Mahadevapura Station to be read as Saraswathi Nagar station

B. Physiography

125. Bengaluru Urban District lies on top of south Karnataka Plateau (Mysore Plateau) and has two types of unique topographies. The district is physiographically divided into rocky upland, plateau and flat-topped hills and a general elevation of about 900 m above mean sea level (AMSL) with its major part sloping towards south and south-east forming Pedi-plains interspersed with hills all along the western part. The Pedi-plains form the major part of the district underlain by granites and gneisses with the highest elevation of 839 to 962 m. AMSL. Major part of the Pedi-plain constitute low relief area having matured dissected rolling topography with erosional land slope covered by a layer of red loamy soil of varied thickness. Major part of the Pedi-plain is dissected by streamlets flowing in southern direction. The North Bengaluru Taluk is a relatively more level plateau and lies between 839 and 962 m AMSL. Prominent ridge runs in the middle of taluk in NNE-SSW direction and lies east of the Vrishabhavathi River. The highest point in the Taluk, Doddabettahalli, (962 m AMSL) is on this ridge. There are gentle slopes and valleys on either side of this ridge. The low-lying area is marked by a series of water tanks varying in size from a small pond to those of considerable extent, but all fairly shallow. The South Bengaluru taluk has an uneven landscape with a combination of hills and valleys. The southern and western portions of the city consist of granite and gneissic masses. The eastern portion of the district is a plane, with intermittent minor undulations.

C. Climate

126. Bengaluru has a tropical savanna climate (Koppen climate classification Aw) with distinct wet and dry seasons. Because of its elevation, Bengaluru, enjoys a pleasant and equable climate throughout the year.
127. **Rainfall:** Bengaluru receives about 970 mm of rain annually, the wettest months being August, September and October. The heaviest rainfall recorded in a 24-hour period was 159.7mm recorded on 1October1997.November 2015 (290.4mm) was recorded as one of the wettest months in Bengaluru with heavy rains causing severe flooding in some areas. Month-wise rainfall and annual total rainfall data for Bengaluru urban district is given in the Table 4-1.
128. **Humidity:** The average annual relative humidity in Bengaluru is 65.2% and average monthly relative humidity ranges from 45% in March to 79% in August. On an average, July is the most humid and January is the least humid month.
129. **Temperature:** The coolest month in Bengaluru is January with an average low temperature of 15.1 °C and the hottest month is April with an average high temperature of 35 °C. The highest temperature ever recorded in Bengaluru is 39.2 °C as there was a strong El Niño in 2016. The lowest ever recorded is 7.8 °C in January 1884. Winter temperatures rarely drop below 14 °C and summer temperatures seldom exceed 36 °C. Month-wise annual average temperature data for Bengaluru urban district is given in the Table 4-2.
130. **Wind:** Wind roses for Bengaluru are given in Figure 4.3. These month-wise wind-rose plots indicate the dominant wind directions and the direction of strongest wind speeds. The highest average wind speed of 14.1 mph was recorded in the month of July and the lowest average wind speed of 6.2 was recorded in the month of January. Highest calm condition prevailed in the month of February and lowest calm condition prevailed in the moths of June and July. Easterly winds are predominant during the months from November to March. Westerly winds are predominant starting from May to September. April and October months show the easterly and westerly winds.

Table 4- 1: Average month wise and annual rainfall in mm for Bengaluru urban district in years 1985-2010

| Rainfall (mm) | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|----------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|---------------|
| Minimum | 0 | 0 | 0 | 10 | 72 | 32 | 30 | 40 | 32 | 16 | 12 | 0 | 603 |
| Average | 2 | 2 | 14 | 54 | 130 | 100 | 104 | 117 | 145 | 181 | 53 | 15 | 919 |
| Maximum | 17 | 12 | 115 | 105 | 226 | 206 | 215 | 257 | 335 | 446 | 180 | 73 | 1351 |

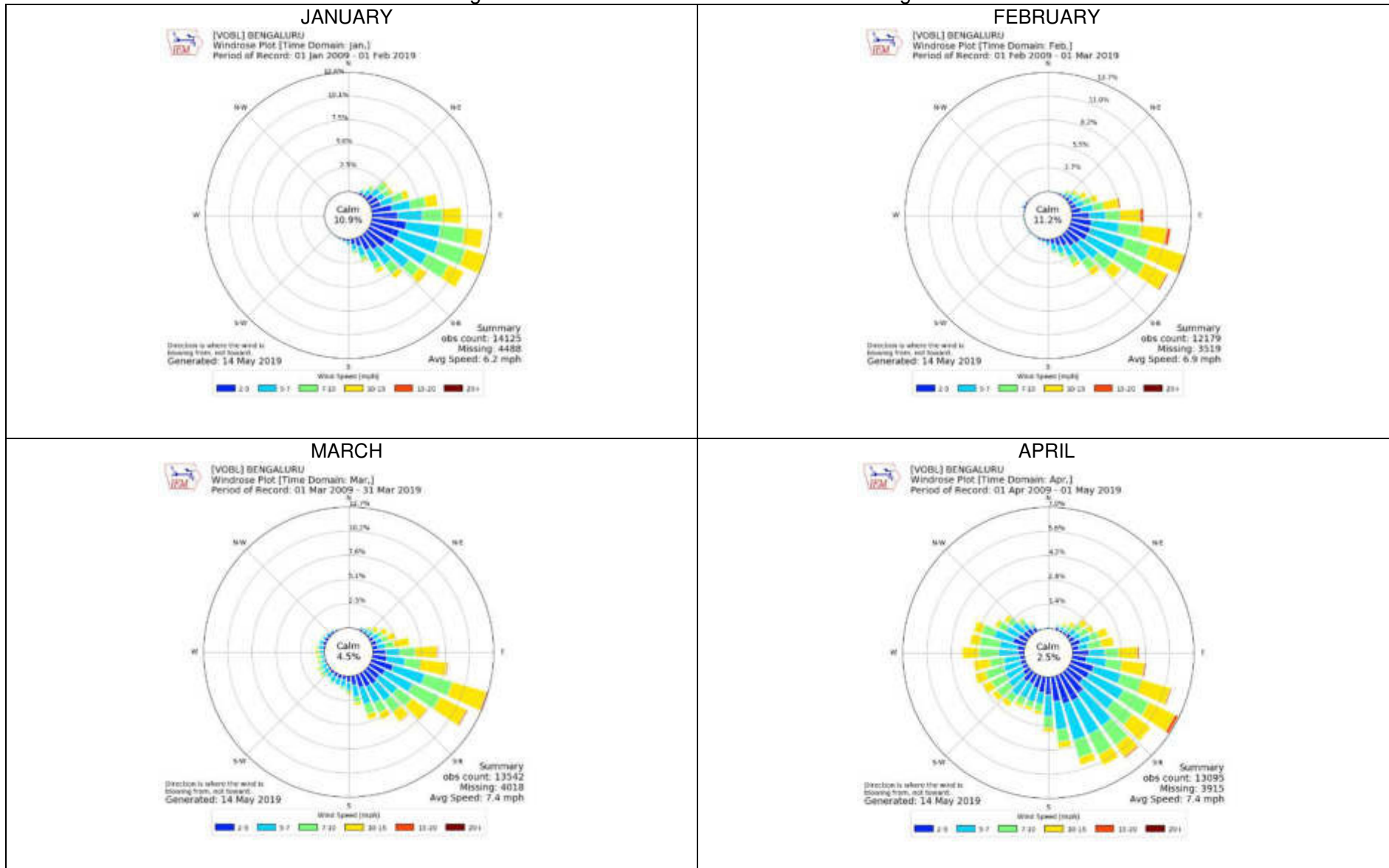
Source: http://www.indiawaterportal.org/met_data/

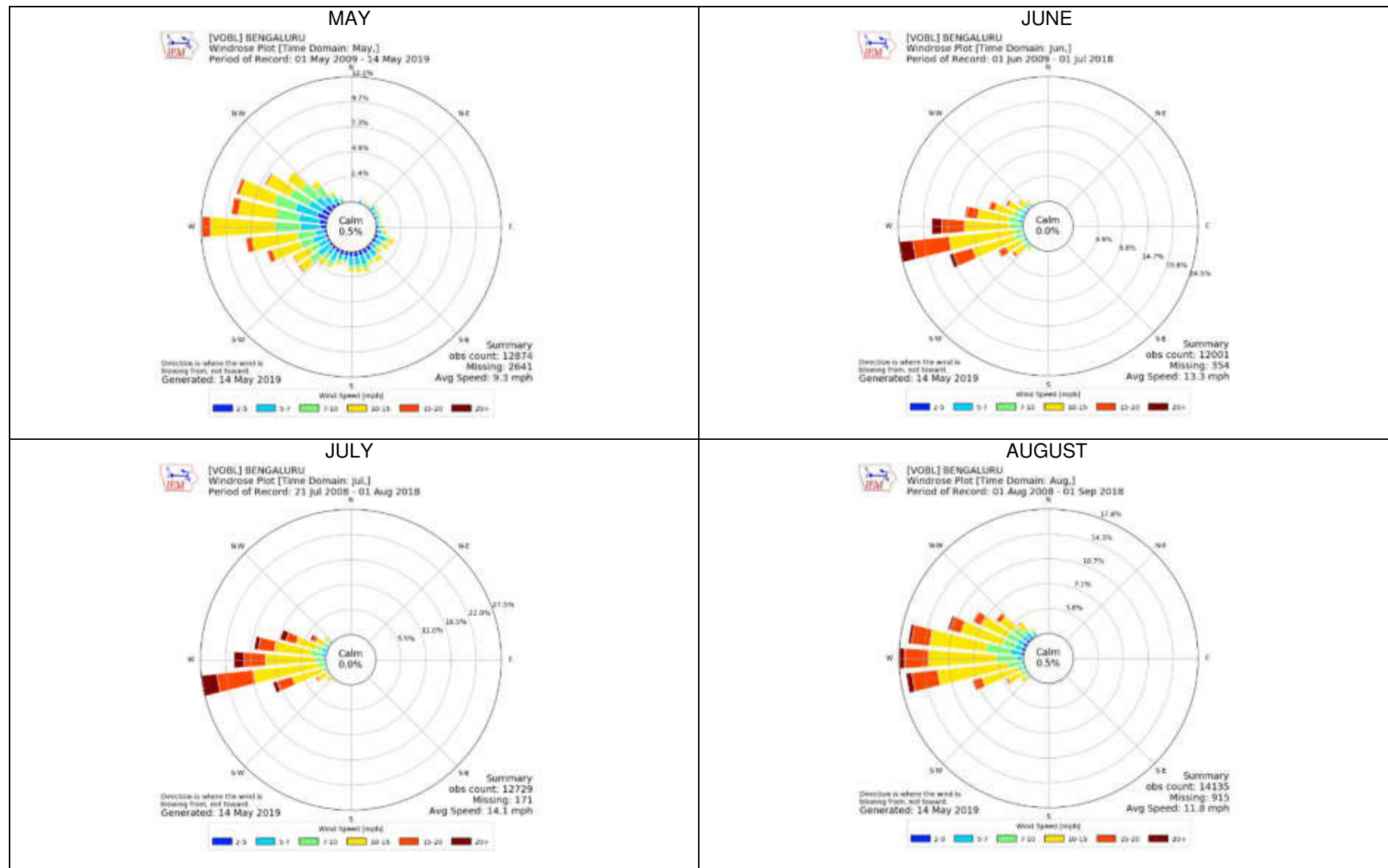
Table 4- 2: Month wise and annual average temperature for Bengaluru urban district in years 1885-2002

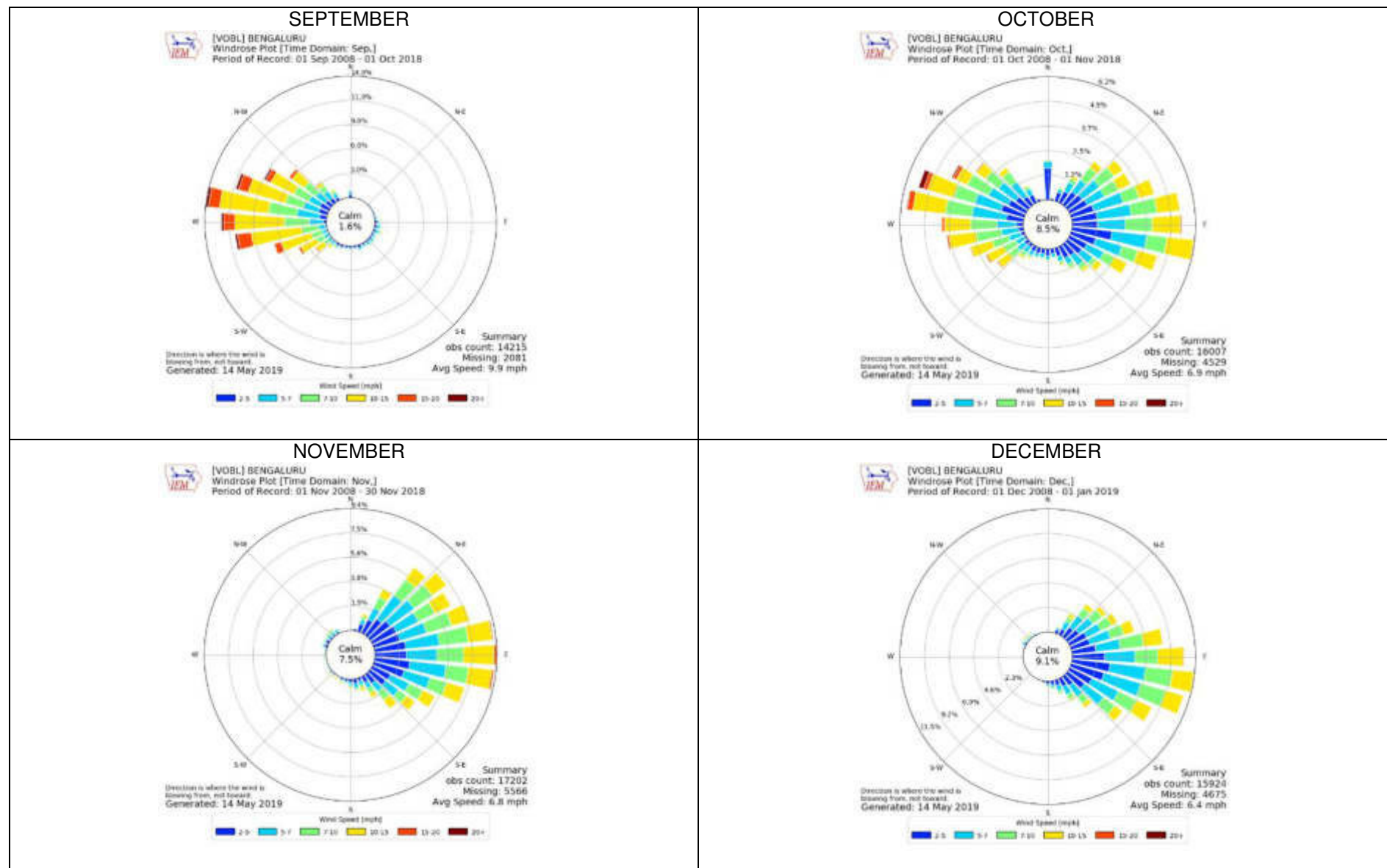
| Temperature (° Celsius) | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|--------------------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|---------------|
| Minimum | 21.4 | 23.5 | 26.0 | 26.9 | 25.8 | 24.3 | 23.6 | 23.6 | 24.1 | 23.9 | 22.5 | 21.3 | 24.6 |
| Average | 22.7 | 24.7 | 27.0 | 28.1 | 27.3 | 25.1 | 24.3 | 24.3 | 24.9 | 24.5 | 23.5 | 22.2 | 24.9 |
| Maximum | 23.5 | 26.1 | 27.9 | 28.9 | 28.3 | 26.4 | 25.2 | 24.8 | 25.9 | 25.1 | 24.5 | 23.1 | 25.4 |

Source: http://www.indiawaterportal.org/met_data/

Figure 4- 3: Monthwise Windrose Plots for Bengaluru







Source: http://mesonet.agron.iastate.edu/sites/windrose.phtml?station=VOBL&network=IN__ASOS

D. Ambient Air Quality

131. The ambient air quality in Bengaluru city is rapidly deteriorating over the recent years towards an alarming level. The city suffers significantly with dust and air pollution issues. Increase in vehicular traffic, growing number of industries, and construction of infrastructure projects are some of the major sources of rising air pollution in Bengaluru. KSPCB has set up thirteen ambient air quality monitoring stations within Bengaluru city. These manual monitoring stations are now being replaced by continuous ambient air quality monitoring stations (CAAQMS) by which real-time data can be measured every 15 minutes. The monitored ambient air quality in Bengaluru city from January to December 2019 is presented in the table 4-3 below. The ambient air quality monitored by State Pollution Control Board at 13 different locations in and around Bengaluru city shows the monthly average of daily measurements for each of the pollutants such as PM₁₀, PM_{2.5}, NO₂, NH₃. The general trend of monitored results shows that the values for pre-monsoon season are higher compared to monsoon and post monsoon.

Table 4- 3.: Status of Ambient Air Quality in Bengaluru from January to December 2019

| No | Monitoring station | Yearly average values (µg/m ³) | | | | | Air Quality Index Value | Cat. |
|----|--|--|-------------------|-----------------|-----------------|-----------------|-------------------------|------|
| | | PM ₁₀ | PM _{2.5} | SO ₂ | NO ₂ | NH ₃ | | |
| | | 20 | 10 | - | 40 | - | | |
| | WBG 1-year guideline values (µg/m³) | | | | | | | |
| 1 | Export Promotion Industrial Park, ITPL, White Field Road | 92 | 33 | 2 | 27 | 25 | 91 | S |
| 2 | AMCO Batteries, Mysore Road | 90 | 36 | 2 | 29 | 26 | 90 | S |
| 3 | Rail Wheel Factory, Yelahanka | 92 | 29 | 2 | 26 | 25 | 89 | S |
| 4 | Swan Silk Pvt. Ltd., Peenya Industrial Area | 98 | 37 | 2 | 30 | 25 | 94 | S |
| 5 | Victoria Hospital, K.R. Market | 55 | 23 | 2 | 26 | 24 | 57 | S |
| 6 | Yeswanthapura Police Station, Yeswanthapura | 81 | 35 | 2 | 29 | 25 | 80 | S |
| 7 | TERRI Office Premises, Domlur | 86 | 31 | 2 | 28 | 25 | 85 | S |
| 8 | Central Silk Board, Hosur Road | 106 | 41 | 2 | 28 | 24 | 101 | M |
| 9 | Mr. Madhachari's house, Kazissonnenihalli | 83 | 30 | 2 | 26 | 23 | 83 | S |
| 10 | Urban Eco Park, KSPCB Office Premises, Peenya | 95 | 36 | 2 | 25 | 24 | 93 | S |
| 11 | Indira Gandhi Children Health Care Centre | 59 | 24 | 2 | 26 | 23 | 59 | S |
| 12 | Banasawadi Police Station, Banasawadi | 74 | - | 2 | 21 | 21 | 73 | S |
| 13 | S.K.R Silver Jubilee Building, K. R. Circle. | 66 | 20 | 2 | 24 | 22 | 65 | S |

| Sl. No. | Range | Category | Associated Health Impacts |
|---------|---------|------------------|--|
| 1 | 0-50 | G – Good | Minimal impact |
| 2 | 51-100 | S – Satisfactory | May cause minor breathing discomfort to sensitive people |
| 3 | 101-200 | M – Moderate | May cause breathing discomfort to people with lung disease such as asthma, and discomfort to people with heart disease, children and older adults |
| 4 | 201-300 | P – Poor | May cause breathing discomfort to people on prolonged exposure, and discomfort to people with heart disease |
| 5 | 301-400 | V - Very Poor | May cause respiratory illness to the people on prolonged exposure. Effect may be more pronounced in people with lung and heart diseases |
| 6 | > 401 | Se – Severe | May cause respiratory impact even on healthy people, and serious health impacts on people with lung/heart disease. The health impacts may be experienced even during light physical activity |

Source:http://kspcb.gov.in/ambient_air_quality.html

132. Air quality monitoring by KSPCB using continuous ambient air quality monitoring (CAAQM) cannot be compared with that of monitored baseline values for air quality near to the proposed construction of metro project as the monitored values vary by location, sample numbers, frequency (monthly average), season of monitoring and it is difficult draw logical conclusion on the results.

133. Baseline data on ambient air quality along the project alignment was collected from 7 representative air pollution sensitive locations in the month of November 2019. The monitoring locations were selected based on the potential sensitive receptors, predominant wind direction and topography of the study area. Other factors considered in the selection of monitoring stations include representative nature of the sample, accessibility, and availability of power. Noise levels were also monitored at these locations along the project alignment. The air quality monitored at 7 locations along the study area was assessed and compared to check its compliance with the National Ambient Air Quality Standards (NAAQS) specified by Central Pollution Control Board (CPCB) and presented in Table 4-5. The monitored values of air quality should also comply with WBG Standards. The details of ambient air quality monitoring stations and their land use category are given in Table 4-4. The monitoring locations are shown in Figure 4-4.

Table 4- 4.: Details of Ambient Air Monitoring Stations

| Sample Code | Ambient Air Sampling Locations | Land use Category |
|-------------|--|-----------------------|
| AAQ-1 | Near JSS public School, HSR layout, Outer Ring Road, Bengaluru | Schools & Hospitals |
| AAQ-2 | Near Akme Harmony Apartments, Bellandur, Outer Ring Road, Bengaluru | Mixed use |
| AAQ-3 | Near New Horizon College of Engineering, Kaadabeesanahalli, Outer Ring Road, Bengaluru | Group of Colleges |
| AAQ-4 | Near VIMS Hospital, Marathahalli, Outer Ring Road, Bengaluru | Hospital & School |
| AAQ-5 | Near ISRO, Sanjaynagar, Marathahalli, Outer Ring Road (Near proposed ISRO Metro Station) | Residential |
| AAQ-6 | Near Bhagmane Tech Park, Mahadevapura, Outer Ring Road, Bengaluru | Public and Commercial |
| AAQ-7 | Near Lowry Memorial Educational Institutions, Chinappa Colony, Mahadevapura Outer Ring Road, Bengaluru | Schools & Colleges |

134. The sampling and analysis of ambient air quality parameters was carried out as per the procedures detailed in IS-5182 (Indian Standards for Ambient Air Quality Parameters). The applied testing procedures are given in brief in table 4-5.

Table 4- 5: National Ambient Air Quality Standards (NAAQS)

| Parameter | Method/ Protocol Followed | Analysis Procedure |
|-------------------|---------------------------------|---|
| PM ₁₀ | IS-5182 (Pt-23) | - Sample collection for PM-10 with fine dust sampler NPM-FDS 2.5A without PM-2.5 inlet. |
| PM _{2.5} | IS-5182 (Pt-23) | - Sample collection for PM-2.5 with fine dust sampler NPM-FDS 2.5A with impactor. - Analysis by gravimetric method. |
| SO ₂ | IS:5182 (Pt.-2) | - Sample collection in multi-gas sampler, absorption in Potassium tetrachloro-mercurate solution. - The absorbance of the intensely colored para-rosaniline methyl sulphonic acid was measured and the amount of SO ₂ in the sample was computed. |
| NO _x | IS:5182 (Pt.-6) | - Sample collection carried out through orifice-tipped Impinger containing solutions of sodium hydroxide and sodium arsenite. - The ambient NO _x concentrations were computed from the total nitrite ion present in the impingers, overall efficiency of the Impinger and the procedure, and the volume of air sampled. |
| CO | IS:5182 (Pt.10) | - Collection of air in rubber bladder and aspirator. - Analysis by electrochemical sensor |
| Pb | IS:12074 (Pt.10) | - Analysis of Lead by Atomic Absorption Spectrophotometer |

Figure 4- 4: Air and Noise Sampling Locations



Table 4- 6:. Ambient Air Quality along proposed ORR Metro Line

| Parameters | Sample | AAQ1 | AAQ2 | AAQ3 | AAQ4 | AAQ5 | AAQ6 | AAQ7 |
|--|-----------|-------|--------|-------|--------|-------|--------|--------|
| PM10 24 Hourly (in $\mu\text{g}/\text{m}^3$) | NAAQS | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | WBG | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| | Sample I | 83.6 | 57.2 | 66.3 | 64.6 | 93.6 | 82.6 | 77.1 |
| | Sample II | 85.1 | 65.5 | 71.1 | 82.4 | 94.5 | 93.1 | 75.8 |
| | Average | 84.35 | 61.35 | 68.7 | 73.5 | 94.05 | 87.58 | 76.45 |
| PM 2.5 24 Hourly (in $\mu\text{g}/\text{m}^3$) | NAAQS | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| | WBG | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| | Sample I | 28.8 | 17.8 | 24.2 | 25.1 | 35.4 | 30.3 | 28.6 |
| | Sample II | 23.2 | 21.2 | 27.3 | 24.2 | 30.08 | 37.5 | 22.4 |
| | Average | 26 | 19.5 | 25.75 | 24.65 | 33.1 | 33.9 | 25.5 |
| SO ₂ 24 Hourly (in $\mu\text{g}/\text{m}^3$) | NAAQS | 80 | 80 | 80 | 80 | 80 | 80 | 80 |
| | WBG | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| | Sample I | 9.30 | 10.34 | 9.56 | 7.28 | 8.21 | 12.06 | 9.41 |
| | Sample II | 10.18 | 8.36 | 8.81 | 9.07 | 11.09 | 10.54 | 8.56 |
| | Average | 9.74 | 9.35 | 9.185 | 8.175 | 9.65 | 11.3 | 8.985 |
| NO _x 24 Hourly (in $\mu\text{g}/\text{m}^3$) | NAAQS | 80 | 80 | 80 | 80 | 80 | 80 | 80 |
| | WBG | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| | Sample I | 24.79 | 31.13 | 27.66 | 30.91 | 24.77 | 31.02 | 29.92 |
| | Sample II | 26.93 | 25.50 | 24.08 | 26.38 | 28.03 | 27.70 | 25.06 |
| | Average | 25.86 | 28.315 | 25.87 | 28.645 | 26.4 | 29.36 | 27.49 |
| CO 8 Hourly (in mg/m^3) | NAAQS | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| | WBG | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| | Sample I | 0.82 | 0.67 | 0.99 | 0.85 | 0.90 | 0.93 | 0.76 |
| | Sample II | 1.02 | 0.71 | 0.86 | 1.19 | 1.42 | 1.24 | 0.88 |
| | Average | 0.92 | 0.69 | 0.925 | 1.02 | 1.16 | 1.085 | 0.82 |
| Pb, $\mu\text{g}/\text{m}^3$ | NAAQS | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | WBG | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| | Sample I | 0.109 | 0.028 | 0.033 | 0.088 | 0.076 | 0.115 | 0.540 |
| | Sample II | 0.035 | 0.114 | 0.099 | 0.160 | 0.116 | 0.078 | 0.099 |
| | Average | 0.072 | 0.071 | 0.066 | 0.124 | 0.096 | 0.0965 | 0.3195 |

NAAQS: National Ambient Air Quality Standards

WBG: World Bank Group EHS Guidelines

Figure 4- 5: Graphical Representation of Monitored Values of PM10

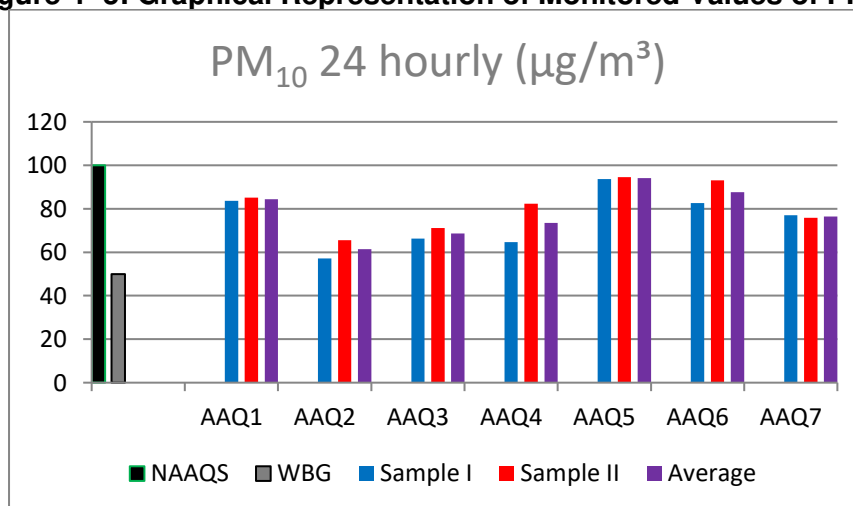


Figure 4- 6: Graphical Representation of Monitored Values of PM2.5

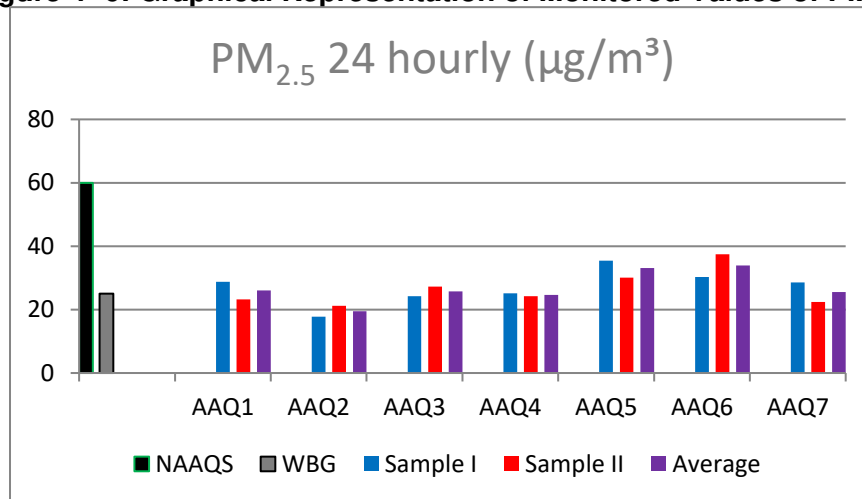


Figure 4- 7: Graphical Representation of Monitored Values of SO2

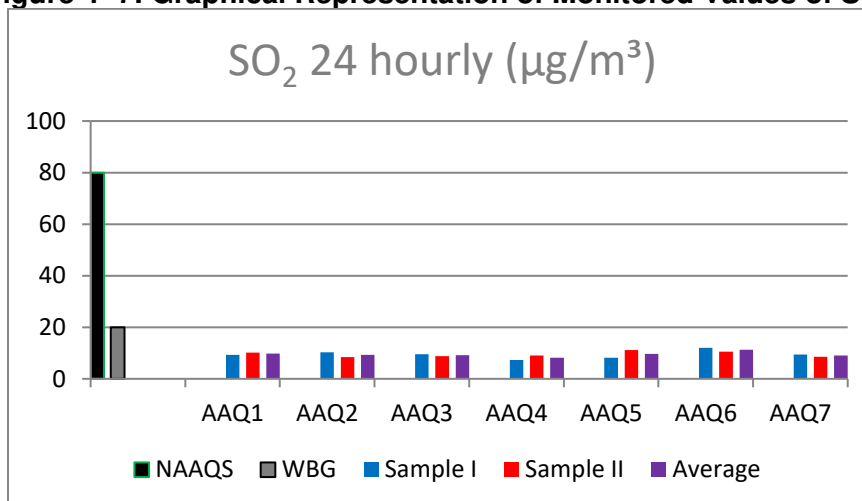


Figure 4- 8: Graphical Representation of Monitored Values of NOx

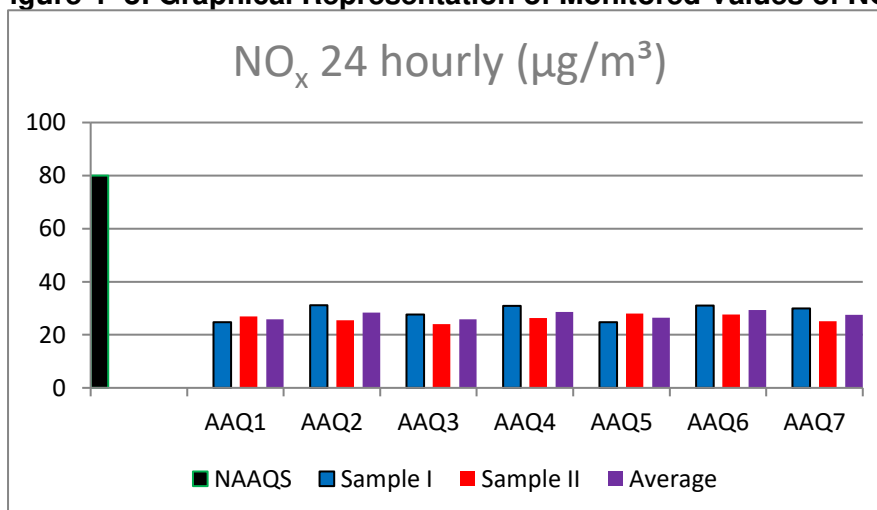


Figure 4- 9: Graphical Representation of Monitored Values of CO

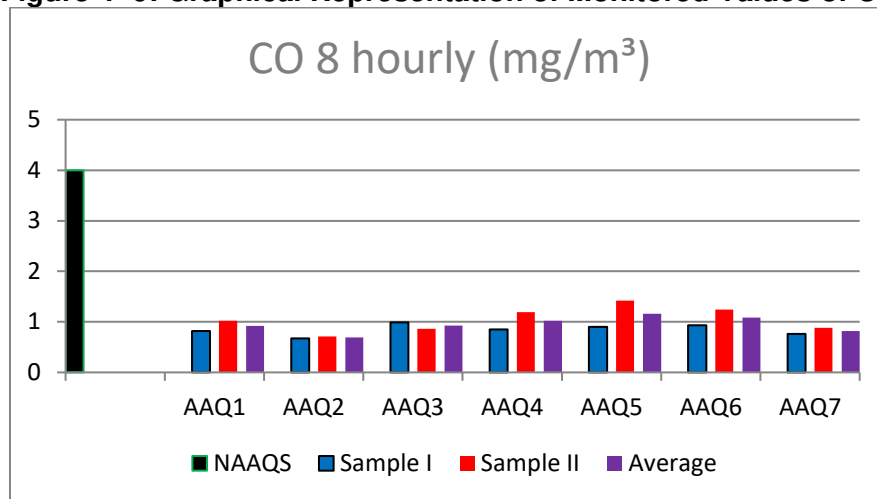


Figure 4- 10: Graphical Representation of Monitored Values of Pb

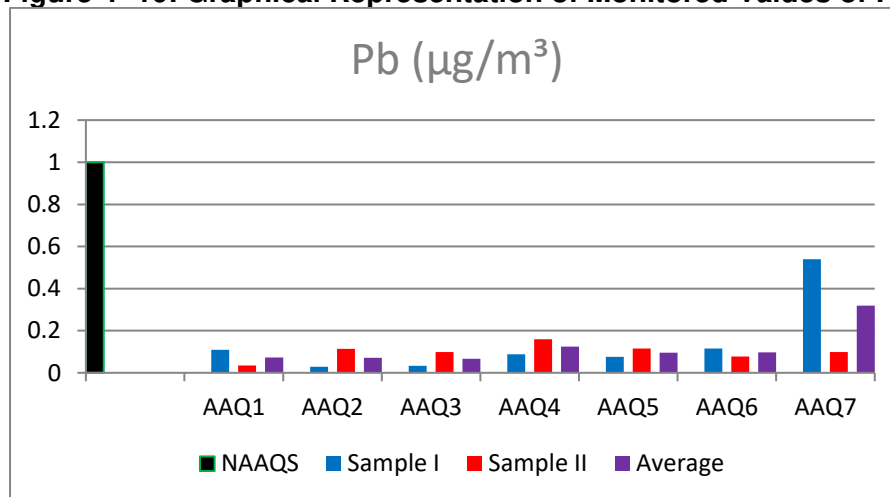







Figure 4- 11: Photographs of Air Quality Monitoring



| | |
|--|---|
|  |  |
| <p>AAQ 3 –Near New Horizon College of Engineering</p> | <p>AAQ 4 –Near VIMS Hospital, Marathahalli</p> |
|  |  |
| <p>AAQ 5 –Near ISRO, Sanjaynagar, Marathahalli</p> | <p>AAQ 6 –Near Bhagmane Tech Park, Mahadevapura</p> |
|  | |
| <p>AAQ 7 – Near Lowry Memorial Educational Institutions</p> | |

135. Table 4-6 shows that the average concentrations for PM₁₀ recorded were within the prescribed CPCB limit of 100 µg/m³ but exceeded the WBG guideline value of 50 µg/m³ at all the seven monitored locations. The concentrations of PM_{2.5} were all within the prescribed CPCB limit of 60 µg/m³ but exceeded the WBG guideline value of 25 µg/m³ at 5 out of 7 monitored locations. The concentrations of all other monitored parameters were within the prescribed CPCB limit or WBG guideline values.

E. Noise Environment

136. Noise levels were monitored continuously for 24 hours at seven (7) locations (Table 4-7) within the study zone, using a spot noise measurement device. Noise level measurement locations were identified for assessment of existing noise level status, keeping in view the noise sensitive receptors, land use pattern, residential areas, etc.

Table 4- 7: Noise Monitoring Location in the study area

| Sl. No. | Location | GPS Coordinates | Land Use | CPCB/WBG Category |
|---------|--|--------------------------------|-------------|---------------------------|
| N-1 | JSS Public School, HSR Layout, Outer Ring Road | 12°54'55.53"N 77°38'16.99"E | Educational | Silence/ educational |
| N-2 | Akme Harmony Apartments, Bellandur, Outer Ring Road | 12°55'22.56"N 77°40'14.50"E | Mixed | Residential |
| N-3 | New Horizon College of Engineering, Kaadabeesanahalli, ORR | 12°56'3.87"N 77°41'25.50"E | Educational | Silence/ educational |
| N-4 | VIMS Hospital, Marathahalli, ORR | 12°56'54.11"N 77°41'57.78"E | Hospital | Silence/ institutional |
| N-5 | Near ISRO, Sanjaynagar, Marathahalli, ORR (near Proposed ISRO Metro Station) | 12°58'6.20"N 77°42'4.32"E | Residential | Residential |
| N-6 | Bhagmane Tech Park, Mahadevapura, ORR | 12°58'56.76"N 77°41'35.62"E | Commercial | Commercial |
| N-7 | Lowry Memorial Educational Institutions, Chinappa Colony, Mahadevapura, ORR | 12°59'56.63"N 77°40'53.38"E | Educational | Silence/ educational |

137. The results of the ambient noise level monitoring along with CPCB and WBG noise limits for daytime and nighttime are presented in table 4-8 below.

Table 4- 8: Noise Levels at different noise monitoring stations

| Station Id. | Parameters in dB(A) | | | CPCB/WBG Standards in dB(A) | | | |
|-------------|---------------------|------|-------|-----------------------------|-----------|--------------|-------------|
| | Max. | Min. | Leq | CPCB (day) | WBG (day) | CPCB (night) | WBG (night) |
| N-1 | 92.0 | 58.8 | 72.42 | 50 | 55 | | |
| | 84.2 | 47.5 | 69.06 | | | 40 | 45 |
| N-2 | 83.9 | 48.5 | 70.35 | 55 | 55 | | |
| | 73.4 | 42.3 | 56.54 | | | 45 | 45 |
| N-3 | 98.9 | 57.8 | 75.76 | 50 | 55 | | |
| | 81.1 | 50.0 | 74.30 | | | 40 | 45 |
| N-4 | 81.5 | 60.7 | 67.43 | 50 | 55 | | |
| | 88.2 | 55.1 | 66.22 | | | 40 | 45 |
| N-5 | 93.0 | 59.6 | 73.33 | 55 | 55 | | |
| | 87.4 | 57.7 | 72.14 | | | 45 | 45 |
| N-6 | 81.6 | 54.5 | 69.9 | 65 | 70 | | |
| | 73.9 | 60.3 | 69.96 | | | 55 | 70 |
| N-7 | 83.1 | 48.6 | 67.85 | 50 | 55 | | |
| | 80.3 | 46.9 | 57.96 | | | 40 | 45 |

Figure 4- 12: Graphical Representation of Noise Levels at N1

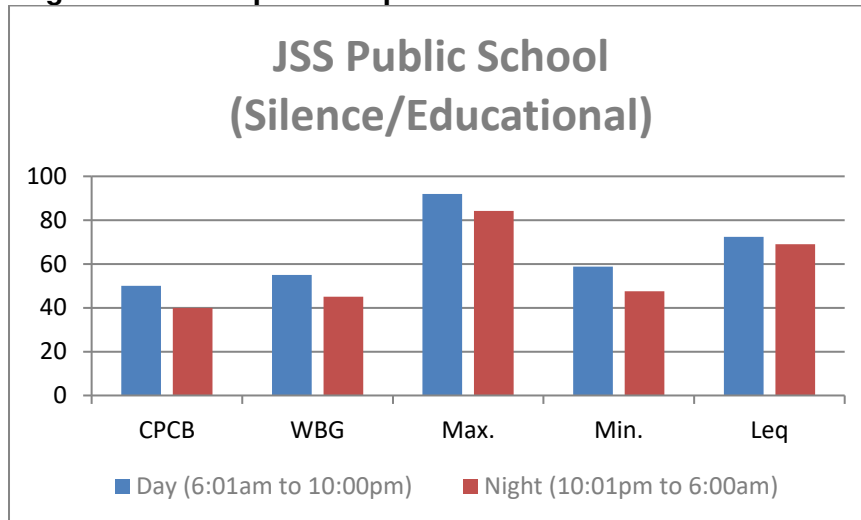


Figure 4- 13: Graphical Representation of Noise Levels at N2

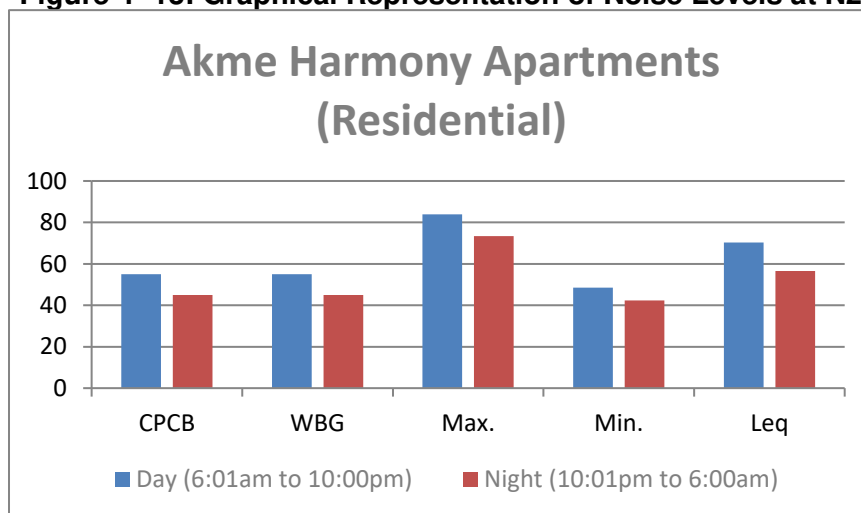


Figure 4- 14: Graphical Representation of Noise Levels at N3

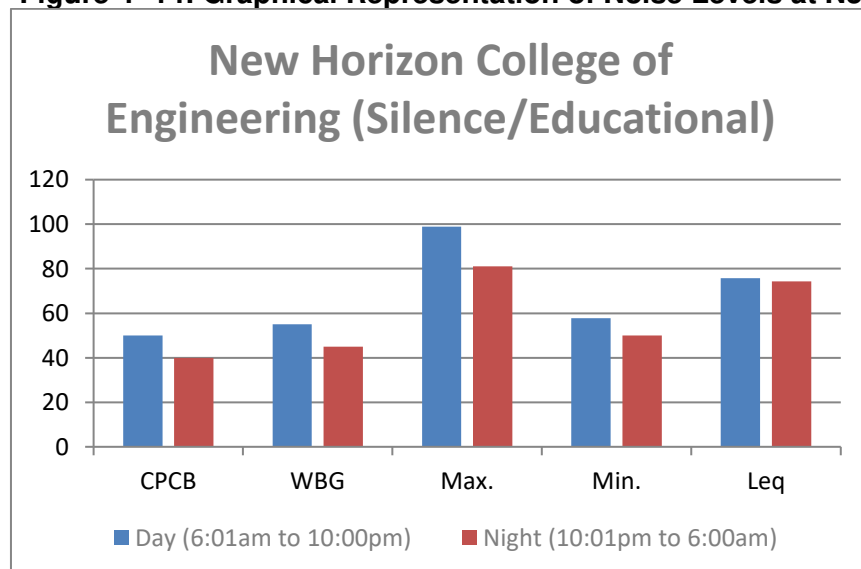


Figure 4- 15: Graphical Representation of Noise Levels at N4

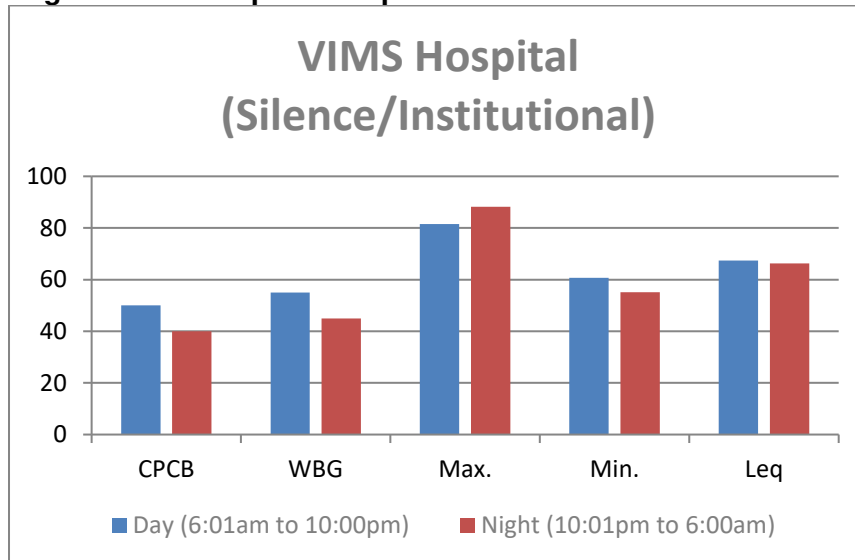


Figure 4- 16: Graphical Representation of Noise Levels at N5

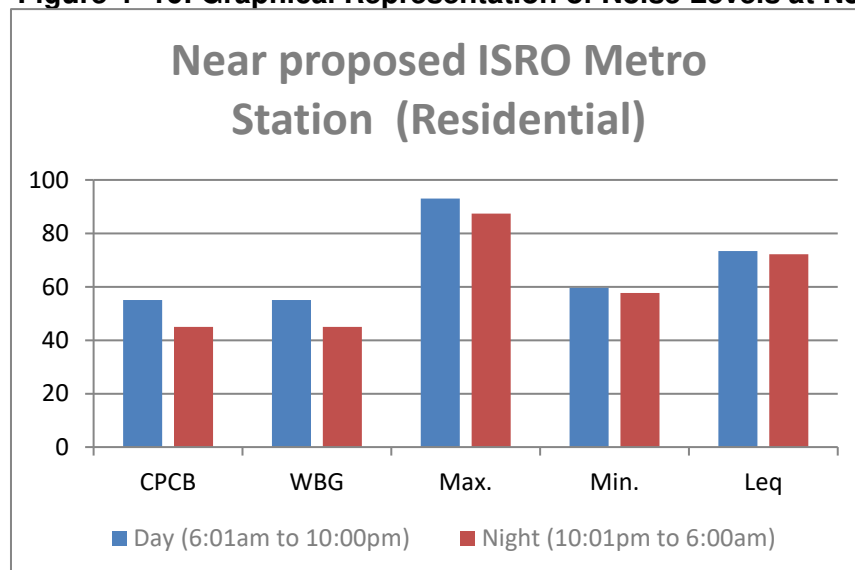


Figure 4- 17: Graphical Representation of Noise Levels at N6

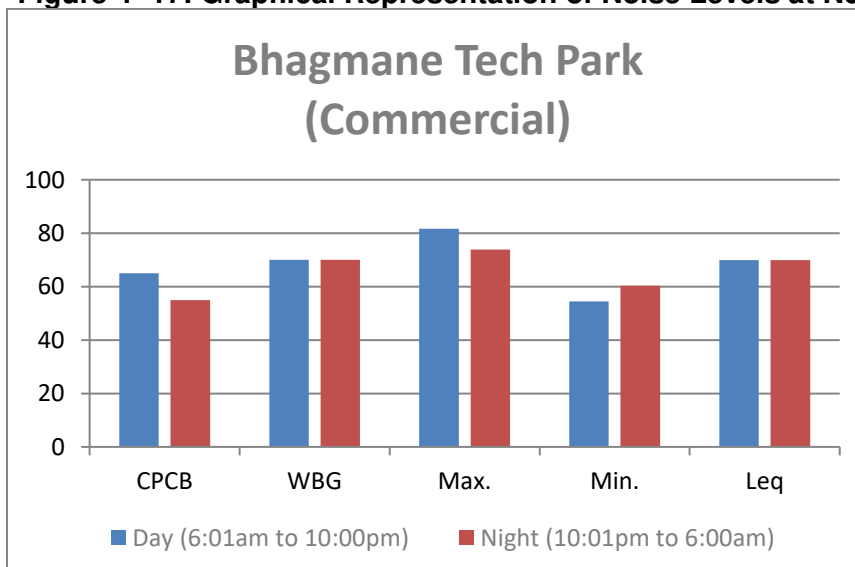


Figure 4- 18: Graphical Representation of Noise Levels at N7

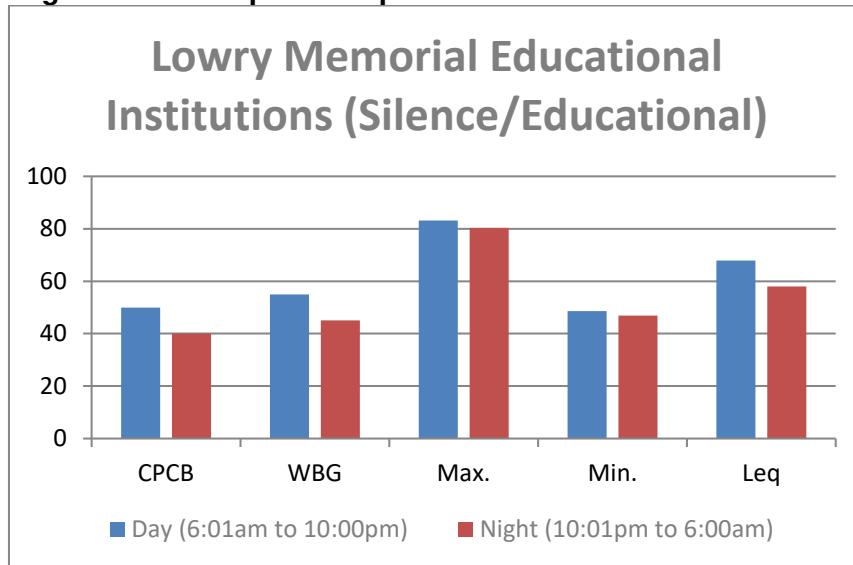






Figure 4- 19: Photographs of Ambient Noise Monitoring



| | |
|---|---|
|  <p>A surveyor in a yellow safety vest and white hard hat is operating a surveying instrument on a tripod. The location is an open area with a blue and white striped barrier in the background. A timestamp '27.11.2019 13:48' is visible in the bottom left corner.</p> |  <p>A surveyor in a yellow safety vest and white hard hat is operating a surveying instrument on a tripod. The location is a paved area with buildings and trees in the background. A timestamp '27.11.2019 12:40' is visible in the bottom left corner.</p> |
| <p>N3 - New Horizon College of Engineering</p> | <p>N4 - VIMS Hospital</p> |
|  <p>A surveyor in a yellow safety vest and white hard hat is operating a surveying instrument on a tripod. The location is a paved area with buildings and trees in the background. A timestamp '27.11.2019 16:24' is visible in the bottom right corner.</p> |  <p>A surveyor in a yellow safety vest and white hard hat is operating a surveying instrument on a tripod. The location is a paved area with trees and buildings in the background. A timestamp '28.11.2019 12:48' is visible in the bottom left corner.</p> |
| <p>N5 - ISRO, Sanjaynagar, Marathahalli</p> | <p>N6 - Bhagmane Tech Park</p> |
|  <p>A surveyor in a yellow safety vest and white hard hat is operating a surveying instrument on a tripod. The location is a paved area with a white car and a building under construction in the background. A timestamp '28.11.2019 13:27' is visible in the bottom right corner.</p> | |
| <p>N7 – Lowry Memorial Educational Institutions</p> | |

138. A second set of noise measurements was performed between December 12 to 17 2019 to supplement the initial ambient noise monitoring and suffice the requirement for more detailed noise assessment. Details can be found in annex 5. With the additional measurements the density of data was decreased from 1:3.7 kms to 1:1 km which significantly improves the quality of the assessment. In contrast to the initial 24-hour measurement, the supplementary was shorter duration with each measurement spanning 30-minutes with 1-minute intervals. A shorter duration was made primarily to reduce cost, turnaround time and ability to represent one-hour Leq as required by the US Federal Highways Administration⁴ Noise Measurement Handbook. A 30-minute measurement duration was selected in anticipation of widest range of noise fluctuations during the day of more than 30 dB(A). Below is a guide to determine the duration of short-term measurement based on anticipated fluctuations during the worst noise hour:

- Range of 10 dB or less: 10 minutes.
- Range of 10–30 dB: 15–20 minutes.
- Range greater than 30 dB: 30 or more minutes.

139. In summary, the ambient noise level during daytime were recorded within a range from 58.05 to 78.56 dB(A). During nighttime the ambient noise level ranges from 46.69 to 71.09 dB(A). The lowest ambient noise levels during both day and nighttime exceed the limits for silence, educational as well as residential areas.

F. Vibration Monitoring

140. The common sources of vibration during metro construction in this project are generated through the use of a backhoe with pavement breakers and vibro-hammers for pile driving. The proposed Phase 2A metro project construction does not involve construction of tunnels. For piling, alternative methods such as vibration or hydraulic insertion method will be used. Drilled holes for cast-in-place piles are another alternative that may produce noise and vibrations significantly lower than the traditional driving methods. The operation of metro trains induces vibration mainly due to the rolling stock, track and the friction between them. It is important to monitor the vibrations to establish the baseline and to know the impact of continuous vibrations by operating metro trains on the buildings. Baseline vibration monitoring was carried out for 24 hours at 5 locations which are adjacent to the proposed metro lines and susceptible for vibrations. The instrumentation used for measuring vibration includes transducers and data recording system. The transducer would consist of a tri-axial sensor which records the vibration in three directions namely vertical, longitudinal, and transversal. The data recording system consisting of processors record the measurement into the system. The Vibration monitoring location details are given in Table 4-10 and are shown in Figure 4-20.

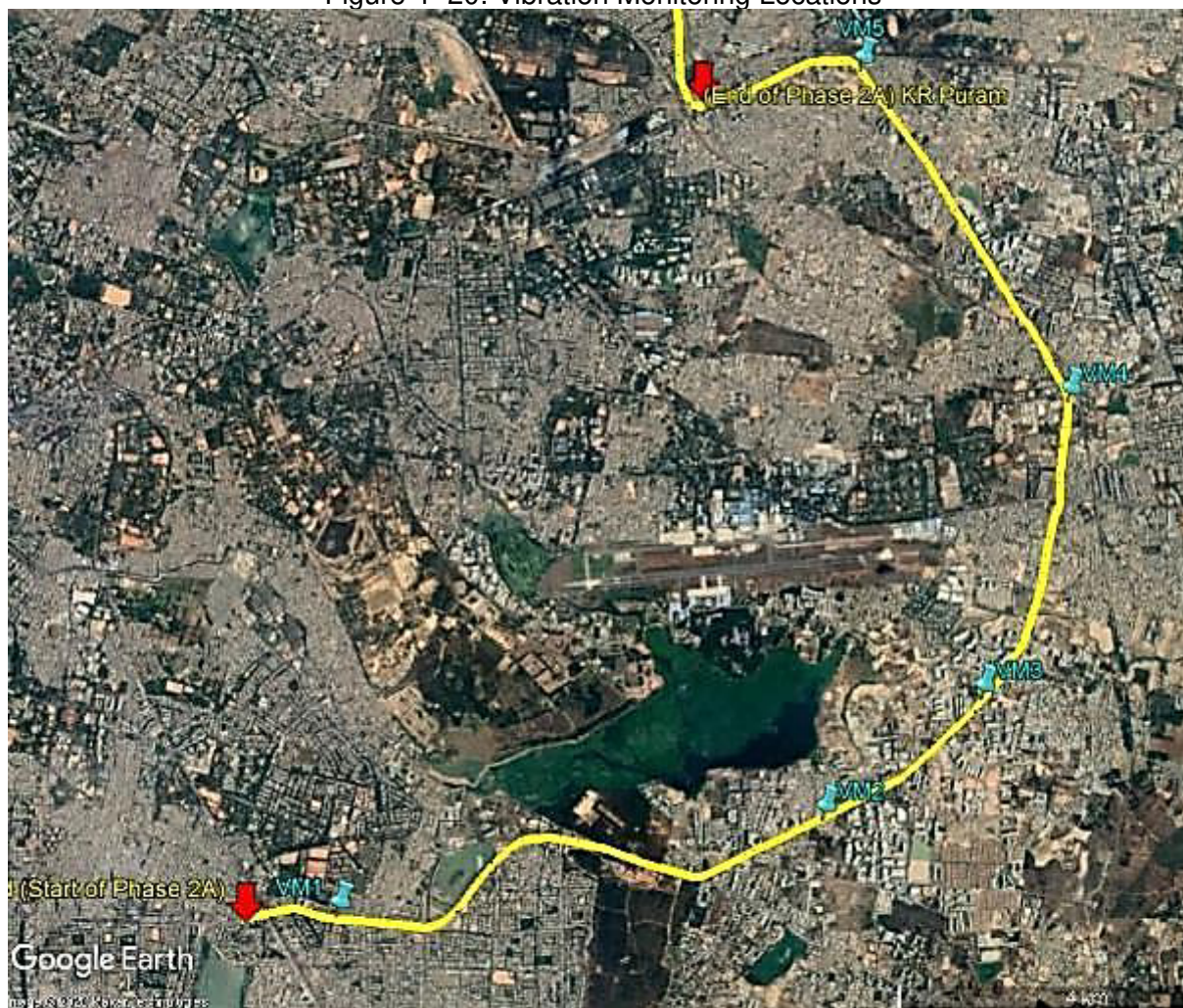
141. The values for noise and vibrations monitored along the proposed alignment are used to model and predict the impact of construction activities and train operation on the baseline noise and vibration. The detailed noise and vibration study is annexed to this report.

⁴ US FHWA (2018). "Noise Measurement Handbook (Final Report)" FHWA-HEP-18-065 US Department of Transportation.

Table 4- 9: Details of Vibration monitoring locations

| Sl. No. | Station Code | Locations of Vibration Monitoring Stations | Chainage (km) | LHS/ RHS | Distance from Center Line (m) |
|---------|--------------|---|---------------|----------|-------------------------------|
| 1 | VM1 | Near HSR Apartment Bus Stop | 1+020 | LHS | 25.00 |
| 2 | VM2 | Krupanidhi College (RHS) & Thick Residential Area (LHS) | 6+800 | RHS | 50.00 |
| 3 | VM3 | Saphire Honda Show room Near Altran India | 8+900 | LHS | 15.00 |
| 4 | VM4 | Car Care Showroom near Jeevika hospital | 12+370 | LHS | 15.00 |
| 5 | VM5 | Lowry Memorial Education Institution | 16+800 | LHS | 58.00 |

Figure 4- 20: Vibration Monitoring Locations



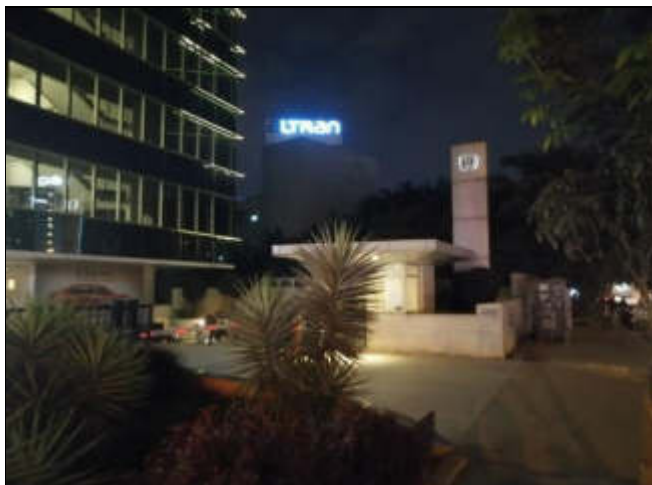
142. The predominant frequencies and amplitude of the vibration depend on many factors including suspension system of operating vehicles, soil type and stratification, traffic time peak/non-peak hours, distance from the road and type of building, and the effects of these factors are interdependent. Threshold limit (upper limit) has been set to 0.5 mm/s which refers the event has been captured above 0.5 mm/s. The impact load generated ground vibrations that are predominant at the natural vibration frequencies of the soil / structures for the monitored locations are given in the table 4-11 below. The operating traffic such as buses and trucks on the ORR were the predominant source of vibration.

Table 4- 10: Results of Vibration Monitoring

| Sl. No. | Station Code | Location | Maximum Value (mm/s) |
|---------|--------------|---|----------------------|
| 1. | VM 01 | Near HSR Apartment Bus Stop | <0.5 |
| 2. | VM 02 | Krupanidhi College (RHS) & Thick Residential Area (LHS) | <0.5 |
| 3. | VM 03 | Saphire Honda Show room Near Salarpuria Hallmark | <0.5 |
| 4. | VM 04 | Car Care Showroom near ISRO | 1.22 |
| 5. | VM 05 | Lowry Memorial Education Institution | <0.5 |

Figure 4- 21: Photographs of Vibration Monitoring Locations





VM 3 - Saphire Honda Show room Near Salarpuria Hallmark



VM 4 - Car Care show room near ISRO



VM 5 – Lowry Memorial Educational Institutions

143. Based on the results of the vibration monitoring, the ground vibrations during monitoring period were below typical threshold limits and no waveforms were recorded except at VM04. VM04 recorded a maximum value of 1.22 mm/s.

G. Water Environment

144. No major rivers run through the Bengaluru city, though the Arkavathi and South Pennar cross paths at the Nandi Hills, 60 km to the north. River Vrishabhavathi, a

minor tributary of the Arkavathi, arises within the city at Basavanagudi and flows through the city. The rivers Arkavathi and Vrishabhavathi together carry much of Bengaluru's sewage. There are two major river basins in the district namely Cauvery and South Pennar. Shimsha and Kanva River of the Cauvery basin is draining majority of the district and Anekal taluk is drained by South Pennar River of Ponnaiyar basin, which takes its birth from Nandi hills and flows towards south.

145. The city has major freshwater lakes and water tanks such as Madivala tank, Hebbal Lake, Ulsoor lake, Bellandur lake, Varthur lake, Sankey Tank, Agara Lake, Ibbalur Lake, Nekkundi Lake (Mahadevapura Lake), B Naranyanpura Lake, and Benniganahalli Lake. Groundwater occurs in silty to sandy layers of alluvial sediments and jointed quartzite. Presently, none of the lakes within Bengaluru serve as important ecological habitat for avian and aquatic fauna. Most of the Lakes in Bengaluru have been transformed from ecological habitats and community resources valued for water and cultural services, to urban recreational spaces used largely for jogging and walking as a consequence of urbanization.

146. After realizing the importance of waterbodies and the need for preservation and restoration of lakes, the Government transferred these lakes from Minor Irrigation Department to the Forest Department. Recently it was proposed to hand over all the lakes within Bengaluru city to BBMP. The detail on lakes as per the Lake Development Working Circle of the Forest Department is given in Table 4-12 and the details of water bodies located adjacent to the metro alignment is given in Table 4-13 below.

Table 4- 11:. Abstract of Lakes / Tanks under Bengaluru Urban (Forest) Division

| Sl. No. | Name of the Range / Unit | Number of Tanks | Extent In Ha |
|---------|--------------------------|-----------------|----------------|
| 1 | Bengaluru town unit | 17 | 306.96 |
| 2 | Banashankari unit | 17 | 170.45 |
| 3 | Rajajinagar unit | 16 | 117.77 |
| 4 | Tree unit | 7 | 51.78 |
| 5 | Kaggalipura range | 7 | 54.97 |
| 6 | KR Puram town unit | 25 | 470.69 |
| 7 | Ulsoor Unit | 31 | 343.17 |
| 8 | Yelahanka Range | 6 | 60.30 |
| | Total | 126 | 1576.09 |

Table 4- 12: Details of alignment passing near water bodies, lakes, rajakaluve, etc.

| Sl. No. | Water bodies / Lakes | Chainage (Km) | LHS / RHS | Distance from Metro alignment (m) |
|---------|-----------------------------------|------------------|------------|-----------------------------------|
| 1 | Agara Lake | 2+100 to 3+100 | LHS | 30 |
| 2 | Bellandur Lake | 4+200 to 4+900 | LHS | 300 |
| 3 | Ibbalur Lake | 5+500 to 5+700 | LHS | 30 |
| 4 | Pond @ chainage | 7+200 to 7+300 | LHS | 60 |
| 5 | Drain / Stream | 10+070 | both sides | 25 |
| 6 | Nekkundi Lake / Mahadevapura Lake | 14+950 to 15+100 | RHS | 44 |
| 7 | Pond @ chainage | 15+600 | RHS | 50 |
| 8 | Pond @ chainage | 15+750 to 15+850 | LHS | 25 |
| 9 | Pond @ chainage | 16+250 to 16+330 | RHS | 30 |
| 10 | B Naranyanpura Lake | 16+350 to 16+450 | LHS | 40 |
| 11 | Benninganahalli Lake | 18+200 | RHS | 30 |

147. **Agara Lake:** Agara Lake spread across an area of about 143 acres is located at chainage 2+500 km along Phase 2A metro line on the ORR close to Koramangala and HSR residential layouts. The lake is one of the natural lakes in the city which once attracted several species of migratory birds where they could be seen nesting and breeding. However, due to the excessive water pollution and mismanagement of the lake maintenance, the once-attractive lake was turned into a dumping site for garbage.

In the recent past, due to the conscious effort of the citizens living around the lake and the cooperative approach of the authorities, the lake is gaining its lost glory. As of now, the water quality is good and common native fauna species are returning to the area. Walking and jogging around the lake is a major attraction among visitors.

148. **Bellandur Lake:** Bellandur lake spreads over 892 acres and is 300 m away on left hand side of the proposed metro alignment. The lake is one of the oldest and largest lakes in Bengaluru. It is connected to the Varthur lake and flows into the Pinakini river basin. The lake forms an important part of Bengaluru's drainage system. The lake once was an ecological system supporting wildlife and fauna, but has since ceased to serve this function due to influx of the city's wastewater. Recently, there have been fires on the lake and a layer of foam that formed over it as a result of extreme pollution. Despite repeated attempts to clean and revive the lake, none have so far succeeded, and the water quality is still very poor.
149. **Ibbalur Lake:** Ibbalur lake is located at chainage 5+600 km of Phase 2A metro project. The lake spreads over 18 acres in area. When the lake was under the control of Bangalore Development Authority in 2009, not much was done to develop and conserve the lake. During 2015 the lake was handed over to BBMP which took up lake rejuvenation. The current redevelopment marks the second major restoration of the lake in the last 15 years. The lakebed has been cleaned and levelled, the bund has been built, and bund walls pitched with stone. Water inlets and outlets have been constructed, and the newly built storm water drains along ORR will bring rainwater runoff into the lake.
150. **Nekkundi Lake:** Nekkundi Lake is located on RHS of proposed Phase 2A metro project. This 26 acre lake falls under two wards, Mahadevapura and Vignana Nagar. Nekkundi lake was once a much bigger ecosystem with a huge catchment area, it supported a lot of flora and fauna, including rare migratory and residential birds. Until 2015, the lake had a large open drain flowing into it, and garbage-filled storm-water drains around it, which were contributing waste water into the lake. The sewage was flowing into the lake from Kaggadaspura Lake. In 2015, the BBMP undertook a 10 crore project for rejuvenation of the lake by dredging, building bunds, de-weeding and fencing the lake area to prevent encroachment. At the moment the water quality is considered good and common native fauna is returning to the area.
151. **B Naranyanpura Lake:** B Narayanpura lake is located at chainage 16+300 km on LHS of the proposed metro alignment. The lake spreads over an area of 15 acres. Then lake land is encroached upon by temple, slums and other settlements. The lake is polluted mainly by sewage inflow. Recently the lake is rehabilitated by desilting and construction of bunds around the lake.
152. **Benniganahalli Lake:** Benniganahalli lake is located at the end of Phase 2A and start of Phase 2B metro corridors. The lake was developed by the Bengaluru Development Authority (BDA) two decades ago and handed over the lake to BBMP in 2016. The lake is spread over around 45 acres located near residential layouts such as Pai Layout. Benniganahalli was a favourite destination for morning and evening walkers. The developed portion of the lake has good water quality whereas the undeveloped portion is polluted with sewage from nearby layouts. In January 2018 BBMP took up the task of cleaning the lake by dredging, desilting and weed removal and constructed a channel to divert the sewage flow. This year, the lake is filled up with water from good monsoon received last year.
153. The above lakes located adjacent to the proposed metro alignment are facing problems such as ingress of sewage from adjacent residential areas; encroachment and unauthorised buildings, siltation and subsequent eutrophication. Most of these lakes are seasonal and completely dry up during summer. Water sampling has been done and water quality parameters have been analysed for Agara Lake, Nekkundi Lake and Mahadevapura Lake and the results of water quality is discussed in

subsequent sections. Google earth images showing major water bodies along the proposed metro corridor is shown in Figure 4-22.

Figure 4- 22:: Google Earth images showing major water bodies along Metro corridor



H. Hydrogeology

154. Granites and Gneisses of peninsular gneissic group constitute major aquifers in the urban district of Bengaluru. Laterites of Tertiary age occur as isolated patches capping crystalline rocks in Bengaluru north taluk. Alluvium of limited thickness of 20 to 25m and aerial extent that occur along the valley portions possess substantial groundwater potential. Groundwater occurs in phreatic or unconfined conditions in the weathered zone and under semi confined to confined conditions in fractured and jointed rock formations. The occurrence of groundwater movement and recharge to aquifers are controlled by various factors like fracture pattern, degree of weathering, geomorphological setup and amount of rainfall received. The yield in the bore wells is dependent upon factors like degree of weathering, presence of joints and fractures and its connectivity and the presence of intrusive bodies. Granites and gneisses of peninsular gneissic group constitute the major aquifers in the urban district. Ground water occurs in phreatic conditions in the weathered zone and under semi confined to confined conditions in fractured and jointed rock formations. The map for hydrogeology and ground water prospectus of Bengaluru District is given in Figure 4-23. The surface drainage network, water bodies and water shed boundaries for Bengaluru urban district is shown in figure 4-24.
155. Studies have been done on the ground water quality for Bengaluru Urban District by Central Ground Water Board (CGWB) based on hydro-chemical data of network hydrograph stations wells and exploration bore wells. Results show wide variations in its chemical composition. The shallow and deep groundwater is alkaline with pH value ranging from 7.8 to 8.5. Total hardness varies from 100 to 600 ppm. Fluoride content in general is less than 1 ppm. Major part of the district has fresh water with EC ranging from 250 to 2000 micro mhos/cm at 25° C.
156. Dependence on groundwater for water-supply in Bengaluru city is increasing due to accelerated growth, increasing per capita water use and poor reliability of supply of surface water from distant sources. Although surface water supply from the Bengaluru Water Supply and Sewerage Board (BWSSB) has increased over time, it has been unable to catch up with the rapid growth and expansion of city. As a result, groundwater is heavily used to make up the deficit. As a result, ground water provides a proportion of the current water consumption and is likely to continue to do so in most of the wards of the BBMP. There is no effective regulation of the use of groundwater for domestic, commercial and industrial or government agency purposes and use of this resource is unrestricted. Consequently, there is practically no reliable data on the rate and distribution of ground water withdrawals. Monitoring of the aquifers from which ground water is withdrawn is conducted by Department of Mines and Geology and the CGWB. However, it is not useful for assessing the state of the urban groundwater system as the density of existing monitoring network is very low and the frequency of monitoring by CGWB is once every few months which reveal larger, regional scale groundwater status over many years. Based on this sparse monitoring network, the CGWB has estimated that groundwater is more than 100% developed in Bengaluru, which means that the abstraction rate is more than the recharge rate to the aquifer.
157. In the urban area of Bengaluru district, main problems affecting groundwater are sewage pollution, industrial pollution, high nitrate concentration and overexploitation of ground water resources.⁵ This is attributed to factors like rapid urbanization in the last three decades paving the way for commercial buildings, industries, new residential layouts. The green cover, tanks and lakes have been diminished leading to depletion of water levels. This rapid urbanization, IT boom, related economic activities, trade and commerce have exerted pressure, increasing the inflow of sewage waste into the lakes. Improper environmental planning has given room for establishment of new residential layouts without proper sewerage network

⁵Central Ground Water Board Ground Water Information Booklet, Bangalore Urban District, 2012.

and, even if such systems have been provided, they are mostly not functional or connected to trunk sewers of Bangalore Water Supply Sewerage Board (BWSSB). The municipal effluents from natural drains leading to tanks and lakes have deteriorated the quality of the water. Sedimentation of pollutants has not only reduced the surface area of the water but has also reduced groundwater levels on account of poor permeability with more and more silt, clay deposits, trash and toxic waste accumulation in the lakes year after year.

158. Sewage pollution is observed in the western part of Bengaluru city where all the sewage goes into Vrishabhavathi River valley and most of the tanks are also polluted from sewage due to unplanned urbanization. As per CGWB studies, most of the open wells/bore wells situated in the vicinity of Vrishabhavathi River is polluted by sewerage. Rapid and unplanned urbanization has taken its toll on groundwater resource of the district, with increased exploitation by bore wells dug up in all possible terrains. The only solution is building up of groundwater resource through artificial recharge and rainwater harvesting.

Figure 4- 23: Project with respect to Hydrogeology of Bengaluru Urban district

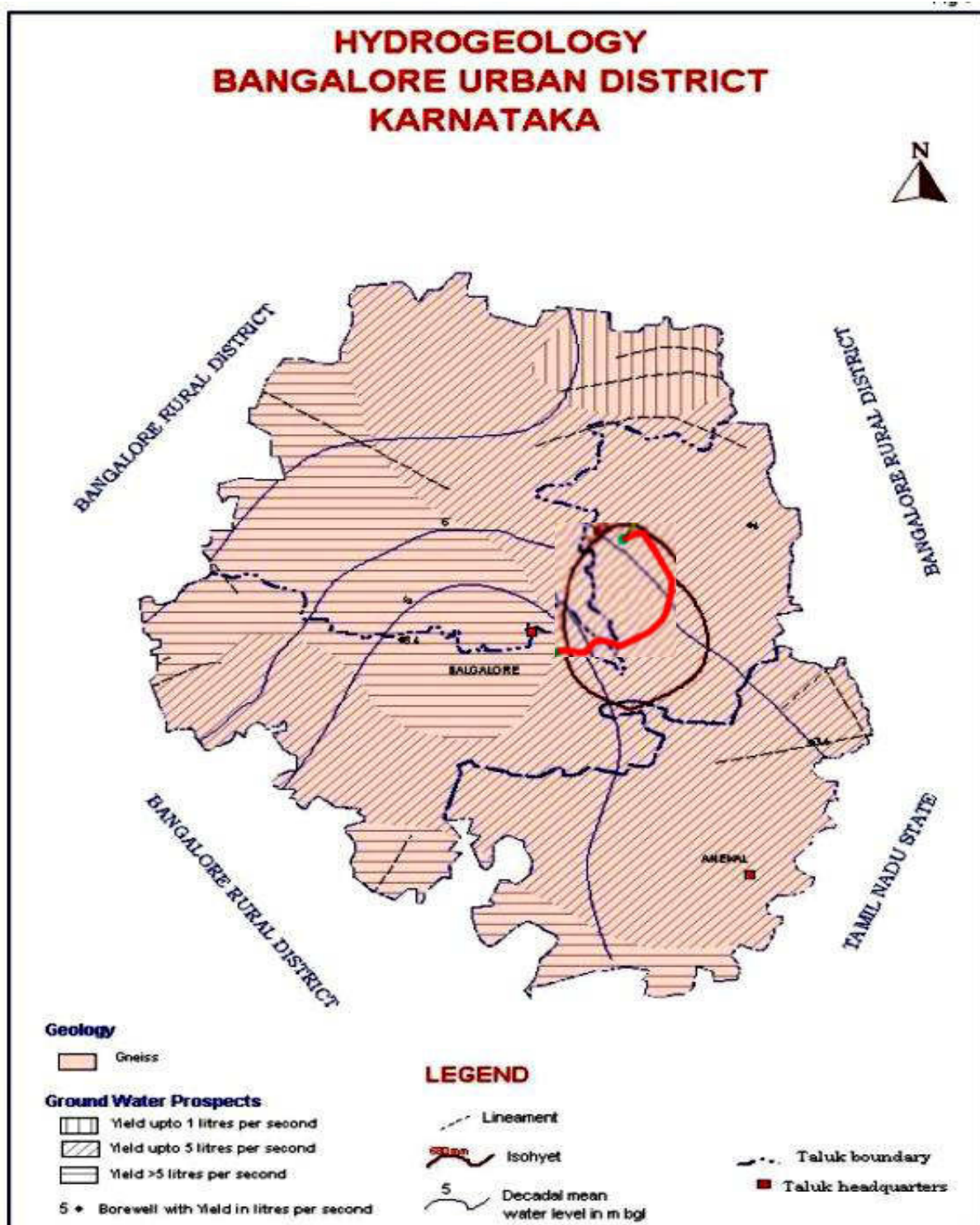
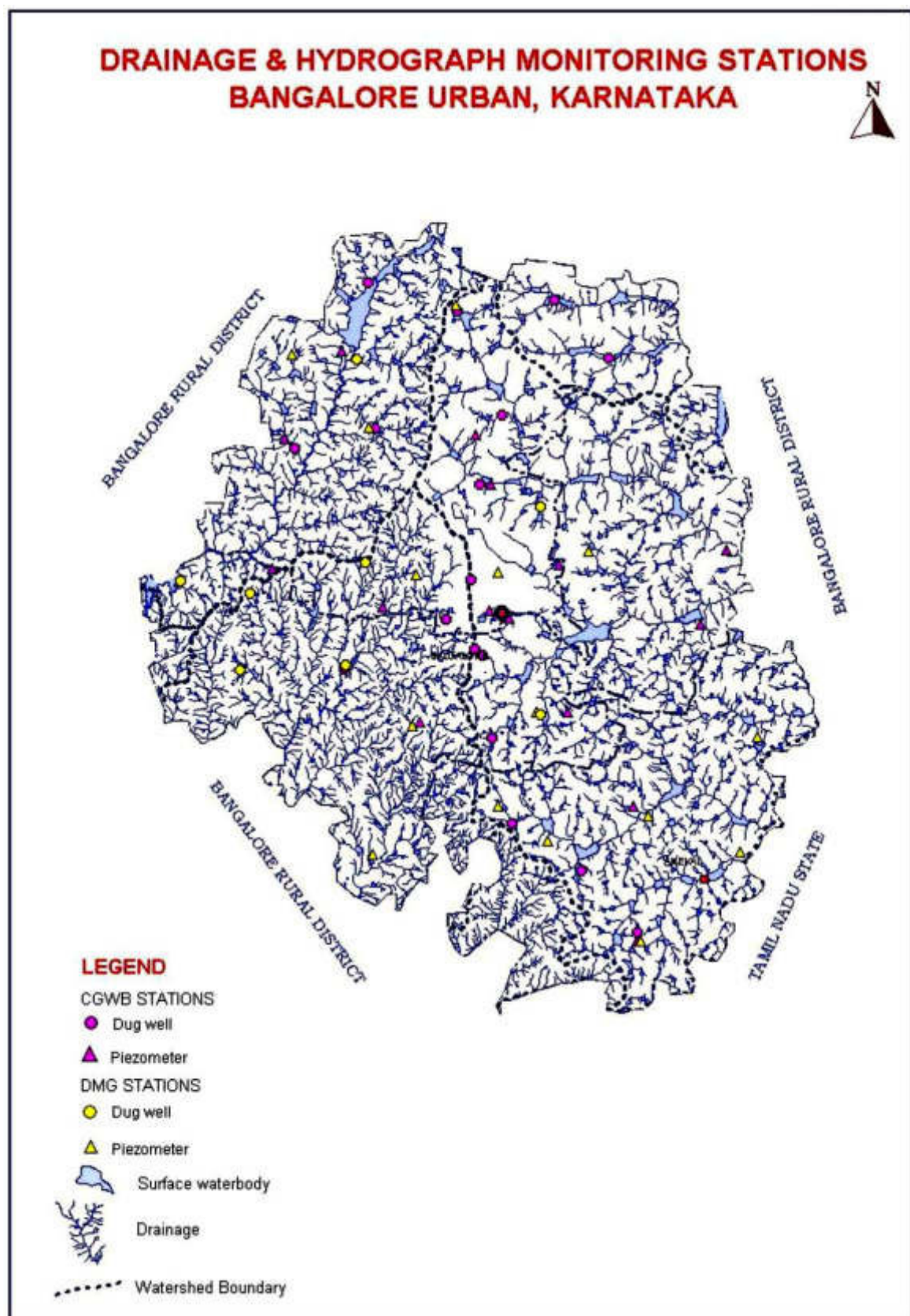


Figure 4- 24: Drainage map of Bengaluru Urban district

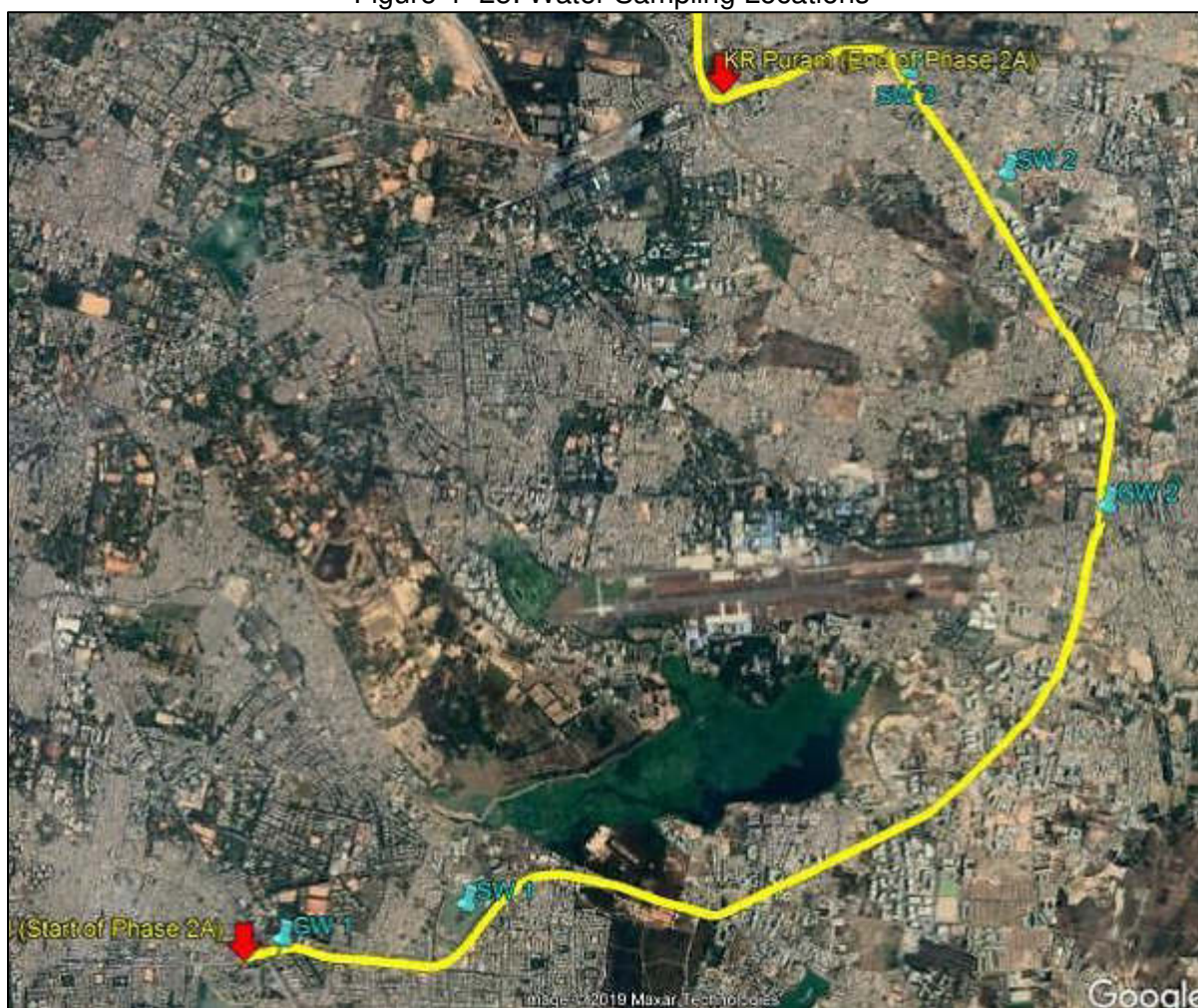


159. Three surface water samples and two ground water samples were collected from the study area (Table 4-14) for analysis of water quality. Samples from lakes and ponds located along the alignment were collected for surface water analysis while borewell water samples were collected from accessible borewells along the alignment to analyse the groundwater quality and get an idea of the baseline water conditions. The results of the analysis of surface water and ground water are given in Tables 4-15 and 4-16 respectively.

Table 4- 13: Locations of Surface Water and Ground Water sampling in the Study Area

| Sl. No. | Sample Code | Name of the Location |
|---------|-------------|--|
| 1 | SW-1 | Agara Lake (LHS) |
| 2 | SW-2 | Nekkundhi Lake (Mahadevapura Lake) (RHS) |
| 3 | SW-3 | B Naranyanpura Lake (LHS) |
| 4 | GW-1 | Bore Well near Central Silk Board along Outer Ring Road with a well depth of 350 ft. |
| 5 | GW-2 | Bore Well near Marathahalli along Outer Ring Road with a well depth of 400 ft. |

Figure 4- 25: Water Sampling Locations



160. The surface water samples were analysed for parameters as specified in IS: 10500 (2012) standards, "Drinking Water-Specifications" and analysed as per methods specified in IS: 3025.

Table 4- 14: Results of Surface Water Analysis

| Sl. No. | Parameters | Unit | Water Quality Criteria | | | | | SW1 | SW2 | SW3 |
|---------|---------------------------------------|------------------|------------------------|-----|------|------|------|--------------|--------------|--------------|
| | | | A | B | C | D | E | | | |
| 1. | pH | - | 6.5-8.5 | | | | | 7.30 | 7.95 | 7.59 |
| 2. | Colour | Hazen | 10 | 300 | 300 | - | - | <1 | <1 | <1 |
| 3. | Odour | -- | - | - | - | - | - | Disagreeable | Disagreeable | Disagreeable |
| 4. | Turbidity | NTU | - | - | - | - | - | 2.41 | 7.37 | 1.10 |
| 5. | Electrical Conductivity | µs/cm | - | - | - | 1000 | 2250 | 417 | 955 | 489 |
| 6. | Total Dissolved Solids | mg/L | 500 | - | 1500 | - | 2100 | 298 | 651 | 340 |
| 7. | Total Hardness as CaCO ₃ | mg/L | - | - | - | - | - | 108 | 156 | 128 |
| 8. | Calcium as Ca | mg/L | - | - | - | - | - | 30.4 | 41.6 | 40.0 |
| 9. | Magnesium as Mg | mg/L | - | - | - | - | - | 7.77 | 12.63 | 6.80 |
| 10. | Chloride as Cl | mg/L | 250 | - | 600 | - | 600 | 45.00 | 140.89 | 23.48 |
| 11. | Sulphate as SO ₄ | mg/L | 400 | - | 400 | - | 1000 | 13.77 | 30.49 | 56.56 |
| 12. | Dissolved Oxygen | mg/L | 6 | 5 | 4 | 4 | - | 4.7 | 4.4 | 4.8 |
| 13. | BOD (3 Days@27°C) | mg/L | 2 | 3 | 3 | - | - | 8.0 | 56.0 | 16.0 |
| 14. | Chemical Oxygen Demand | mg/L | - | - | - | - | - | 40 | 184 | 56.0 |
| 15. | Fluoride as F | mg/L | 1.5 | 1.5 | 1.5 | - | - | 1.01 | 1.25 | 0.44 |
| 16. | Total Alkalinity as CaCO ₃ | mg/L | - | - | - | - | - | 132 | 160 | 132 |
| 17. | Nitrate as NO ₃ | mg/L | 20 | - | 50 | - | - | 6.38 | 13.04 | 3.54 |
| 18. | Phosphate as PO ₄ | mg/L | - | - | - | - | - | 0.36 | BDL | 0.22 |
| 19. | Sodium as Na | mg/L | - | - | - | - | - | 28.28 | 96.35 | 20.34 |
| 20. | Potassium as K | mg/L | - | - | - | - | - | 9.93 | 17.30 | 10.31 |
| 21. | Iron as Fe | mg/L | 0.3 | - | 50 | - | - | 0.18 | 0.13 | 0.15 |
| 22. | Manganese as Mn | mg/L | - | - | - | - | - | 0.269 | 0.084 | 0.078 |
| 23. | Copper as Cu | mg/L | 1.5 | - | 1.5 | - | - | BDL | BDL | BDL |
| 24. | Zinc as Zn | mg/L | 15 | - | 15 | - | - | 0.006 | 0.011 | 0.008 |
| 25. | Mercury as Hg | mg/L | - | - | - | - | - | BDL | BDL | BDL |
| 26. | Total Chromium as Cr | mg/L | - | - | - | - | - | BDL | BDL | BDL |
| 27. | Total Coliform | MPN Index /100ml | 50 | 500 | 5000 | - | - | 2400 | 3200 | 2800 |
| 28. | <i>E-coli</i> | MPN Index /100ml | - | - | - | - | - | 84 | 220 | 170 |

Table 4- 15: Results of Ground Water Analysis

| Sl. No. | Parameters | Std. IS 10500:2012 (Second Revision) | | Unit | GW1 | GW2 |
|---------|---------------------------------------|--------------------------------------|------|-----------------|-----------|-----------|
| | | AL | PL | | | |
| 1. | pH | 6.5-8.5 | | - | 7.22 | 8.02 |
| 2. | Colour | 5 | 15 | Hazen | <1 | <1 |
| 3. | Odour | Agreeable | | -- | Agreeable | Agreeable |
| 4. | Turbidity | 1 | 5 | NTU | 0.11 | 0.11 |
| 5. | Electrical Conductivity | Not specified | | µs/cm | 998.0 | 1171 |
| 6. | Total Dissolved Solids | 500 | 2000 | mg/L | 683 | 799 |
| 7. | Total Hardness as CaCO ₃ | 200 | 600 | mg/L | 232 | 192.0 |
| 8. | Calcium as Ca | 75 | 200 | mg/L | 64.0 | 48.0 |
| 9. | Magnesium as Mg | 30 | 100 | mg/L | 17.49 | 17.49 |
| 10. | Chloride as Cl | 250 | 1000 | mg/L | 74.35 | 172.20 |
| 11. | Sulphate as SO ₄ | 200 | 400 | mg/L | 39.34 | 48.56 |
| 12. | Dissolved Oxygen | Not specified | | mg/L | 5.1 | 5.1 |
| 13. | BOD (3 Days @ 27°C) | Not specified | | mg/L | BDL | BDL |
| 14. | Chemical Oxygen Demand | Not specified | | mg/L | 3.2 | BDL |
| 15. | Fluoride as F | 1 | 1.5 | mg/L | 0.88 | 0.50 |
| 16. | Total Alkalinity as CaCO ₃ | 200 | 600 | mg/L | 312 | 208 |
| 17. | Nitrate as NO ₃ | 45 | | mg/L | 15.47 | 17.77 |
| 18. | Phosphate as PO ₄ | Not specified | | mg/L | 0.15 | 0.24 |
| 19. | Sodium as Na | Not specified | | mg/L | 54.0 | 108.84 |
| 20. | Potassium as K | Not Specified | | mg/L | 22.0 | 6.22 |
| 21. | Iron as Fe | 0.3 | | mg/L | BDL | BDL |
| 22. | Manganese as Mn | 0.1 | 0.3 | mg/L | 0.010 | 0.154 |
| 23. | Copper as Cu | 0.05 | 1.5 | mg/L | BDL | BDL |
| 24. | Zinc as Zn | 5 | 15 | mg/L | 0.038 | 0.007 |
| 25. | Mercury as Hg | 0.001 | | mg/L | BDL | BDL |
| 26. | Total Chromium as Cr | 0.05 | | mg/L | BDL | BDL |
| 27. | Total Coliform | Not specified | | MPN Index/100ml | <1.8 | <1.8 |
| 28. | <i>E-coli</i> | Not specified | | MPN Index/100ml | 13 | <1.8 |

161. **Water Quality Requirement for Different Uses:** For any water body to function adequately in satisfying the desired use, it must have corresponding degree of purity. Drinking water should be of highest purity. Each water use has specific quality need. Therefore, to set the standard for the desired quality of a water body, it is essential to identify the uses of water in that water body. In India, the CPCB has developed a concept of designated best use. According to this, out of the several uses of water of a particular body, the use which demands highest quality is termed its designated best use. Five designated best uses have been identified as given in Table 4-17.

Table 4- 16: Water Quality Standards by CPCB for Best Designated Usage

| Designated-Best-Use | Class of water | Criteria |
|---|----------------|--|
| Drinking Water Source without conventional treatment but after disinfection | A | Total Coliforms Organism MPN/100ml shall be 50 or less |
| | | pH between 6.5 and 8.5 |
| | | Dissolved Oxygen 6mg/l or more |
| | | Biochemical Oxygen Demand 5 days 20°C 2mg/l or less |
| Outdoor bathing (Organized) | B | Total Coliforms Organism MPN/100ml shall be 500 or less pH between 6.5 and 8.5 |
| | | Dissolved Oxygen 5mg/l or more |
| | | Biochemical Oxygen Demand 5 days 20°C 3mg/l or less |
| Drinking water source after conventional treatment and disinfection | C | Total Coliforms Organism MPN/100ml shall be 5000 or less pH between 6 to 9 |
| | | Dissolved Oxygen 4mg/l or more |
| | | Biochemical Oxygen Demand 5 days 20°C 3mg/l or less |
| Propagation of Wild life and Fisheries | D | pH between 6.5 to 8.5 |
| | | Dissolved Oxygen 4mg/l or more |
| Irrigation, Industrial Cooling, Controlled Waste disposal | E | Free Ammonia (as N) 1.2 mg/l or less |
| | | pH between 6.0 to 8.5 |
| | | Electrical Conductivity at 25°C micro mhos/cm Max.2250 |
| | | Sodium absorption Ratio Max. 26 |
| | | Boron Max. 2mg/l |
| - | Below-E | Not Meeting A, B, C, D & E Criteria |

Figure 4- 26: Photographs of Water Sampling



SW1 – Agara Lake

SW2 – Nekkundi Lake (Mahadevapura Lake)

| | |
|--|--|
| SW3 – B Naranyanpura Lake | GW1 - Bore Well near Central Silk Board, Outer Ring Road |
|  | |
| GW2- Bore Well near Marathahalli, Outer Ring Road | |

i. Inference on the water quality analysis

162. The inferences of the analysis of water samples are as follows:

SW-1 –Agara Lake:

163. Based on the measured values for the water quality parameters with respect to dissolved oxygen, biological oxygen demand (3 days @27°C) and total coliform water sample from Agara lake is likely to conform to Class 'D' fit for propagation of wildlife and fisheries.

SW-2 - Nekkundhi Lake (Mahadevapura Lake):

164. Based on the measured values for the water quality parameters with respect to total dissolved solids, dissolved oxygen, biological oxygen demand (3 days @27°C) and total coliform water sample from Nekkundhi lake is likely to conform to Class 'D' fit for propagation of wildlife and fisheries.

SW-3 - B Naranyanpura Lake:

165. Based on the measured values for the water quality parameters with respect to dissolved oxygen, biological oxygen demand (3 days @27°C) and total coliform water sample from B Narayanapura lake likely to conform to Class 'D' fit for propagation of wildlife and fisheries.

GW-1 - Bore Well near Central Silk Board, Outer Ring Road:

166. The measured values for total dissolved solids, total hardness and total alkalinity exceed the acceptable limits of IS 10500:2012 (second revision) standards. However, the presence of e-coli renders it not suitable for drinking water without prior proper treatment.

GW-2 - Bore Well near Marathahalli Outer Ring Road:

167. The measured values for total dissolved solids, total alkalinity and Manganese as Mn exceeds the acceptable limits of IS 10500:2012 (second revision) standards.

However, the presence of e-coli renders it not suitable for drinking water without prior proper treatment.

I. Land Environment

168. Bengaluru (Urban) district consists of Charnokites and peninsular gneisses complex. The peninsular gneiss is the dominant group of rocks and covers two-thirds of the area and includes granites, gneisses and migmatites with intrusions. Small patches of porphyritic granite are also seen in Bengaluru South and Bengaluru North taluks.
169. Bengaluru district lies over a hard and moderately dense gneissic basement which dates back to Archean era (2500-3500 million years). The principal rock formations are upper Vindhyan super group, Deccan traps and Inter-trappean beds, alluvium and laterite. These rock types represent different time segments within Archean era. The study area is predominantly covered by red loamy and sandy soils, laterite soil. Red loamy and sandy soils generally occur on undulating land slope on granite and gneissic terrain. The soils are light textured and are highly leached in nature with good infiltration rate. It is mainly seen in the eastern and southern parts of Bengaluru North and South taluks. Laterite soils occur on undulating terrain forming plain to gently sloping topography of peninsular gneissic region. It is mainly covered in Anekal taluk and western parts of Bengaluru North and South taluks.
170. Five soil samples from the proposed metro alignment vicinity were analysed for 20 different parameters. The details of sampling locations and results of soil quality analysis are presented below in Tables 4-18 and 4-19.

Table 4- 17: Details of Soil Sampling Locations

| Sl. No. | Location Code | Soil Sampling Locations | Chainage (km) |
|---------|---------------|----------------------------|---------------|
| 1 | S-1 | Teachers Colony Park (LHS) | 1+150 |
| 2 | S-2 | Agara Park (LHS) | 3+250 |
| 3 | S-3 | Ibbalur Park (LHS) | 5+450 |
| 4 | S-4 | BBMP Park, (RHS) | 12+600 |
| 5 | S-5 | Narayanapura Park (LHS) | 15+900 |

Table 4- 18: Results of Soil Quality Analysis

| Sl. No | Parameters | Unit | S1 | S2 | S3 | S4 | S5 |
|--------|---|----------|------------|------------|------------|------------|------------|
| 1 | pH | - | 7.10 | 7.3 | 7.15 | 7.53 | 6.80 |
| 2 | Electrical Conductivity | µs/cm | 148 | 120 | 193 | 111.1 | 222 |
| 3 | Organic Carbon | Percent | 0.23 | 0.28 | 0.34 | 0.40 | 0.17 |
| 4 | Sand | Percent | 70.96 | 62.96 | 64.96 | 58.96 | 56.96 |
| 5 | Silt | Percent | 19.28 | 27.28 | 25.28 | 29.64 | 31.28 |
| 6 | Clay | Percent | 9.76 | 9.76 | 9.76 | 11.76 | 11.76 |
| 7 | Porosity | Percent | 57.94 | 50.82 | 56.22 | 53.15 | 46.42 |
| 8 | Texture | - | Sandy loam | Sandy loam | Sandy loam | Sandy loam | Sandy loam |
| 9 | Available Nitrogen as N | kg/ha | 280.98 | 204.68 | 182.64 | 375.06 | 205.47 |
| 10 | Available Potassium as K | kg/ha | 462.89 | 510.60 | 780.19 | 462.11 | 475.88 |
| 11 | Available Phosphorus as P ₂ O ₅ | kg/ha | 158.01 | 167.08 | 182.62 | 132.11 | 172.26 |
| 12 | Calcium as Ca | meq/L | 7.3 | 4.9 | 8.0 | 4.9 | 13.0 |
| 13 | Magnesium as Mg | meq/L | 1.3 | 0.9 | 1.0 | 1.6 | 1.0 |
| 14 | Sodium as Na | mg/100gm | 5.60 | 2.89 | 8.09 | 1.66 | 9.30 |
| 15 | Boron as B | mg/100gm | BDL | BDL | BDL | BDL | BDL |
| 16 | Iron as Fe | Ppm | 78.059 | 107.702 | 40.53 | 71.67 | 62.22 |
| 17 | Zinc as Zn | mg/kg | 9.6 | 24.2 | 8.5 | 41.4 | 19.6 |
| 18 | Manganese as Mn | mg/kg | 210.4 | 108.3 | 137.8 | 125.4 | 110.6 |
| 19 | Molybdenum as Mo | mg/kg | BDL | BDL | BDL | BDL | BDL |

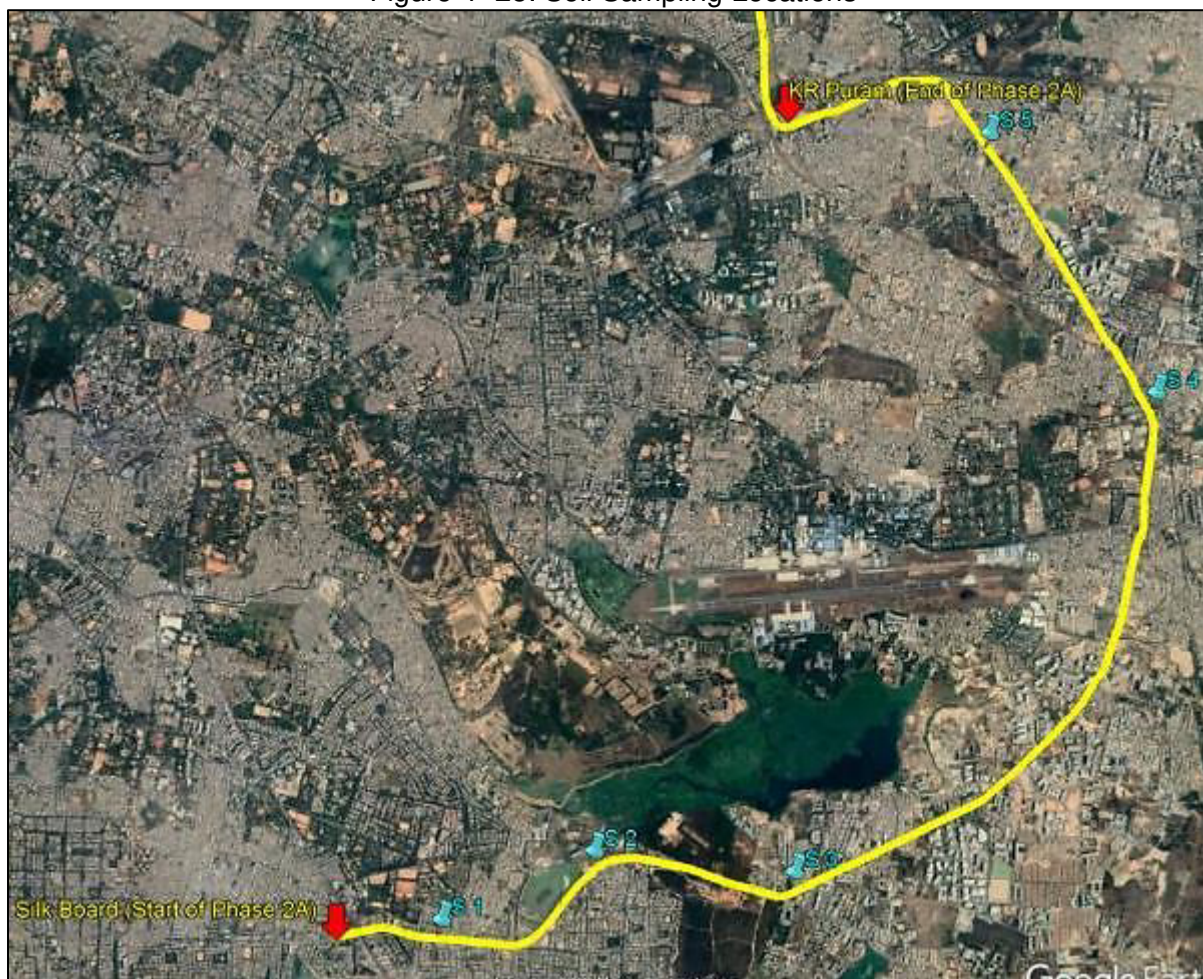
| Sl. No | Parameters | Unit | S1 | S2 | S3 | S4 | S5 |
|--------|-----------------|-------|--------|--------|--------|--------|--------|
| 20 | Copper as Cu | mg/kg | 8.6 | 18.2 | 8.3 | 9.4 | 10.8 |
| 21 | Aluminium as Al | mg/kg | 3521.8 | 4580.6 | 2246.4 | 3111.7 | 3037.0 |

BDL: Below Detectable Limit.

Figure 4- 27: Photographs of Soil Sampling



Figure 4- 28: Soil Sampling Locations



J. Land use pattern

171. Bengaluru city is being heavily flooded with public investment in industry and infrastructure which is leading to significant changes in the land use patterns.
172. Major contributors for rapid land use changes in Bengaluru are increased population, rapid urbanization, industrialization, commercial establishments, political influences, tourism, etc. leading to an unplanned growth of the city. The change in land use is leading to expansion of urban sprawl consuming productive agricultural land, vegetation cover and water bodies. Functioning of the city has been hampered due to overcrowding, inadequate housing, development of slums, social polarization, traffic congestion, and environmental pollution, among others. This land-use change has complex interactions with the ecosystem, hydrological cycle and atmospheric circulation leading to modification of micro-climate ultimately affecting the quality of life. Category wise land use change in the city of Bengaluru is outlined from 1973 to 2013 is given in the following Table 4-20.

Table 4- 19: Land use changes in Bengaluru during 1973 to 2013

| Land use Class | Urban | | Vegetation | | Water | | Others | |
|----------------|-------|-------|------------|-------|--------|------|--------|-------|
| | Ha | % | Ha | % | Ha | % | Ha | % |
| 1973 | 5448 | 7.97 | 46639 | 68.27 | 2324 | 3.40 | 13903 | 20.35 |
| 1992 | 18650 | 27.30 | 31579 | 46.22 | 1790 | 2.60 | 16303 | 23.86 |
| 1999 | 24163 | 35.37 | 31272 | 45.77 | 1542 | 2.26 | 11346 | 16.61 |
| 2002 | 25782 | 37.75 | 26453 | 38.72 | 1263 | 1.84 | 14825 | 21.69 |
| 2006 | 29535 | 43.23 | 19696 | 28.83 | 1073 | 1.57 | 18017 | 26.37 |
| 2010 | 37266 | 54.42 | 16031 | 23.41 | 617 | 0.90 | 14565 | 21.27 |
| 2013 | 50440 | 73.72 | 10050 | 14.69 | 445.95 | 0.65 | 7485 | 10.94 |

The changes in land use over 40 years is represented in the form of bar chart and land use changes with respect Bengaluru city is given in Figure 4-29 and Figure 4-30 respectively.

Figure 4- 29: Trends in Land use changes in Bengaluru city (1973 to 2013)

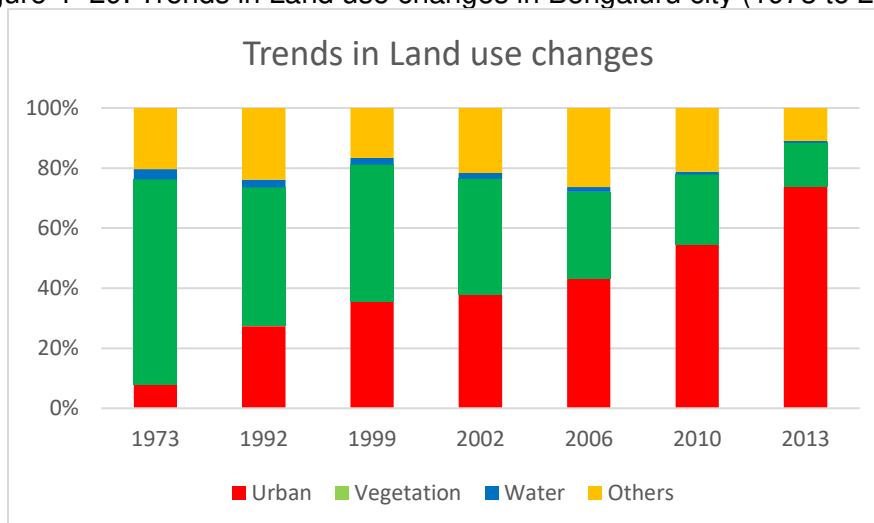
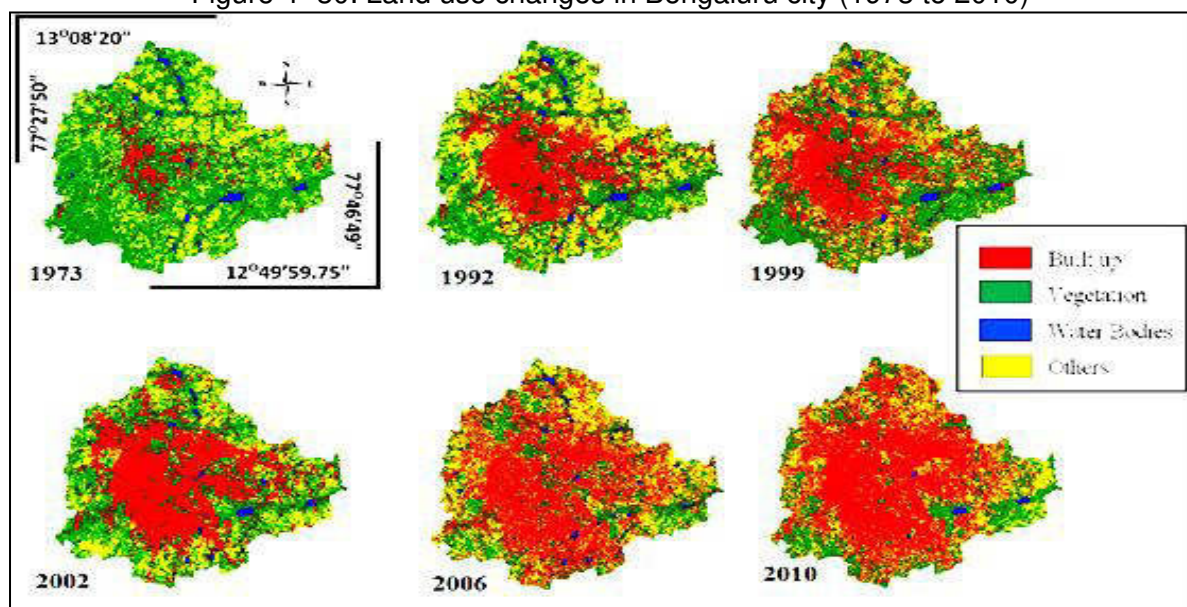


Figure 4- 30: Land use changes in Bengaluru city (1973 to 2010)⁶

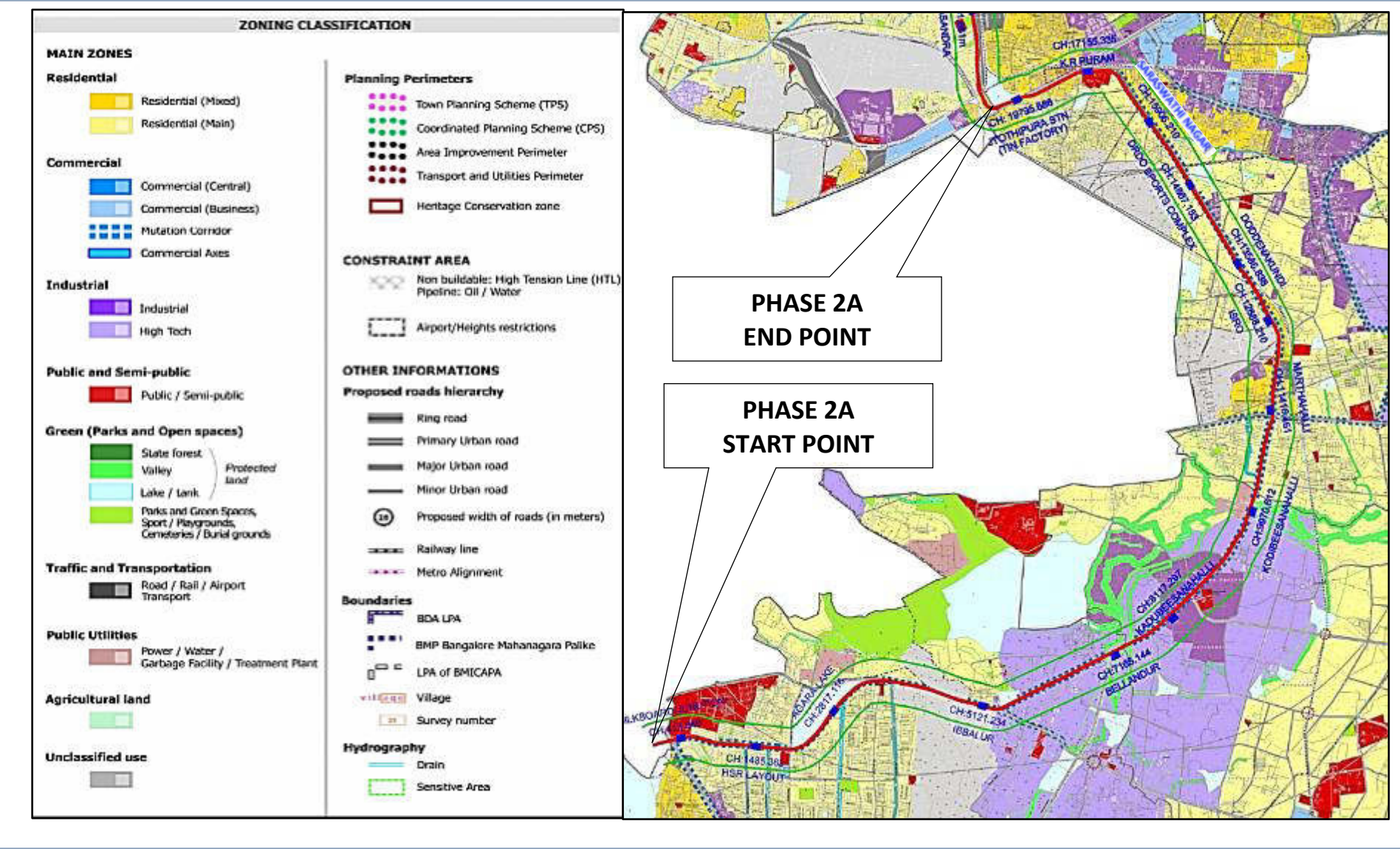
173. The land use map along the proposed Phase 2A metro alignment is presented in Figure 4-32 and the details of land use classes are given in Table 4-21.

Table 4- 20: Details of Land use Classes adjacent to proposed project

| Sl. No. | Land use Type | Length in M (LHS) | Length in M (RHS) | (%) |
|--------------|--|-------------------|-------------------|---------------|
| 1 | Residential | 1600 | 2800 | 11.96 |
| 2 | Commercial | 12450 | 12800 | 68.61 |
| 3 | Industrial | 0 | 750 | 2.04 |
| 4 | Public & Semi Public | 950 | 0 | 2.58 |
| 5 | Green (Parks & Open Spaces) Lake / Tank (Pond) | 2000 | 550 | 6.93 |
| 6 | Traffic & Transportation | 0 | 0 | 0.00 |
| 7 | Public Utilities | 470 | 0 | 1.28 |
| 8 | Agricultural Land | 0 | 0 | 0.00 |
| 9 | Unclassified Use | 930 | 1500 | 6.60 |
| Total | | 18400 | 18400 | 100.00 |

⁶Source: Ramachandra T V, Vinay S and Bharath H.Aithal, 2015. Detrimental land use changes in Agara-Bellandur wetland, ENVIS Technical Report 95, CES, IISc, Bangalore, India.

Figure 4- 31: Landuse adjacent to proposed project corridor



K. Biological Environment

174. Bengaluru has been well known for its green spaces and lakes. In recent years, city has witnessed accelerated and unplanned growth leading to transformation of green lung spaces into a concrete jungle flats and commercial agglomerations. Bengaluru, the Garden City of India has two nationally renowned botanical gardens Cubbon Park which is located at the centre of Bengaluru city at a distance of 6.5 km from the proposed alignment and Lal Bagh which is also located at the centre of Bengaluru city at a distance of 5 km from the proposed alignment. The Cubbon Park was established in the year 1870 by John Meade and has a history of over 100 years. Indigenous and exotic botanical species are found in the park. There are about 68 genera and 96 species with a total of around 6,000 plants/trees. Some of the indigenous species found in the park are *Artocarpus* species, *Cassia fistula*, *Ficus* species, *Polyalthias*, etc., and exotic species such as *Araucaria*, *Bamboo*, *Castanospermum Australe*, *Grevillea robusta*, *Millettia*, *Peltophorum*, *Schinusmolle*, *Swieteniamahagoni*, *Tabebuia* species, etc. Lalbagh, is a botanical garden and has been a treasure house of plants. The rich floral wealth of Lalbagh extends over an area of 97 hectares (240 acres) accommodating 1,854 species 673 genera and 890 cultivars of plants. It is also home to numerous wild species of birds and other wildlife.
175. In 1982, a Forest Division was created under the name Bengaluru Green Belt Division which was entrusted with the job of greening of Bengaluru Metropolitan Region. Later on, the same has been enlarged to cover the Bengaluru Urban District. The natural vegetation consists of species like *Albizia amara*, *Albizia lebbek*, *Anogiessuslatifolia*, *Acacia* species, *Shoreatalura* and *Santalum album*, etc.
176. The geographical area of Bengaluru Urban (Forest) division is 2,17,410 ha. The extent of forestlands within the division is 4,298.43, ha which includes both notified and other Government lands constituting 1.97 % of the geographical area. The forests in the division are of tropical dry deciduous type mostly containing *Acacias*, *Albizia*, *Wrightiatinctoria*, *Zizyphus*, *Pongamia*, etc.
177. As per the Working Plan of Bengaluru Urban forest division, the total area has been divided into five territorial ranges comprising of reserved forests, protected forests and other Government lands. The details of ranges reserved and protected forests, other Government lands and lakes are given in Table 4-22.

Table 4- 21: Details of various categories of forests, range wise abstract (Area in ha)

| Sl. No. | Name of the Range | Total area of notified forests | Other Govt. Lands (in ha.) | Total tanks Extent in ha. | Total forest Area in ha. |
|---------|-------------------|--------------------------------|----------------------------|---------------------------|--------------------------|
| 1 | Anekal | 34.07 | 112.00 | - | 146.07 |
| 2 | Bengaluru | 504.33 | 86.67 | 646.96 | 1237.96 |
| 3 | Kaggalipura | 1831.24 | 252.97 | 54.97 | 2139.18 |
| 4 | KR Puram | 395.70 | 701.45 | 813.86 | 1911.01 |
| 5 | Yelahanka | 380.00 | - | 60.30 | 440.30 |
| | Total | 3145.34 | 1153.09 | 1576.09 | 5874.52 |

Source: Working Plan for Bengaluru Urban Forest Division (period - 2002-03 to 2011-12)

178. All the government lands which are under the control (ownership) of the Forest Department are not notified forests but they have been transferred to Forest Department to take up the tree plantation on these lands under social forestry and community forestry schemes to increase the total green cover in the region. These lands include revenue kharab lands, gomal lands and other areas where the department has raised plantations over the years. Besides, the Revenue Department quite often grants these lands under

some Government schemes. Hence the extent of these lands is decreasing day by day. In addition to the above, Social Forestry wing of the Forest Department also own government lands that have not been notified as forests.

179. The government lands such as C & D class lands, Gomals, tanks, etc. which are originally under the control of Revenue Department are now under the control of Bengaluru Urban Division, Forest Department. These transferred lands can be utilized for taking up compensatory plantation in lieu of trees being impacted by the proposed metro project
180. The following Table 4-23 shows the details of names of the forests and their extent in the jurisdiction of Bengaluru Urban Division.

Table 4-22: Forests and their extent in Bengaluru Urban Division

| Sl. No. | Name of the forest | Forest area in Ha. | Distance to alignment (km) |
|---------|------------------------------------|--------------------|----------------------------|
| 1 | Jarakabande Reserved Forest | 199.92 | 15.0 |
| 2 | Marasandra Reserved Forest | 380.00 | 11.0 |
| 3 | Kumbaranahalli Reserved Forest | 34.07 | 18.5 |
| 4 | Govindapura Reserved Forest | 19.42 | 6.0 |
| 5 | Arkavathi Reserved Forest | 42.89 | 24.00 |
| 6 | Madappanahalli Plantation | 62.29 | 20.0 |
| 7 | Jarakabande Sandal Reserved Forest | 129.81 | 7.50 |
| 8 | Sulikere Reserved Forest | 210.01 | 17.00 |
| 9 | TurahalliGudda Protected Forest | 238.97 | 10.00 |
| 10 | Basavanathara Reserved Forest | 566.80 | 5.00 |
| 11 | Doresanipalya Reserved Forest | 54.88 | 3.50 |
| 12 | Jyothipura Reserved Forest | 228.00 | 30.00 |
| 13 | Mandoor Reserved Forest | 129.60 | 10.50 |
| 14 | B.M.Kaval Reserved Forest | 562.87 | 14.00 |
| 15 | Kadugodi Reserved Forest | 38.10 | 4.50 |
| | Total | 2897.63 | |

Critical Habitats

181. The nearest wildlife sanctuary which is adjacent to Bengaluru Urban District is Bannerghatta National Park. Bannerghatta National Park is notified under the Wildlife (Protection) Act, 1972. It is located at distance of 9 km from the proposed metro alignment. Most of the animals found in these protected areas are also found in the forests of Bengaluru urban division. Wild animals like elephant, wild boar, bear from the sanctuary destroy agricultural crop raised by farmers in and around their habitations. There are also instances of human beings and domestic cattle being killed by wild animals. Often elephants are found migrating from adjacent forests of Bannerghatta National Park.
182. There are no critical habitats except Bannerghatta National Park which is located at a distance of 9.5 km from the proposed project alignment. This national park is peculiarly shaped having a length of 59 km and varying width from 0.3 km to 13.8 km which is mainly due to the impact of urbanization. This park establishes crucial wildlife landscape by connecting the Eastern and Western ghats which mainly support elephant habitat. The State Government has notified the eco-sensitive zones – buffer zones – around this protected space declaring approximately 200 sq km as buffer zone based on the conservation standpoint. Forest Department has taken up barricading, trenches and

electrical fences to conserve wild animals by preventing man-animal conflicts. It is unlikely that the proposed project impacts either on the habitat or the wild animals of the park because of the distance and the presence of urban growth and there is no need for engaging a biodiversity specialist or conservation experts for further assessment and planning.

183. The other key biodiversity areas found within 10 km of the project area is Hoskote Kere which is at a distance of 11.8 km from the proposed project. Other identified habitats like Hesarghatta Lake, Hosur Forest Division, Nandi Hills, Ramanagara Reserve Forest, Thippagondanahalli Reservoir which are within 50 km distance are not key biodiversity areas notified under Wildlife Protection Act, 1972 and are not impacted by the proposed project.
184. With the lack of key biodiversity areas close to the project site, with only water bodies that vary in quality due to the inflow of sewage and pollution, it is unlikely that the project will have any significant impact on key flora and fauna.

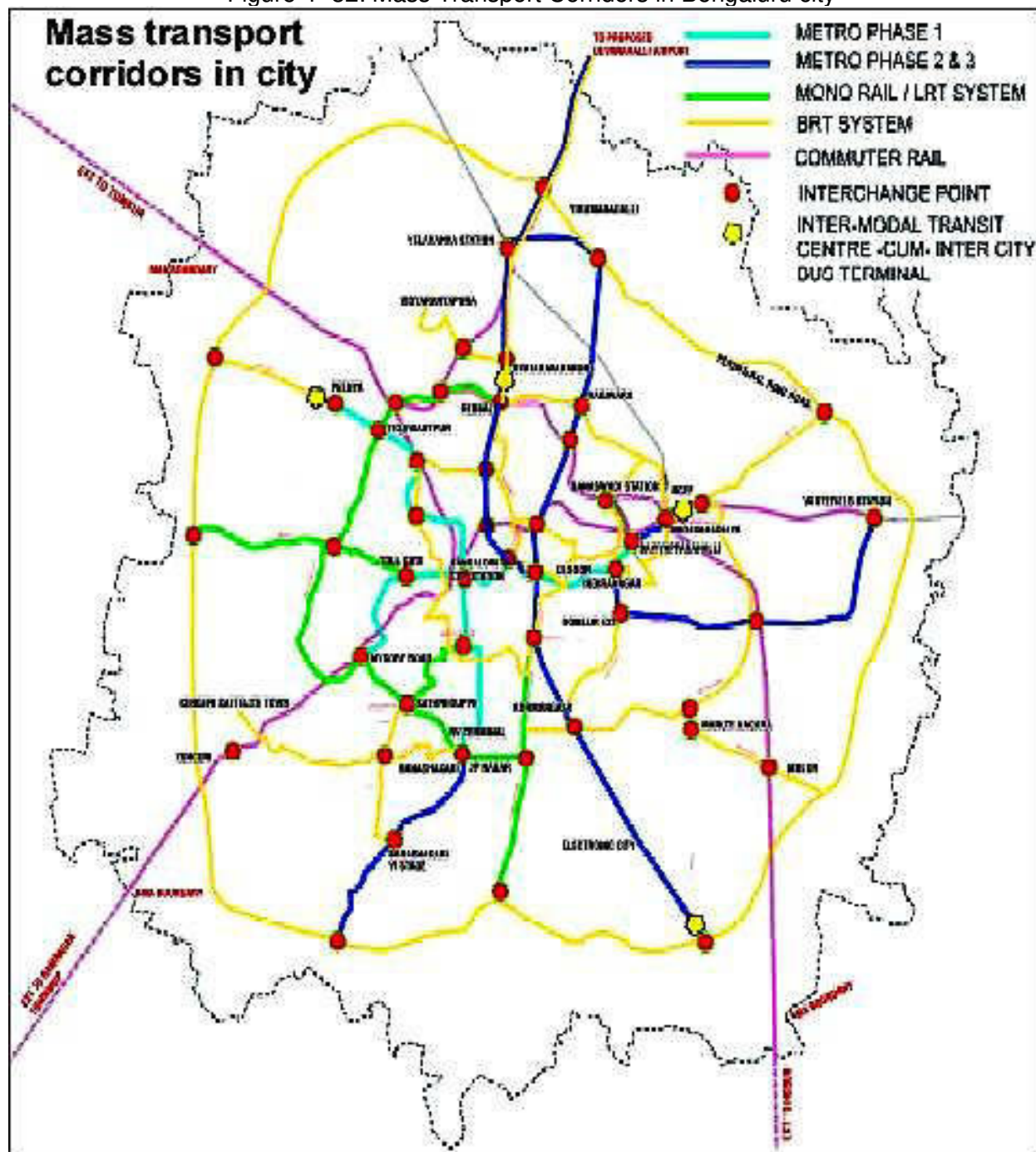
L. Social Economic Environment

185. Bengaluru had population of 9,621,551 as per 2011 Census, of which male and female were 52.20 % and 47.80 % respectively. In contrast, as per 2001 Census, Bengaluru had a population of 6,537,124 of which males were 52.42 % and remaining 47.58 % were females. The Census data shows that population density of 4,381 people per sq. km in 2011 in the district as against 2,985 people per sq. km in 2001.
186. Average literacy rate of Bengaluru in 2011 were 87.67 compared to 82.96 of 2001. Gender wise, male and female literacy were 91.01 and 84.01 respectively. For 2001 census, same figures stood at 87.92 and 77.48 in Bengaluru District.⁷
187. Infrastructure: Annual average power consumption by Bengaluru district is about 14,225 MU and 28% of it is industrial requirement and 33% is for domestic consumption. Power transmission in the district is provided by Bengaluru Electricity Supply Company Limited (BESCOM). At present BWSSB is supplying treated Cauvery Water to Bengaluru City under the Cauvery Water Supply Scheme, Stage I, II, III and Stage IV Phase I and II with total installed capacity of 1,440 MLD as against the current city's demand of 1,575 MLD. Water is sourced from Arkavathi and Cauvery Rivers for drinking purpose. The quantity of water provided to the core areas of BBMP including city municipal councils and town municipal council area, covering a total area of 575 sq.km. BWSSB is finding it difficult to meet the water requirements even after implementation of CWSS Stage IV, Phase II scheme. Considering the water demand, Stage V Scheme has been proposed for implementation in two Phases i.e., Phase I of 500 MLD capacity and Phase II of 275 MLD capacity.⁸ Bengaluru Urban has 46 water tanks of various capacities serving the irrigation needs and has 52 reservoirs and 118 ground level reservoirs.
188. Bengaluru district has a total national highway length of 147 km. NH44 and NH 75 passes through the district. The district has a total railway route of 148.32 km. KIA is the fourth busiest airport in India. Bengaluru Metro (Namma Metro) – Mass Rapid Transit System extends for a total length of 137 km under different phases of execution (Figure 4-32).

⁷Source: <http://www.census2011.co.in/census/district/242-bangalore.html>

⁸https://www.bwssb.gov.in/com_content?page=3&info_for=4

Figure 4- 32: Mass Transport Corridors in Bengaluru city



189. **Economy** - Bengaluru is the highest contributor to the State's economy. Its total Gross Domestic Product (GDP) is INR 993.25 billion contributing 33.3% to Gross State Domestic Product (GSDP) with the per capita annual income in the district being INR. 2,02,340. However, the Gross District Domestic Product (GDDP) trend is 5.5% Compound Annual Growth Rate (CAGR) from 2007-8 to 2012-13, with the services sector reigning supreme at INR 683.30 billion with 39.5% contribution to the state.⁹

⁹<http://www.investkarnataka.co.in/district-profiles-bangaloreurban>

190. **Agriculture** - Bengaluru has 14.09% of its land for cultivation. Amongst this, cereals and pulses occupy 66.36% and 9.94% of the land respectively. Bengaluru is best known for ragi, especially in Anekal Taluk which is called 'Ragi Bowl' in the State. Bengaluru Urban is recognized as Class A destination for floriculture projects. Major crops grown are paddy, ragi, maize, horse gram and oilseeds along with horticultural crops like banana, grapes, papaya, mango sapota, pomegranate and plantation crops like coconut and rose. The district also has 649 milk co-operatives that annually produce 119 Million liters of milk, 34.7 million Eggs, and 5,880 tonnes of meat.
191. **Business and Industries** - Bengaluru Urban district is a vital business hub with 315 large scale industries with an investment of INR 147.9249 billion, 211 medium scale industries with an investment of INR 134.233 billion and 74,282 small-scale industries with a massive investment of INR 412.13 billion. The district has 16 odd industrial areas and Peenya has the largest industrial cluster in Asia. Thirteen industrial estates and 14 notified operational SEZ in Bengaluru forms the framework to the rich industrial landscape in the region.
192. The district is India's highest IT-related exporter with 35% of the 1 million IT pool of India employed here. Bengaluru has India's largest bio-cluster with 40% of India's biotechnology companies present here. It houses 137 of 340 units in India at Electronic city. Bengaluru also anchors aerospace industries in India. Bengaluru is the headquarters of ISRO and DRDO, and many internationally renowned institutions like HAL, DRDO, ISRO, ADA, NAL, IISC, and Antrix Corporation. Also, 4 out of 9 RD Centres of HAL and DRDO's 5 Aeronautic Centres are in Bengaluru.
193. Bengaluru city hosts number of autonomous institutions with high calibre medical professionals, such as National Institute of Mental Health and Neuroscience (NIMHANS) and the Jayadeva Institute of Cardiology. Further, a huge private sector caters to the health needs of the population. Bengaluru is a hub for medical tourism, with super-specialty hospitals boasting state-of-the-art treatment facilities.
194. The land acquisition and resettlement for the proposed line will affect private assets, mainly land and structures which are being acquired by BMRCL following the Karnataka Industrial Area Development Act, 1966. Line 2A will entail impacts on 108 households comprised of 46 titled-owners and 62 tenants. The total land acquisition for the section is 40,403 sqm, of which 21,817 is private land and the rest are government land. Details about land acquisition can be found in the separate Resettlement Plan for the project.

M. Sites of Tourist interest and Environmental significance

195. **Cubbon Park:** Cubbon park was established in the year 1870 and was initially called Meade's Park. Later, the name was changed to 'Cubbon Park' in order to commemorate Sir Mark Cubbon, who was the longest-serving British commissioner at that time. The park has been acting as a lung space of Bengaluru city in the central administrative area. The park was also expanded and landscaped with variety of trees, and flowering shrubs and rocky outcrops. Today, the park covers an area of 121.406 hectares, making it the largest green space in the city. It has a rich recorded history of abundant flora plantation coupled with numerous impressive and aesthetically located buildings and statues of famous personages. The park is home to a variety of exotic and indigenous trees. There are about 6,000 types of plants and trees and one of the most popular species is Silver Oak (*Grevillea robusta*), which is perhaps the first oak to be brought in the city from Australia. Other popular attractions include ornamental species like Gulmohar tree, and the exotic varieties like Polyalthia Bamboo and Cassia Fistula.

196. **Lal Bagh:** One of the popular botanical gardens of India, Lal Bagh is home to approximately 1,000 species of rare herbs and plants. Sprawled across 2,400 acres, the garden is well secured with stone walls. Visitors can visit this park anytime between 6 am in the morning to 7 pm in the evening. Lalbagh botanical garden was commissioned by the ruler of Mysore, Hyder Ali.

Figure 4- 33: Lal BaghandCubbon Park

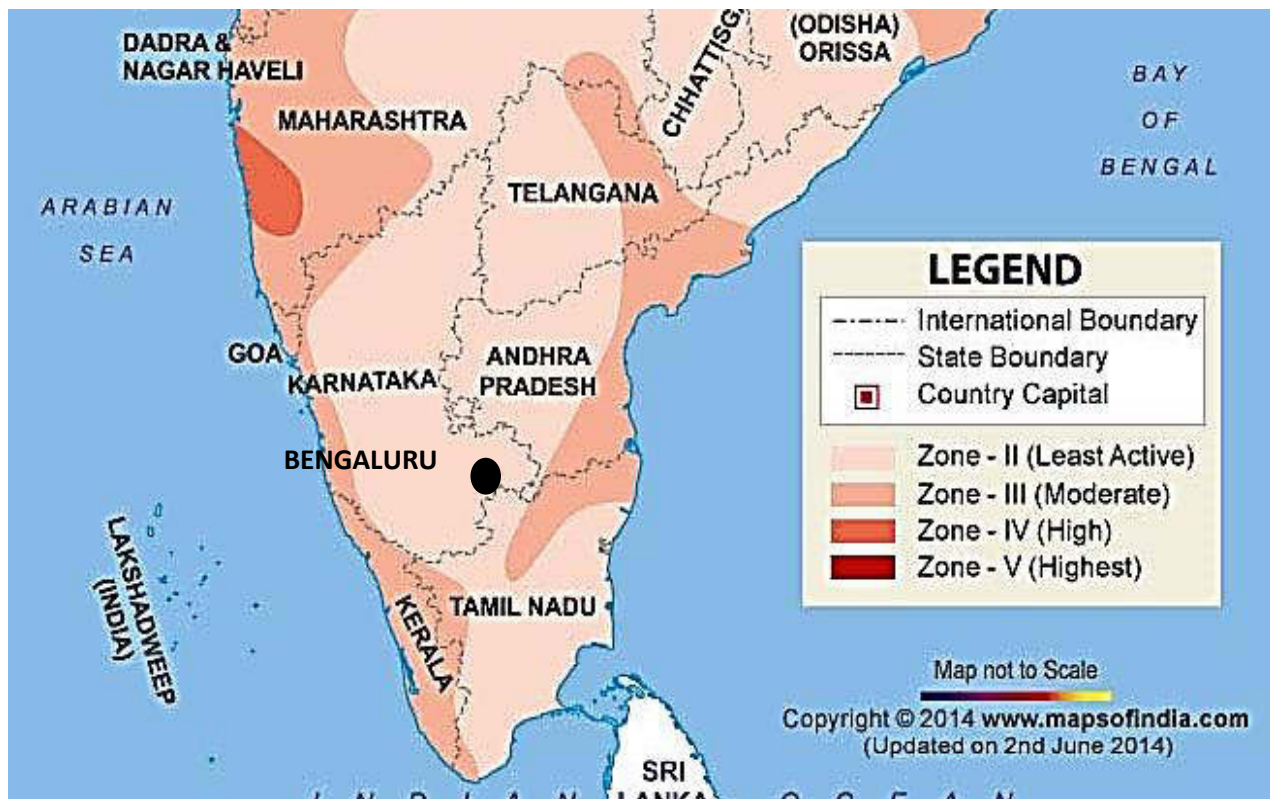


N. Seismicity

197. Bengaluru Urban district lies in a seismically stable region, Zone II(Figure 4-34). Bengaluru has been untouched by major seismic events with only mild tremors recorded in the past. The Indian Peninsular region which was once considered to be seismically stable is experiencing many earthquakes recently. As a part of micro-zonation programme, Department of Science and Technology, GOI has carried out seismic hazard analysis of Bengaluru region considering the regional seismo-tectonic activity based on faults, lineaments, shear zones and historic earthquake events of more than 150 events in about 350 km radius around Bengaluru city. About 21 numbers of faults and lineaments are identified as vulnerable sources as a first step. The vulnerable source for Bengaluru city is identified as Mandya – Channapatna – Bengaluru lineament (Figure 4-35) with an earthquake moment magnitude of 5.1¹⁰.

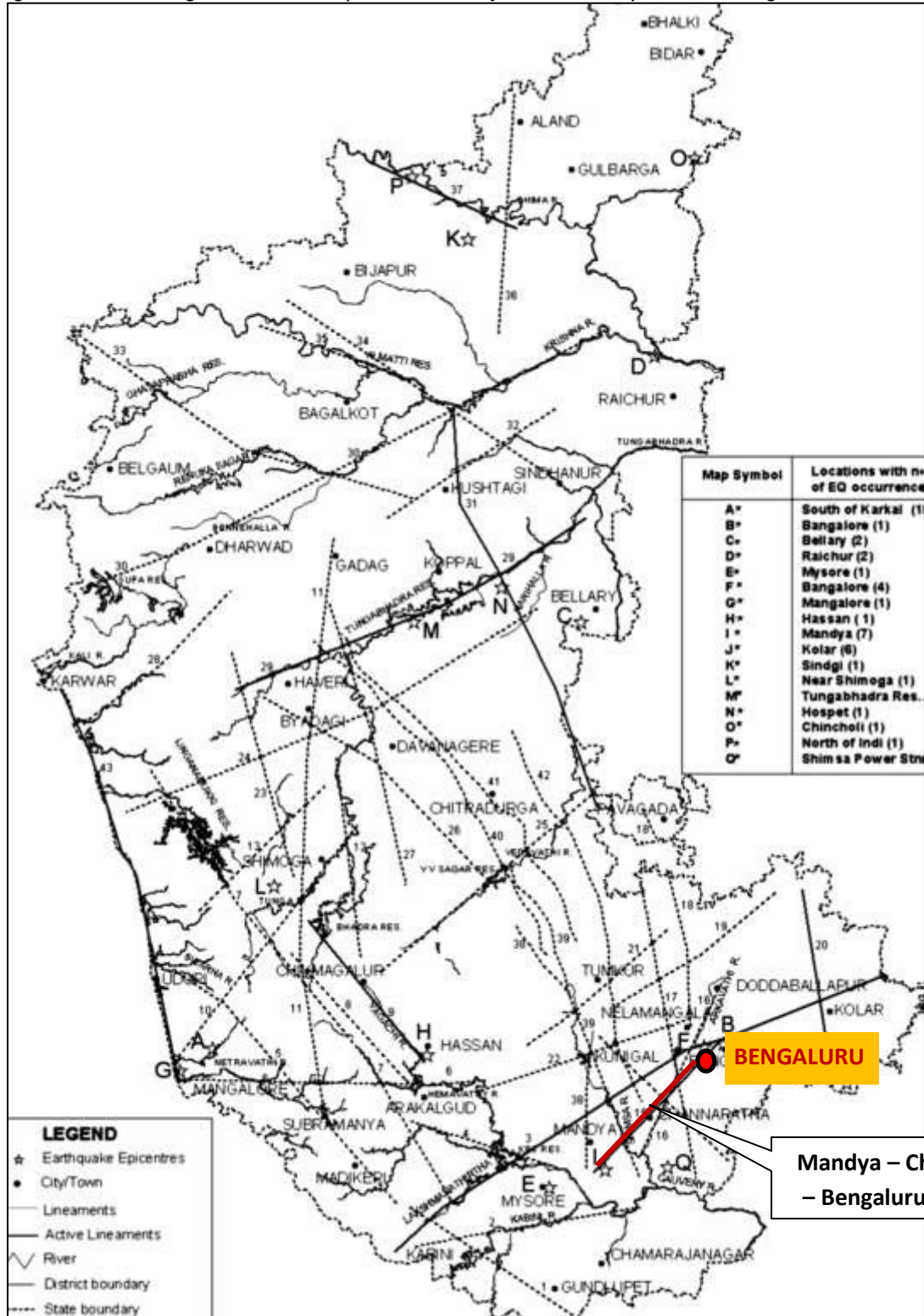
¹⁰http://civil.iisc.ernet.in/~microzonation/index_files/NCW-5.pdf

Figure 4- 34: Bengaluru with respect to Seismic Zones of India



Source: www.mapsofindia.com

Figure 4- 35: Bengaluru with respect to Mandya – Channapatna – Bengaluru lineament



V. ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

A. Methodology

198. The methodology of assessing environmental impacts from the project entailed clearly identifying the environmental components that will be impacted, type of impacts, assessment area where the impacts will be felt and defining the criteria for assessing the significance of each type of impact. After defining these aspects, a screening of project impacts during design and pre-construction (D), construction (C) and operation (O) stages of the project was carried out to identify the minor, moderate and major impacts to guide development of mitigation measures and ensure that there are no or minimal residual impacts.

i. Identification of environmental components

199. This includes identifying the valued environmental components (VEC) of the physical, biological, and human environments that are at risk of being impacted by the project. The VECs for this project which are based on the environmental baseline are:

- Physical environment – air quality and greenhouse gas emissions, land and soil, surface water quality and quantity, and groundwater quality and quantity;
- Biological environment – terrestrial and aquatic vegetation, mammals, avifauna, and ecologically important areas;
- Social environment – private land and buildings, public infrastructure including utility structures, noise and vibration levels, cultural/heritage buildings, and occupational health and safety for the construction workers and local community living within the vicinity of the project area.

ii. Type of impact on the VECs

200. The type of impact can be described as:

- **Positive:** Improvement in the quality of the VECs because of the project;
- **Negative:** Degradation or reduction in the quality of the VECs because of the project;
- **Neutral:** No noticeable change in VECs.

iii. Area of impact assessment

201. The area covered for assessing **direct project impacts** include a of 300m corridor from the centre line of the existing road. In addition, a 10 km radius along the project alignment was studied for **indirect impacts**.

iv. Significance of impacts

202. The assessment of the significance of the impacts on the VECs requires understanding the (i) sensitivity of each VEC within the project context; (ii) duration of impact; (iii) area of impact and (iv) severity of impact. The following sections elaborate these.

203. **(i) Sensitivity of VEC:** The sensitivity of a VEC can be determined by the existing conditions of the VEC within the project area and existence of important VEC's within the project areas. Sensitivity of each VEC is described as high, medium or low as described below.

- **Low:** No environmentally important areas (such as protected areas, natural or critical habitat areas, heritage sites, places of worship etc.) are located within the direct and indirect impact zone. The quality of existing conditions of VECs is good or fair;
- **Medium:** There are one or more environmentally important areas within the indirect impact zone of the project area. The quality of existing conditions of VECs is good or fair;
- **High:** There are one or more environmentally important areas within the direct impact zone of the project area. The quality of existing conditions of the VECs is poor or degraded (such as poor air quality, high noise levels, poor water quality), which makes the VEC highly susceptible to further deterioration.

204. Based on baseline conditions in the project area and sensitivity criteria, the level of sensitivity of each VEC is provided in Table 5-1.

Table 5-1: Sensitivity of VECs in the project area

| Table 3-1: Sensitivity of VECs in the project area | | |
|--|-------------------|---|
| VEC | Sensitivity level | Remarks |
| 1. Physical environment | | |
| 1.1 Air quality | High | The average ambient air quality in the project area is generally poor with PM ₁₀ and PM _{2.5} being the main pollutants. |
| 1.2 GHG emissions | High | Vehicular pollution is expected to be the main source of GHG pollution. |
| 1.3 Surface water quality | High | Water quality of the surface waters in the project area is poor, mainly due to high amounts of organic components and the presence of E. coli. |
| 1.4 Surface water quantity | High | Bengaluru is facing major water shortages. |
| 1.5 Ground water quality | Medium | Water quality of the groundwater in the project area is moderate due to the presence of E. coli. |
| 1.6 Ground water quantity | High | Bengaluru is facing major water shortages. |
| 1.7 Land degradation and pollution | Low | The project alignment is following the median of the Outer Ring Road which passes mainly through residential and industrial areas |
| 2. Biological environment | | |
| 2.1 Trees, terrestrial and aquatic vegetation | Medium | The critical habitat area of Bannerghatta National Park is located at a distance of 9.5 km from the proposed project alignment with extensive urban development in between. The alignment passes a number of freshwater bodies, however none of these serve as ecological habitat for avian and/or aquatic fauna. Approx. 1248 trees have to be removed from the project alignment. |
| 2.2 Terrestrial fauna (mammals, birds, insects) | Low | |
| 2.3 Ecologically important areas) | Low | |
| 3. Social environment | | |
| 3.1 Private land and buildings | Medium | Approximately 108 families will be affected, approx. 21,000 m ² of private land needs to be acquired. |
| 3.2 Public property/ | Medium | In order for the alignment to follow the |

| | | |
|---------------------------------------|--------|---|
| infrastructure/ utility structures | | median of the Outer Ring Road a major gas pipeline at Kadubeesanahalli Junction needs to be shifted. |
| 3.3 Noise | High | The ambient noise levels exceed CPCB limits during daytime as well as nighttime |
| 3.4 Vibration | High | There are several structures located near the elevated sections and above the underground sections. Regular traffic such as buses and trucks on the Outer Ring Road add to vibration levels |
| 3.5 Occupational health and safety | Medium | The project area already experiences some road safety issues due to the heavy traffic plying on the highway |
| 3.6 Public health and safety | Medium | |
| 3.7 Physical cultural resources (PCR) | Low | There are several religious places located within 150m on either side of the alignment but not directly next to it. |

205. **(ii) Duration of the impact:** Duration means the time dimension of the impact on the VECs. The terms permanent, temporary and short-lived are used to describe the duration of impact:

- **Short-lived:** The impact disappears promptly;
- **Temporary:** The impact is felt during one project activity or, at most, during the construction period of the project;
- **Permanent:** The impacts are felt throughout the life of the infrastructure.

206. **(iii) Area of impact:** The area of impact entails the spatial scale of impact on one or more of the VECs. The terms regional, local and limited are used to describe the area of impact:

- **Limited:** The impact is felt within the direct impact zone;
- **Local:** The impact is felt within the indirect impact zone;
- **Regional:** The impact is felt beyond the indirect impact zone.

207. **(iv) Severity of impact:** The severity or seriousness of an impact entails understanding the repercussion or risks posed by the impact. This is a subjective criteria which is defined as high, medium or low as below:

- **High:** The severity of impact is high if grave repercussions are expected as a result of the impact due to any of the following or similar situations: the impact will be felt by a large number of people or receptors; the receptors are highly sensitive; the impacts will cause serious health issues; there is already a history of complaints from the project area and people have raised significant concerns during public consultation; some of the VEC in the project area already severely degraded and maybe further worsened by the project; there will be a significant change in one or more VEC because of the project;
- **Medium:** The severity of impact is medium due to any of the following or similar situations: the impact will be felt by a small number of people; some receptors are affected but they are not sensitive; the impact will not cause serious health issues; some concerns were raised during public consultations, but they were not significant; there will be minor changes in one or more VEC because of the project;
- **Low:** The severity of impact is low due to any of the following or similar situations: the impact will not be felt by anyone; no or limited receptors are affected; no concerns

were raised during public consultations; there will be no noticeable changes in one or more VEC because of the project.

208. Based on the sensitivity of the VEC and the rating of duration, area and severity of impact as described above, the overall significance of each impact was classified as major, moderate or minor as demonstrated in table 5-2 below.

Table 5- 2: Criteria for rating the significance of impacts

| Significance | VEC Sensitivity | Duration | Area | Severity |
|--------------|-----------------|--------------------------|----------------------------|----------|
| Minor | Medium or Low | Short-lived or Temporary | Limited, Local or Regional | Low |
| | Low | Permanent | Limited | Low |
| Moderate | High or Medium | Temporary | Limited, Local or Regional | Medium |
| | Medium | Permanent | Limited | Medium |
| Major | High | Permanent or Temporary | Limited, Local or Regional | High |
| | High or Medium | Permanent | Local or Regional | Medium |

v. Screening of impacts

209. Based on the rating criteria provided in table 5-2, environmental impacts anticipated during the project design and pre-construction/design stage (D), construction (C) stage and operation (O) stage were screened for their level of significance as demonstrated in Table 5-3 below. The screening was carried out for impacts that are expected without mitigation. Hence, it guided the identification of impacts that need mitigation and clearly point out significant/major negative impacts that need to be prioritized for mitigation.

210. The significance of each environmental impact or project activity is indicated by the colors of the cells in the last column of the table 5-3. Red indicates major negative impact, orange indicates moderate negative impact, yellow indicates minor negative impact and green indicates positive impact. The following section discusses the details of impacts on each of the VECs in line with the identification of major, moderate, and minor impacts in the screening matrix. Major impacts have been given priority for identification of mitigation measures to ensure that there are minimal or no residual impacts.

Table 5- 3: Screening of environmental impacts

| VEC/Sensitivity | Impact/Activity | Stage | Duration | Area | Severity | Significance |
|---|---|-------|-----------|----------|----------|--------------|
| 1. Physical environment | | | | | | |
| 1.1 Air quality (high sensitivity) | More efficient and environmentally friendly movement of people | D | Permanent | Local | High | +ve |
| | Dust and gaseous emissions | C | Temporary | Limited | High | Major -ve |
| | Modal shift towards public transport | O | Permanent | Local | High | +ve |
| 1.2 GHG emissions (high sensitivity) | More efficient and environmentally friendly movement of people | D | Permanent | Regional | High | +ve |
| | Gaseous emissions from construction equipment and vehicles | C | Temporary | Limited | Low | Moderate -ve |
| | Modal shift towards public transport | O | Permanent | Regional | High | +ve |
| 1.3 Surface water quality (high sensitivity) | Degradation of water quality due to sewage discharge | D | Permanent | Limited | Low | Moderate -ve |
| | Pollution arising from construction and labor camps and spillages | C | Temporary | Limited | Low | Moderate -ve |
| | Degradation of water quality due to sewage discharge | O | Permanent | Limited | Low | Moderate -ve |
| 1.4 Surface water quantity (high sensitivity) | None | D | | | | Neutral |
| | Increased water scarcity due to utilization for construction | C | Temporary | Limited | High | Moderate -ve |
| | None | O | | | | Neutral |
| 1.5 Ground water quality (medium sensitivity) | None | D | | | | Neutral |
| | Pollution arising from construction and labor camps and spillages | C | Temporary | Limited | Low | Minor -ve |
| | Degradation of water quality due to sewage discharge | O | Permanent | Limited | Low | Moderate -ve |
| 1.6 Ground water quantity | None | D | | | | Neutral |

| VEC/Sensitivity | Impact/Activity | Stage | Duration | Area | Severity | Significance |
|--|--|-------|-----------|---------|----------|--------------|
| (high sensitivity) | Increased water scarcity due to utilization for construction | C | Temporary | Limited | Low | Moderate -ve |
| | Increased water demand from public water supply | O | Permanent | Limited | Medium | Moderate -ve |
| 1.7 Land degradation/ pollution (low sensitivity) | Pollution due to poor waste management practices | D | Permanent | Limited | Low | Minor -ve |
| | Change in topography, soil erosion, muck and debris generation, removal of trees, removal of bituminous pavement | C | Temporary | Local | Low | Minor -ve |
| | None as long as proper waste management procedures are followed | O | | | | Neutral |
| 2. Biological environment | | | | | | |
| 2.1 Trees, terrestrial and aquatic vegetation (medium sensitivity) | Removal and transplantation of trees along the alignment | D | Permanent | Limited | Medium | Moderate -ve |
| | Removal of trees along the alignment | C | Permanent | Limited | Medium | Moderate -ve |
| | None | O | | | | Neutral |
| 2.2 Terrestrial fauna (mammals, birds, insects) (low sensitivity) | None | D | | | | Neutral |
| | Disturbance to fauna at construction site | C | Temporary | Limited | Low | Minor -ve |
| | None | O | | | | Neutral |
| 2.3 Ecologically important areas (low sensitivity) | None | D | | | | Neutral |
| | Extraction of sand from riverbeds | C | Permanent | Local | Low | Minor -ve |
| | None | O | | | | Neutral |
| 3. Social environment | | | | | | |
| 3.1 Private land and buildings (medium sensitivity) | Land acquisition | D | Permanent | Limited | Medium | Moderate -ve |
| | Temporary use of land for construction camps and labor camps | C | Temporary | Limited | Medium | Moderate -ve |

| VEC/Sensitivity | Impact/Activity | Stage | Duration | Area | Severity | Significance |
|--|---|-------|-------------|---------|----------|--------------|
| | Increased accessibility | O | Permanent | Local | High | +ve |
| 3.2 Public property/infrastructure/utility structures (medium sensitivity) | Alignment passes multiple utility services that have to be shifted | D | Temporary | Limited | Medium | Moderate -ve |
| | Unforeseen disruptions of utility services and traffic diversions | C | Temporary | Limited | Medium | Moderate -ve |
| | None | O | | | | Neutral |
| 3.3 Noise (high sensitivity) | Increased noise levels in urban area | D | Permanent | Limited | High | Major -ve |
| | Noise from construction activities and equipment, hauling of materials, construction camps | C | Temporary | Local | High | Major -ve |
| | Increased noise levels due to metro operation | O | Permanent | Limited | High | Major -ve |
| 3.4 Vibration (high sensitivity) | Disturbance and damage due to vibrations | D | Permanent | Limited | High | Major -ve |
| | Disturbance and damage due to vibrations caused by construction equipment and machinery | C | Temporary | Local | High | Major -ve |
| | Disturbance and damage due to vibrations caused by metro operation | O | Permanent | Limited | High | Major -ve |
| 3.5 Occupational health and safety (medium sensitivity) | Provision of Health and Safety features in stations and trains | D | Permanent | Local | Medium | Moderate -ve |
| | Large scale construction activities including handling and transport of large quantities of material and operation of heavy machinery and equipment | C | Short-lived | Limited | High | Moderate -ve |
| | Risk of accidents/incidents and communicable diseases | O | Permanent | Local | Medium | Moderate -ve |
| | Large scale movement of people | D | Permanent | Local | High | Moderate -ve |

| VEC/Sensitivity | Impact/Activity | Stage | Duration | Area | Severity | Significance |
|---|---|-------|-------------|---------|----------|--------------|
| 3.6 Public health and safety (medium sensitivity) | Nuisance due to large scale construction activities in urban area | C | Temporary | Limited | High | Moderate -ve |
| | Risk of communicable diseases | O | Permanent | Local | High | Moderate -ve |
| 3.7 Physical cultural resources (PCR) (low sensitivity) | None | D | | | | Neutral |
| | Possible chance finds of objects of archeological interest | C | Short-lived | Limited | Low | Minor -ve |
| | None | O | | | | Neutral |

Note: +ve = positive impact; -ve = negative impact; C = construction stage; D = design & pre-construction stage; O = operation stage; VEC = valued environmental component



: positive impact



: minor negative impact



: moderate negative impact



: major negative impact

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 CO₂. 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 m³ and the concrete debris is estimated at 7,822m³. The details are given in table 5-6.

Table 5- 6: Quantity of Soil Debris and C&D waste generated (m³)

| 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 CO₂ 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 trees 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 m² of which 20,899.33 m² is private land and 32,575.94 m² 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 are addressed 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 Abhayastha 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 construction¹¹

| 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

¹¹These 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 limits¹² 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
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- 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 Criteria¹³

| Structure and Condition | Maximum PPV (in/sec) | |
|--|----------------------|--|
| | 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

| Human Response | Maximum PPV (in/sec) | |
|------------------------|----------------------|--|
| | 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 the 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 disbursement 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 requested that the matter be 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

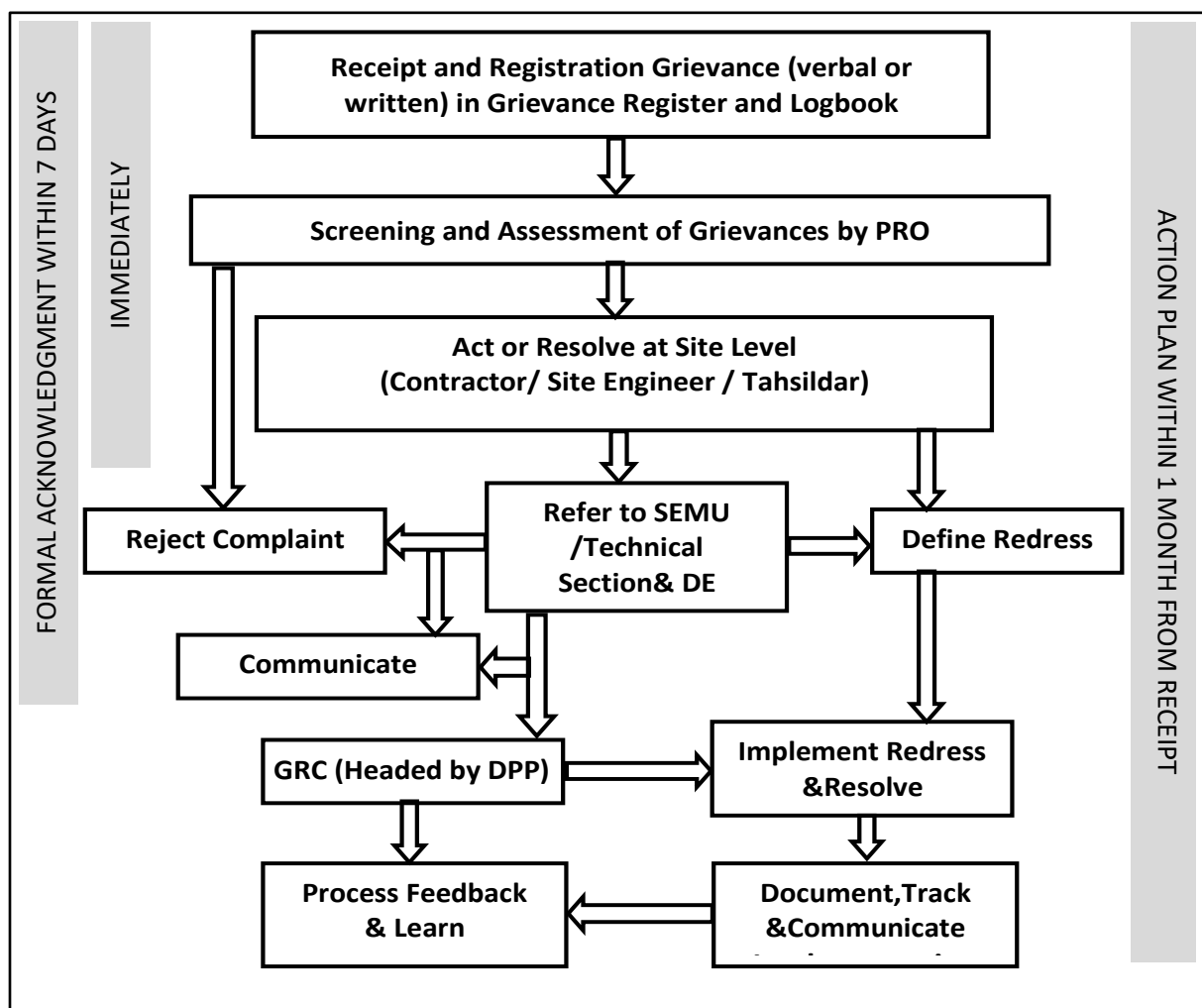
- c. General Manager (F & A), Member
- d. Chief Public Relation Officer, Member
- e. Chief Engineer / (respective Reach), Member
- f. Manager (Transportation), Member
- g. Tahsildar (Respective Reach).

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.

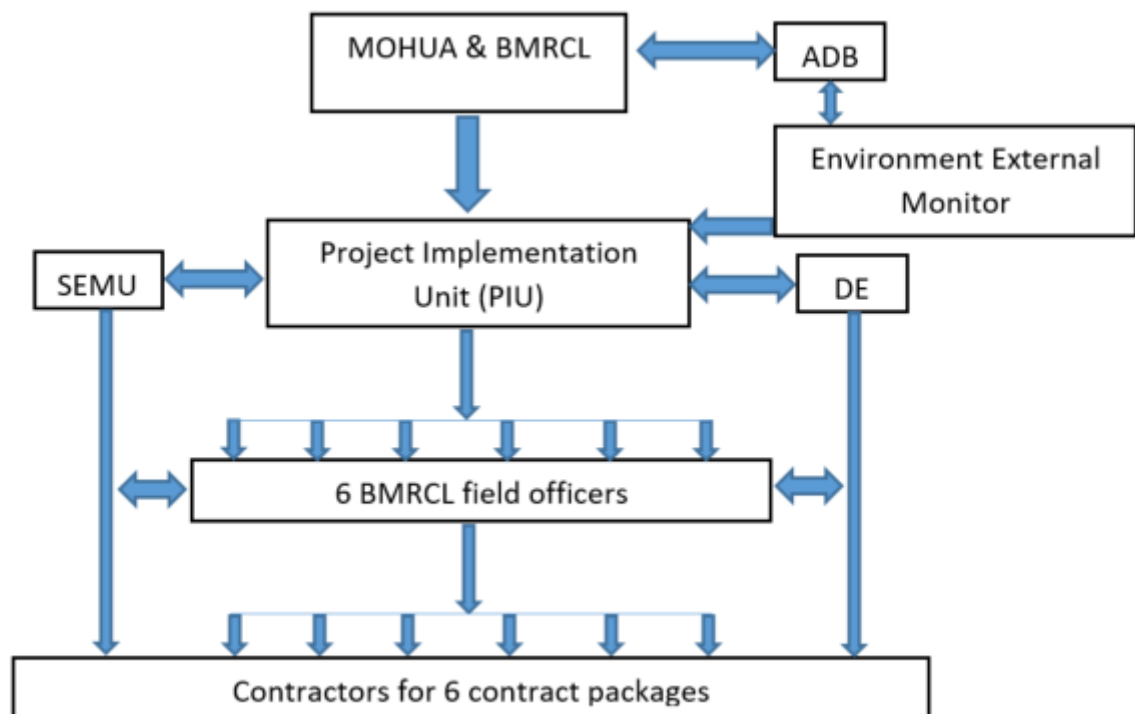


Figure 7- 3: Organizational Chart

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 m² of land of which 20,899.33 m² is private land and 32,575.94 m² 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. | <ul style="list-style-type: none">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 translocated 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 |
| | | | <p>removed shall be marked with paint.</p> <p>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.</p> <p>Transplantation of trees shall be taken up on priority suiting to the tree species, age, size, and health condition of the tree.</p> <p>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.</p> <p>The tree saplings which do not survive during the first year after replanting will be compensated immediately.</p> | | | | | |
| 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. | <p>Barricades of at least 3 m height will be installed to mark the boundary of the areas where public utilities are to be relocated.</p> <p>Workers shall be provided with appropriate PPEs and ensure to operate equipment in a safe manner during shifting works</p> <p>Utility shifting shall be coordinated such that information on utilities' locations is obtained before digging.</p> <p>Concerned departments shall be requested either to shift their utilities or to strictly supervise the shifting works to avoid any unforeseen safety hazards.</p> <p>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.</p> <p>Restoration of road surface, footpaths, signboards that are</p> | 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 |
| | | | <p>damaged during relocation of public utilities immediately to the original conditions.</p> <p>The Contractor shall abide by the terms and conditions stipulated in Condition of Contract of Safety, Health & Environment Manual.</p> | | | | | |
| 9 | Relocation of affected Cultural, Religious and demolition of private properties | <p>Social – There is no major impact on the cultural and religious structures from the proposed metro alignments and 4 metro stations.</p> <p>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.</p> | <p>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.</p> <p>Owners of private buildings shall be compensated in line with Entitlement Matrix and KIADB Act, 1966.</p> <p>Unnecessary damage to the structure shall be avoided and the structures being impacted shall be suitably compensated on par with the applicable statutory requirements.</p> | 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. | <p>Water sprinkling shall be done twice or thrice both at construction sites and haulage routes to encapsulate dust from the excavated heaps.</p> <p>Fugitive dust while loading and unloading should be controlled using water sprinkling.</p> <p>Trucks transporting dismantled debris and excavated soil to dump locations shall be covered with tarpaulins to prevent spillage of soil during transportation.</p> | 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. | <p>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).</p> <p>Haulage of dismantled and excavated debris by trucks should be planned during non-peak hours.</p> | Throughout project section especially at construction sites near identified sensitive receptor locations. | <p>Noise levels measurements</p> <p>Complaints from local people.</p> | <p>As per Noise Rules,2000</p> <p>Consultation with local people</p> | 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. | <p>The Contractor will complete the following activities no later than 30 days upon issuance of Notice to Proceed</p> <p>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 assessment 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</p> | 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. | <p>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.</p> <p>Contractor shall finalize quarry for procurement of construction materials after assessment of availability of sufficient quantity of materials, quality and the logistic arrangements.</p> <p>Contractor shall also work out haul road network and report to Environmental Specialist of DE</p> | 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 |
| | | | <p>and DE shall inspect and in turn report to BMRCL before approval.</p> <p>All the required permissions / consents from SPCB shall be obtained, if it is new quarry.</p> <p>The Contractor shall prepare a reinstatement plan for the quarry site and get approved by the DE.</p> | | | | | |
| 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. | <p>Quarries and crushers shall be sited sufficiently (at least 500m) away from settlements and fertile agricultural lands preferably in the downwind direction.</p> <p>Quarries and crushers shall be located at a distance of 300 m from water bodies and sensitive ecosystems such as forests.</p> <p>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.</p> <p>Specifications for crushers and batching plants shall comply with the requirements of relevant emission control legislations. Consent for the</p> | 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. | <p>prescribed under the Environment Protection Act, 1986 and Motor Vehicles Act, 1988 shall be strictly adhered.</p> <p>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)</p> <p>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.</p> | | 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 | <p>Construction Water Management Plan shall be prepared and implemented after getting approval from Environmental Specialist of DE.</p> <p>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</p> | 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 | |
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| | | | | | indicators | Method | Implementation | Supervision |
| | | source water required for construction without affecting the existing users. | <p>source/s from where water shall be used for the project to DE and BMRCL.</p> <p>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.</p> <p>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,</p> <p>The Contractor shall take all precaution to minimize the wastage of water during construction activities.</p> | | | | | |
| 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 | <p>Sand shall be procured from identified and approved sand mines only.</p> <p>If the sand is being procured from new sand quarry /</p> | Location of sand quarry area. | Approval from competent authority. | Checking of documentation. | Contractor | DE, BMRCL |

| Sl. No. | Activity | Impact | Mitigation Measures | Location | Monitoring | | Responsibility | |
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| | | | | | 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 | |
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| | | | | | indicators | Method | Implementation | Supervision |
| | | | <p>settlements or villages; major surface water bodies and forests.</p> <p>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.</p> <p>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.</p> <p>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).</p> <p>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).</p> | | | | | |

| Sl. No. | Activity | Impact | Mitigation Measures | Location | Monitoring | | Responsibility | |
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| | | | | | 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. | <p>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.</p> <p>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.</p> <p>Contractor's camps shall be identified at least 2km away from the Forest Reserves.</p> <p>Consent to Establishment and Operate (CtE&CtO) shall be taken from State Pollution Control Board to establish batching plants, construction camps.</p> | 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. | <p>BMRCL shall organize orientation sessions and regular training sessions before the start of construction of project. This training shall include general as well as specific context of the project.</p> <p>These sessions shall involve all staff of BMRCL involved in implementation of EMP,</p> | Throughout the project. | Training plan and records | Checking of documentation. | DE | BMRCL |

| Sl. No. | Activity | Impact | Mitigation Measures | Location | Monitoring | | Responsibility | |
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| | | | | | indicators | Method | Implementation | Supervision |
| | | | Environmental Specialists of DE and Contractors. | | | | | |
| Construction Phase: | | | | | | | | |
| 26 | Excavations (Clearing, grubbing and levelling of site) | <p>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.</p> <p>Clearing, grubbing and levelling activities are common all along the proposed metro alignment and metro station locations.</p> <p>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)</p> | <p>Only ground cover / shrubs that impinge directly on permanent works or necessary temporary works shall be removed.</p> <p>A portion of this will be reused for backfilling. The remaining soil debris will be suitably disposed of to the pre-identified approved locations.</p> <p>Infiltration losses due to site leveling and could be countered by installing Rain Water Harvesting (RWH) pits at camp and plant sites.</p> | 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 | |
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| | | | | | 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 | Throughout project corridor with excavation activities. | PM _{2.5} and PM ₁₀ level measurements Dust pollution or complaint of locals. | Contractor | DE, BMRCL |

| Sl. No. | Activity | Impact | Mitigation Measures | Location | Monitoring | | Responsibility | |
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| | | | | | 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 | |
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| | | | | | indicators | Method | Implementation | Supervision |
| | | | <p>meet the project standards (annex 4) for nearby sensitive receptors are prohibited between 10PM and 6AM to reduce construction noise impacts during night hours.</p> <p>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.</p> <p>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.</p> <p>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.</p> | | | | | |

| Sl. No. | Activity | Impact | Mitigation Measures | Location | Monitoring | | Responsibility | |
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| | | | | | indicators | Method | Implementation | Supervision |
| 32 | | <p>Health and Safety - Noise and vibration generated during piling will affect the health and safety of the workers</p> <p>Vibration may cause damage to adjacent sensitive structures</p> | <p>3 m tall screens of GI sheets will be installed between source (pile driver) and receptors (workers & nearby populations).</p> <p>Workers involved in piling will be provided with personal safety gears such as ear plugs, ear muffs.</p> <p>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.</p> | Throughout project section especially at construction sites, residential and identified sensitive locations. | <p>Noise and vibration levels measurements</p> <p>Complaints from local people.</p> | <p>As per SHE Manual, Noise rule,2000</p> <p>Consultation with local people</p> | 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. | <p>Barricading to a height of 3 m will be provided to reduce dust generation.</p> <p>Water sprinkling shall be done twice or thrice both at construction sites and haulage</p> | 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 | |
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| | | | | | indicators | Method | Implementation | Supervision |
| | | | <p>routes to encapsulate dust from the excavated heaps.</p> <p>Fugitive dust while loading and unloading should be controlled using water sprinkling.</p> <p>Trucks transporting excavated soil to dump locations shall be covered with tarpaulins to prevent spillage of soil during transportation.</p> | | 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. | <p>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).</p> <p>Haulage of excavated debris by trucks should be planned during non-peak hours.</p> <p>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.</p> <p>Continuous loud noises around noise sensitive receptors such</p> | Throughout project section especially at construction sites near identified sensitive receptor locations. | <p>Noise levels measurements</p> <p>Complaints from local people.</p> | <p>As per Noise Rules,2000</p> <p>Consultation with local people</p> | Contractor | DE, BMRCL |

| Sl. No. | Activity | Impact | Mitigation Measures | Location | Monitoring | | Responsibility | |
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| | | | | | indicators | Method | Implementation | Supervision |
| | | | <p>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.</p> <p>Noise and vibration control and monitoring stipulated in the SHE manual shall be followed and project limits shall be observed.</p> | | | | | |
| 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. | <p>The local community has to be taken into confidence before the construction commences. Their advice has to be taken and incorporated in decision making.</p> <p>The routing, timing and logistics of the haul truck movement should be planned to have minimal impact on noise level.</p> <p>Strict speed limits should be followed at the settlement areas and on the haulage roads.</p> <p>Haulage of excavated materials should be planned during non-peak hours.</p> | 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 | |
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| | | | | | 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. | <p>Movement of trucks shall be planned such that it causes least problematic and safer to the public.</p> <p>All required safety signboards precautions shall be erected along the haulage routes to ensure uninterrupted flow of traffic.</p> <p>Construction zone shall be separated from inhabited zones to avoid any unforeseen safety threats and consequences.</p> | | | | | |
| 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. | <p>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.</p> <p>All waste debris shall be completely cleared from construction sites on regular basis and disposed of in approved disposal sites and</p> | At all approved dumping sites | <p>Location of dumping sites</p> <p>Public complaints</p> | Field survey and interaction with local people | Contractor | DE, BMRCL |

| Sl. No. | Activity | Impact | Mitigation Measures | Location | Monitoring | | Responsibility | |
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| | | | | | indicators | Method | Implementation | Supervision |
| | | | <p>certified by Environmental Specialist of DE.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>Contractor at his cost shall resolve any claim, arising out of waste disposal or any non-compliance that may arise on</p> | | | | | |

| Sl. No. | Activity | Impact | Mitigation Measures | Location | Monitoring | | Responsibility | |
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| | | | | | 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. | <p>The construction and demolition waste generated during the construction phase should be managed in accordance with the C&D Waste Management Rules, 2016.</p> <p>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.</p> <p>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.</p> | 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 | |
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| | | | | | 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 | |
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| | | | | | 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 | |
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| | | | | | indicators | Method | Implementation | Supervision |
| | | | <p>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.</p> <p>Permission from BBMP and Traffic police shall be sought before commencement of construction works.</p> <p>Contractor shall ensure that the diversion/detour is always maintained in running condition, particularly during the monsoon to avoid disruption to traffic flow.</p> <p>Contractor shall inform local community of the changes to traffic routes; conditions and pedestrian access arrangements with assistance from DE and BMRCL.</p> | diversion and intersections | <p>Safety signs on site</p> <p>Number of traffic accidents</p> | <p>observation of traffic management and safety system</p> <p>Interaction with people in vehicles using the road</p> | | |
| 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 | |
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| | | | | | 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} , NO _x , 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 | |
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| | | | | | 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 | |
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| | | | | | 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. | <p>All vehicles delivering fine materials to the site shall be properly covered with tarpaulins to avoid spillage of materials.</p> <p>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.</p> <p>Contractor shall arrange for regular water sprinkling as necessary for dust suppression of all such roads and surfaces.</p> | 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 | <p>Contractor shall construct silt fencing around the stockpiles at the construction sites including ancillary sites close to water bodies.</p> <p>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.</p> | 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 | |
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| | | | | | 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 | |
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| | | | | | 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 | |
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| | | | | | indicators | Method | Implementation | Supervision |
| | | | <p>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.</p> <p>All the required permissions from the concerned local authorities shall be procured before use of water resources for construction and curing.</p> | | | | | |
| 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 | <p>Proper drainage shall be ensured to guide the curing water to the nearby drains.</p> <p>Garland drainage is proposed to be constructed around the construction yard. This will intercept the runoff generated from site.</p> | 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/m ² /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 | |
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| | | | | | 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). | <p>Cranes and launchers shall be serviced and maintained regularly to prevent them making noise.</p> <p>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.</p> <p>The construction workers working near construction equipment shall be provided with PPEs like ear plugs / muffs complying with relevant standards.</p> <p>Noise emitting crane and launching works at noise sensitive receptors like schools, colleges and hospitals shall be scheduled properly to</p> | 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 | |
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| | | | | | indicators | Method | Implementation | Supervision |
| | | | <p>avoid or reduce impact on them.</p> <p>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.</p> | | | | | |
| 66 | | Health & Safety - Cranes and launchers are a major safety concern during construction. | <p>Contractor shall engage only qualified & trained crane/launcher operators.</p> <p>Contractor shall ensure regular servicing and maintenance of cranes and launchers to avoid malfunction of equipment.</p> <p>Proper training shall be given to crane & launcher operators and labors before the commencement of work.</p> <p>Operation of launchers and cranes shall be done only under the strict supervision of a qualified engineer and a safety supervisor.</p> <p>The operating personnel should follow the operating and maintenance manuals supplied along with the cranes & launchers to understand the</p> | Construction sites | <p>Availability of Safety gears to workers</p> <p>Safety signage Training records on safety</p> <p>Number of safety related accidents</p> | <p>Site observation</p> <p>Review records on safety training and accidents</p> <p>Interact with construction workers</p> | Contractor | DE, BMRCL |

| Sl. No. | Activity | Impact | Mitigation Measures | Location | Monitoring | | Responsibility | |
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| | | | | | indicators | Method | Implementation | Supervision |
| | | | <p>crane and operate the crane efficiently and safely.</p> <p>Instructions in Safety, Health & Environment Manual shall be followed.</p> <p>The Contractor shall abide by the terms and conditions stipulated in Condition of Contract on Safety, Health & Environment and Project Safety, Health & Environment Manual.</p> | | | | | |
| 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. | <p>Contractor shall obtain permission from District Health Officer before establishing labor camps.</p> <p>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.</p> <p>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.</p> | All construction camps | <p>Camp health records</p> <p>Existence of proper first aid kit in campsite</p> <p>Complaints from local people</p> <p>Availability of Safety gears to workers</p> | <p>Camp records</p> <p>Site observation</p> <p>Consultation with local people living nearby</p> <p>Interact with construction workers</p> | Contractor | DE, BMRCL |

| Sl. No. | Activity | Impact | Mitigation Measures | Location | Monitoring | | Responsibility | |
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| | | | | | indicators | Method | Implementation | Supervision |
| 68 | | <p>Resource scarcity – Establishment of labor camps requires resources like water thus increasing pressure on local resources.</p> <p>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.</p> <p>Dependency of laborers on fuel wood for cooking and</p> | <p>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.</p> <p>The Contractor shall also guarantee the following:</p> <ol style="list-style-type: none"> 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. 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. 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. 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 | |
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| | | | | | indicators | Method | Implementation | Supervision |
| | | heating purposes will result in cutting of trees in and around labor camp. | <p>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.</p> <p>f) Analysis of water shall be done every month as per parameters prescribed in IS 10500-1991.</p> <p>Environmental Specialist of DE shall be required to inspect the labor camp once in a week to ensure the compliance of the EMP.</p> <p>Contractor shall provide sufficient quantity and timely supply of liquid petroleum gas to the laborers to discourage cutting of trees and vegetation.</p> | | | | | |
| 69 | | <p>Sanitation and Sewage System – Wastewater generated at the construction camps and labor camps will pollute the soil, surface and ground water if disposed untreated.</p> <p>Impacts from storing, treating and disposing the sewage waste and solid wastes increases breeding sites of mosquitoes in turn</p> | <p>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.</p> <p>The location, layout and basic facility provision of each labor camp shall be submitted to DE</p> | | | | | |

| Sl. No. | Activity | Impact | Mitigation Measures | Location | Monitoring | | Responsibility | |
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| | | | | | indicators | Method | Implementation | Supervision |
| | | <p>increases the risk of vector borne diseases such as malaria.</p> <p>Supply of non-potable water will not only cause communicable diseases to laborers but also act as potential centers for spreading diseases</p> <p>There is also a possibility of spreading diseases such as HIV, COVID 19, and others by having contact with local population.</p> | <p>and BMRCL prior to their construction. The construction shall commence only upon the written approval of the DE.</p> <p>The Contractor shall maintain necessary living accommodation and ancillary facilities in functional and hygienic manner and as approved by the DE.</p> <p>The Contractor shall maintain sufficient and appropriate sanitary facilities available and maintain hygienic conditions functional in the labor camps.</p> <p>Necessary living accommodation and ancillary facilities shall be provided in labor camps as approved by the DE.</p> <p>The Contractor shall ensure that</p> <ul style="list-style-type: none"> - 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 | |
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| | | | | | indicators | Method | Implementation | Supervision |
| | | | <ul style="list-style-type: none"> - 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 <p>The Contractor shall arrange for</p> <ul style="list-style-type: none"> - 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. <p>Contractor should ensure to conduct HIV and other communicable diseases awareness programs.</p> | | | | | |
| 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 | |
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| | | | | | indicators | Method | Implementation | Supervision |
| | | transmission of communicable diseases from workers to local populations. | <p>sent to treatment. Biodegradable wastes are treated by composting and non-biodegradable wastes are either recycled or disposed of to authorized land fill site.</p> <p>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.</p> | | | | | |
| 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. | <p>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.</p> <p>Water shall be sprayed on haulage roads within the premises of batching plants on a regular basis.</p> <p>The batching plants shall be fitted with dust extraction units and collectors to reduce exhaust dust.</p> <p>Batching plants / casting yards shall be barricaded and</p> | 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 | |
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| | | | | | 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). | <p>designated as a compulsory PPE zone to effectively reduce the impact from fugitive dust emissions.</p> <p>Required permissions for electrical connection and supply must be obtained from BESCOM by the Contractor.</p> <p>DG sets, if used, shall:</p> <p>(a) conform to height of stack norms as per CPCB rules;</p> <p>(b) conform to emission norms as per Environment (Protection) Act, 1986;</p> <p>(c) noise level at 1 m distance from enclosure shall not be >75 dB(A).</p> <p>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.</p> | | | | | |
| 72 | | Noise and vibration - Batching plants will generate noise and vibration during operation | <p>Batching plants / casting yards shall be barricaded and designated as a compulsory PPE zone.</p> <p>Workers working in close proximity of the batching plants shall be provided with suitable PPEs like earmuffs & plugs reduce the impacts of noise.</p> | | | | | |

| Sl. No. | Activity | Impact | Mitigation Measures | Location | Monitoring | | Responsibility | |
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| | | | | | 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 | |
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| | | | | | 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 | |
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| | | | | | indicators | Method | Implementation | Supervision |
| 81 | Use of DG sets at construction sites | Air - Air pollution from emissions of DG sets | <p>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.</p> <p>(a) Emissions from DG shall adhere to CPCB prescribed norms</p> <p>(b) Stack height of DG sets shall be as per CPCB requirement (stack height= 0.2* (rating in kVA) 0.5]</p> <p>(c) Low Sulphur diesel shall be used in the DG sets.</p> | 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 | <p>DG sets shall be insulated type to mitigate noise at source itself.</p> <p>DG sets shall be mounted on damping skids to reduce the vibration generated from DG sets.</p> <p>Project limits and monitoring requirements set out in the SHE manual shall be followed</p> | | | | | |
| 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 | Fuelling station, construction | Quality of soil | Site | Contractor | DE, BMRCL |

| Sl. No. | Activity | Impact | Mitigation Measures | Location | Monitoring | | Responsibility | |
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| | | or above ground storage facility will adversely affect the quality of ground and surface water respectively | <p>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.</p> <p>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.</p> <p>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.</p> <p>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.</p> | sites, andconstructi oncamp 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 | <p>Proper onsite emergency plan shall be prepared by the Contractor and get approved through BMRCL.</p> <p>If the diesel storage crosses the threshold limits permissions from Chief Controller of Explosives (CCoE).</p> | | | | | |

| Sl. No. | Activity | Impact | Mitigation Measures | Location | Monitoring | | Responsibility | |
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| | | 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. | <p>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.</p> <p>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.</p> <p>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.</p> <p>The Contractor shall submit the locations and layout plans of such sites prior to their</p> | 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 | |
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| | | | | | indicators | Method | Implementation | Supervision |
| | | | <p>establishment and shall be approved by the Environmental Specialist of DE.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>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</p> | | | | | |

| Sl. No. | Activity | Impact | Mitigation Measures | Location | Monitoring | | Responsibility | |
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| | | | | | 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. | <p>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.</p> <p>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.</p> | 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. | <p>Beds nearby water bodies shall not be excavated for borrowing earth for construction.</p> <p>Silt fencing shall be constructed around the stockpiles at the construction sites including ancillary sites close to water bodies.</p> <p>Construction materials containing fine particles are stored in an enclosure such that sediment-laden water does</p> | 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 | |
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| | | | | | 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. | <p>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</p> <p>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.</p> | 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. | <p>All Construction plants and equipment used in construction shall strictly conform to the MoEF&CC/CPCB noise standards.</p> <p>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.</p> <p>Servicing of all construction vehicles and machinery shall be done regularly and during routine servicing operations.</p> | | | | 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. | <p>Contractor shall provide:</p> <ul style="list-style-type: none"> ➤ 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. <p>The Contractor shall comply with all the precautions as required for ensuring the safety of the workmen as per those applicable to the contract.</p> | 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 |
| | | | <p>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.</p> <p>The Contractor shall also ensure that paint containing lead or lead products is used except in the form of paste or readymade paint.</p> <p>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.</p> <p>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</p> | | | | | |

| 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 | | <p>The Contractor shall take all required precautions to prevent danger from electrical equipment and ensure that.</p> <ul style="list-style-type: none"> ➤ 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. <p>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</p> | 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 | | <p>Contractor shall take reasonable precautions to prevent danger to the workers and public from emergency spillage, fire, flood, etc. resulting from construction activities.</p> <p>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.</p> | The project. | Conditions on contractors' contract. | Checking of document. | Contractor | DE, BMRCL |
| 94 | First Aid | | <p>The Contractor shall arrange for –</p> <p>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.</p> <p>Availability of suitable transport at all times to take injured or sick person(s) to the nearest hospital.</p> | Construction sites | <p>Availability of first aid boxes</p> <p>Number of safety related accidents</p> | <p>Site observation</p> <p>Review records on accidents</p> <p>Interact with construction workers</p> | 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. | <p>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.</p> <p>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.</p> <p>The DE shall seek direction from the Archaeological Survey of India (ASI) before instructing the Contractor to recommence the work in the site. The</p> | 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 | <p>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.</p> <p>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.</p> | 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 | <p>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.</p> <p>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.</p> <p>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.</p> <p>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</p> | 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 |
| | | | <p>background noise level in these areas is already on higher side.</p> <p>Use of vibration resilient pads in tracks will absorb vibration.</p> <p>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.</p> <p>Since the train coaches are enclosed and air conditioned, the impacts of noise on the travelers will be insignificant.</p> | | | | | |
| 102 | | <p>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.</p> | <p>The employment generation capacity has to be extended to the needy and underprivileged people.</p> <p>This positive impact should be enhanced to larger canopy of people by integrating with other modes of transportation to establish last mile connectivity.</p> <p>Metro services should be extended to support disabled, students, senior citizens through special programmes.</p> <p>Parking facilities for private vehicles shall be planned and provided to attract users of metro.</p> | <p>Working areas/offices, stations and depot</p> | <p>Number of Employment generated.</p> | <p>Check of relevant documents.</p> | <p>BMRCL</p> | <p>BMRCL</p> |

| 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. | 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 | | SOP developed 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 satisfaction 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 | BMRCCL | BMRCCL |
| 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 BESCO 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 | BMRCCL | BMRCCL |
| 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 | BMRCCL | BMRCCL |

| 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 satisfaction | 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 | Environment al 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} , SO ₂ , NO _x , 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 Narayanpura 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

